IEI Centenary Publication

Dr Ajudhia Nath Khosla Memorial Lecture

A Compilation of Memorial Lectures
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The Institution of Engineers (India)

8 Gokhale Road Kolkata 700020

Background of
Dr Ajudhia Nath Khosla Memorial Lecture

To perpetuate the memory of Dr Ajudhia Nath Khosla, one of the most distinguished engineer-administrators of the country, this lecture was instituted and the first lecture was delivered at the Second Indian Engineering Congress held in 1988. He was President of The Institution of Engineers (India) for 1948-49 and 1949-50.

Born in 1892 at Jallunder, Dr Khosla graduated from Dayanand Anglo-Vedic College, Lahore in 1912. His first assignment was the survey and investigation connected with the Bhakra Dam Project. The Bhakra Dam has been built on the very axis line marked by him in 1917. During his brief stint with the Mesopotamia Expeditionary Force in Iraq as a Commissioned Officer (1918-20), he made his important contribution to engineering by the invention of Khosla Disc for precision levelling across rivers and wide valleys. During 1921-26, he evolved and introduced precast concrete units for construction of barrages and later was responsible for re-modelling of the Marala headworks and the Upper Chenab Canal works. During this period he also carried out intensive research on the flow of water through subsoil in relation to stability of hydraulic structures. These researches culminated in 1936 in the publication of his treatise on 'Design of Weirs on Permeable Foundations'.

In 1943, he was appointed Chief Engineer and Secretary to the Government of Punjab followed by appointment as Consulting Engineer to the Government of India and the first Chairman of Central Waterways, Irrigation and Navigation Commission and also the Additional Secretary to the Government of India in the Ministry of Works, Mines and Power. He developed the Poona Research Station at Khadakvasla into the Central Water and Power Research Station. He retired from this post in 1953.

Dr Khosla initiated investigation of the water and power potential of the river valleys as a whole and several individual projects, like the Bhakra, Chambal, Damodar Valley, Hirakud, Kosi, Narmada and Tapti. Special mention is necessary of the Hirakud Project on the Mahanadi river, which he conceived in 1945 soon after assuming charges as Chairman, Central Waterways, Irrigation and Navigation Commission. The Mahanadi Valley Project at Hirkud was completed in early 1957 — a record time of 12 years between conception and completion of a project of this magnitude. Dr Khosla thus may well be called 'the father of the river valley projects in India.

In 1953-54 as Special Secretary to the Government of India, he led the Indian delegation to the United Nations for the Indus Water dispute with Pakisthan. These negotiations led to the World Bank proposals, which later formed the basis of the Water Treaty between India and Pakistan. He was a member of the Rajya Sabha from April 1958 to October 1959 and a member of the Planning Commission in 1959. In 1962, he was appointed the Governor of Orissa. This appointment was a historic event for the engineers of this country.

Dr Ajudhia Nath Khosla Memorial Lectures

was delivered during Indian Engineering Congress

The First Dr Ajudhia Nath Khosla Memorial Lecture was delivered during the Third Indian Engineering Congress, Madras, January 23, 1989

River Valley Projects, Earthquakes and Environment

Dr Jai Krishna, *Hon Life Fellow*

Professor Emeritus, University of Roorkee,
Past President, The Institution of Engineers (India) and
President, Indian National Academy of Engineering

I feel greatly honoured on being asked to deliver the First Dr A N Khosla Memorial Lecture today. I would like to congratulate the Institution of Engineers for instituting this lecture to perpetuate the memory of one of the ablest engineers of India.

Dr A N Khosla was born in a family of modest means in 1892, and qraduated from Thomason College of Civil Engineering, Roorkee, in 1916. His ability, courage, sincerity of purpose, and hard work were the main assets. He undertook to get the Bhakra project designed and constructed at a time when the British engineers were not willing to do so in view of the seismicity of the region and weak foundations even though it was a very beneficial project.

Dr Khosla was perhaps the first Indian engineer who used precast reinforced concrete beams to expedite the construction of the Trimmu Barrage in 1926. His bold field experiments on the concept of permeability of water under weirs was an outstanding example of his courage of conviction. This concept of designing the weir foundations has been very widely acclaimed and is still used as a quick approximation.

Dr Khosla remained associated with development and management of water resources from 1916 to 1954 in different capacities. He became Vice-Chancellor of Roorkee University in 1954, member of Planning Commission in 1959, and Governor of Orissa in 1962. Even during these years he continued to be a consultant to different river valley projects. I have therefore, selected the topic of this lecture as river valley projects with emphasis on seismic and environmental considerations a subject which was very close to Dr Khosla's heart - and he gave us immense encouragement in our developing this subject at Roorkee.

Fig 1 shows the river valleys of India along with the location of projects already completed or under construction. It will be seen that several major rivers like the Brahmaputra with its gigantic tributaries flow wholly unbridled. Similarly, rivers flowing from Nepal into Uttar Pradesh and Bihar remain unharnessed. All these rivers are a cause of floods almost every year but, if harnessed, they have enormous potential for power generation and irrigation. When these valleys are developed, many problems of northern and eastern India will have been solved. In the west. and on the southern plateau, although the position is much better, yet rivers like the Narmada, and partly others, can be a source of immense wealth in various forms, when their waters are stored and utilized for irrigation and power generation.

Fig 2 shows the seismic zones of India. These zones have been marked by taking into account the earthquakes that have occurred in the recorded history, which is wholly reliable for about 200 years and is partially so for another 800-900 years. Along with history, zoning has been carried out on the basis of known tectonic features, either indicated by earthquake occurrence or seen on surface, and also to some extent gravity and magnetic surveys carried out by various organizations for oil and mineral explorations. It will be seen that our northern and eastern river valleys lie in moderate to severe seismic zones, and their design will have to take this fact into account.

Fig 3 shows the epicentral map of India and Fig 4 shows the tectonic features. These form the background of the zoning map.

Inspite of the fact that all the known data have been used in preparing the zoning map, it must be considered only a broad indicator of divisions of the seismic intensities. Precise decisions in this respect are not feasible unless detailed data for all Indian earthquakes for a thousand years or more are collected. For river valley projects, such maps are only a starting point and, for each project, a very detailed study is required in view ?f the Importance of these projects with respect to initial Investments and consequent losses on failure.

One would have wished that a method could be evolved for predicting a future earthquake as occurrence of floods and wind storms is forecast. This, however, has not been possible so far inspite of intensive efforts made in the last 20 years particularly in the USA, the USSR and Japan. Table 1 shows the methods tried and percentage of cases in which the method succeeded. An engineer is unable to rest his oars on predictions of uncertain kind. He would like to know more definitely how various tectonic features were likely to behave in

future. For him the time of occurrence is immaterial. He is interested in the size and location since his perspective is in terms of the safety of the structures over a century or more irrespective of when an earthquake strikes during this period. For estimating the size of future earthquakes, and the location of active tectonic feature~ of the area, he has to study the region geologically and seismologically in detail.

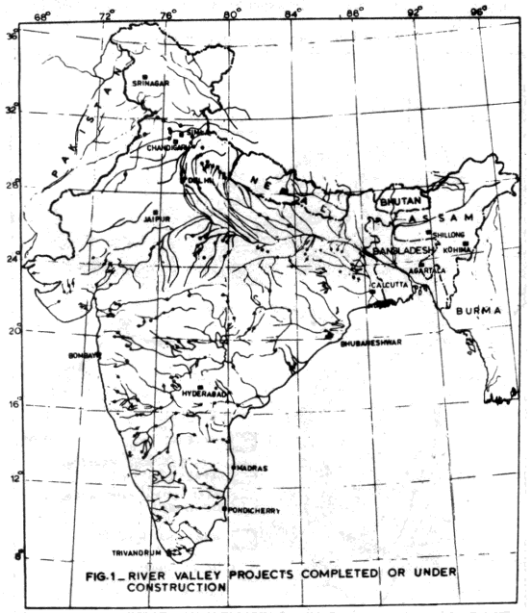

Fig 1 River valley projects completed or under construction

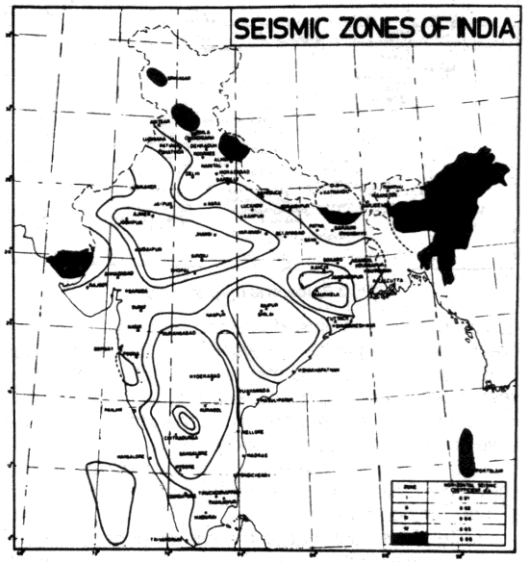

Fig 2 Seismic zones of India

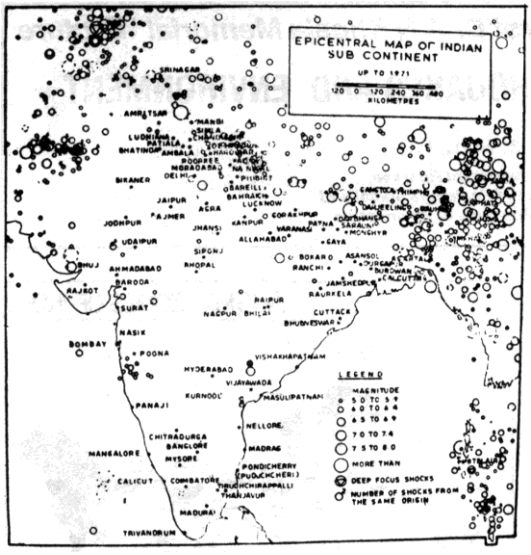

Fig 3 Eplcentral map of India

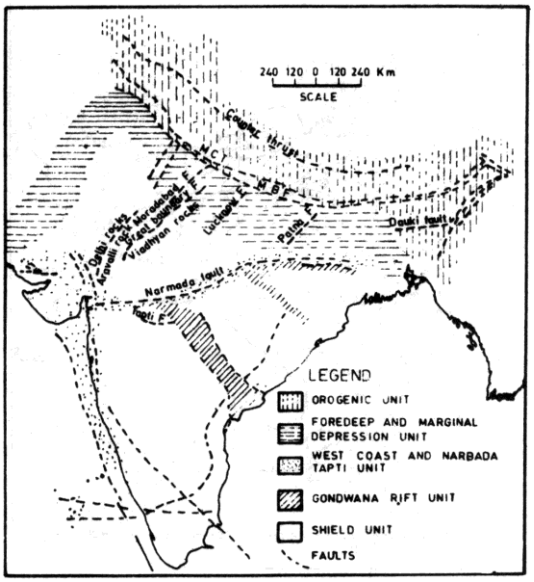

Fig 4 Tectonic features of India

The first step towards seismological investigations for a project is detailed geological mapping. On the basis of this 'map, suitable sites for seismological stations are selected. These stations should be at least 5 to 8 in number around the site. The stations will house seismographs and accelerographs besides a telemetered array of mocro-earthquake recorders, which would help in locating active tectonic features, seen on the surface or hidden below. Since earthquakes have their origin of fractures from about 5 to 700 km below surface, there is no other way of locating the buried sources of disturbance. The instruments should cover a wide band of frequencies so that tremors of all sizes could be recorded by them. The duration of such studies should be as long as possible. I would put three years as the minimum period, 10 to 15 years as the desirable period, but the longer the better. In anticipation of the development of river valleys over the next one century, all the valleys should be instrumented

from now so that adequate guidance is available when the project is taken up and designs are more efficient and reliable. Present empirical approach should be given up as early as feasible.

India suffers from lack of recorded data since. Till about 20 years ago. we had only highly sensitive seismographs. which recorded only distant shocks. So that understanding of the source mechanism is very imprecise. The strong ground motion recorders installed in India by the Roorkee School and other organizations will in due course provide more reliable data.

The traditional geologist had only a chisel and a hammer as his tools for geological mapping. But improvements in techniques of boring deep holes and drifts. carbon dating and seismological aids have put in a lot of science in his extrapolations. In recent years, remote sensing photography has enabled him to see a region as a whole and uncover many details. Which green coverage had hidden. An engineer now expects a geologist to assess the activity of faults discovered by different methods more precisely. He should be able to assess the likely movements of these faults better than before.

It may be appropriate to warn the designer at this stage by showing the extent of uncertainties involved in estimating the size and location of earthquakes. Table 2 gives the error that creeps in present methods of analysis. These are being refined by research workers and I hope the range of compounded error will narrow down in course of time. All the same. we should remember that this data is an input for estimating a future event, which is controlled wholly by nature and man has no control on it. Further. the designers take into account an envelope of responses of structures and cover this shortcoming thereby to a great extent.

TABLE 1 A RELIABILITY OF PREDICTION METHODS

Type of Forerunner	Percentage of about 400 cases in which proved reliable
Surface deformation and tilting	32
Foreshocks and micro-tremors	30
Decrease of velocity ratio of longi-tudinal and transverse waves	17
Changes in electric resistance and electro-magnetic field	14
Changes in radio-activity from radon content	4
Other methods including changes in focal mechanism, fault creep, chemical composition of ground water, anomalies in petroleum discharge	3
Astronomical relationsship of planets	0
Animal behaviour	Only China case on record, but even Varahmira mentioned it about 1500 AD

TABLE 2 EFFECTS OF VARIATIONS IN ESTIMATING MDh ON MAXIMUM ACCELERATION OF GROUND

Parameter	Range of Variation	Difference in Acceleration, %
Magnitude, *M*	+ 0.5	37
Depth of focus, *h*	5 to 10 km	23
Epicentral distance, *D*	5 to 10 km	23

Fig 5 is the accelerogram recorded in Koyna earthquake of December 11. 1967. It would be seen that an earthquake is a vibratory motion having components in all directions-vertical component is more dominantnear the epicentral tracts. while horizontal ones at points away from these. That me9ns stiff structures have to stand bigger forces near the epicentre and flexible ones are safer. while away from epicentre. flexible structures suffer large deformations and stiff ones are safer.

Structures to be constructed for a project have to be designed to stand the forces generated by an earthquake and its after-shocks. The main principle is to ensure that the structures could absorb energy put into them by the ground motion without collapse and preferably without serious damage. and surely without getting out of use. The energy is absorbed by a structure through its elastic and inelastic deformations and some is lost in friction within the structure and with the surroundings and supports.

Since a river valley project may consist of a dam or barrage. tunnels. power houses. buildings and bridges of various types. it will perhaps be appropriate to mention here the different ways in which different types of structures fail during a strong earthquake. Broadly, they can be classified as:

(i) Lack of tensile strength against horizontal forces combined with vertical forces resulting in moments, shears and torsion. Torsion is usually the most devastating among them.
(ii) Unequal settlement of foundations resulting in unbearable additional moments in supporting structure or liquefaction of foundation soil causing excessive settlements
(iii) Excessive sway of tall structures with large additional moments

(iv) Failure of bearings of bridges or equipment.
(v) Excessive deformation in equipment rendering them unworkable
(vi) Large shift in a foundation cutting across a fault
(vii) Large deformation of earthen slopes resulting in seepage or overtopping

Figs 6-17 indicate various type of failures. In order to minimize losses due to earthquakes, research work in the last 50 years has improved analytical procedures particularly with the help of computers. Large number of strong ground motion records round the world have enabled designers to estimate future ground motions more realistically and substituted empirical pseudo-static design methods by dynamic analysis. When these methods are put into use in designing structures and modern tools are used for their construction, the losses will decrease greatly. Recent strong earthquake in Japan two years ago caused no losses. In India also, modern technology is being adopted by project designers for important constructions. The common man, however, when building his dwelling has not made much use of methods evolved by the Roorkee School in strengthening brick and stone houses. Very simple methods of reinforcing brick buildings against earthquake forces have been evolved as shown in Fig 18. There is a need to educate engineers working in seismic zones about these methods, which do not increase the cost by more than 2%-5%, and could save most buildings from collapse or severe damage. Most of the lives are lost during earthquakes through the failure of common people's dwellings. It is suggested that professional institutions may develop these courses as a disaster prevention exercise. It is regretted that if north-eastern India, Bihar and Himachal Pradesh had taken full advantage of this work of the Roorkee School, hundreds of millions of rupees worth of losses could have been reduced to a few millions only. It is interesting to mention that other countries have made extensive use of these methods. The new direction for research is to develop isolators for absorbing energy transmitted by ground motion to reduce damage to the structures. Some methods developed so far are primarily useful for rigid structures and equipment which could stand increased displacement without damage or dislocation of their functions. Finally, it may be said that although there have been very severe seismic zones to tackle, modern developments in knowledge-analytical and experimental-have strengthened us to be able to make our constructions and equipment reasonably safe and this knowledge exists in India itself. I mention this since Dr Khosla was very anxious to develop self-reliance among our scientists and engineers.

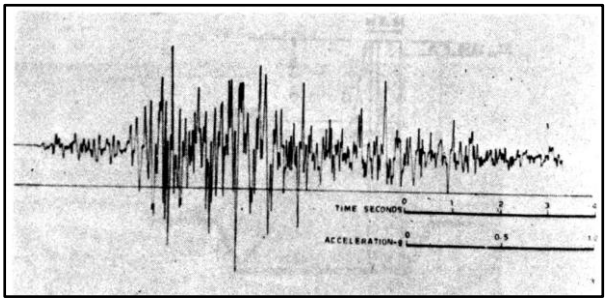

Fig 5 Accelerogram recorded at Koyna Dam during December 11,1967 earthquake

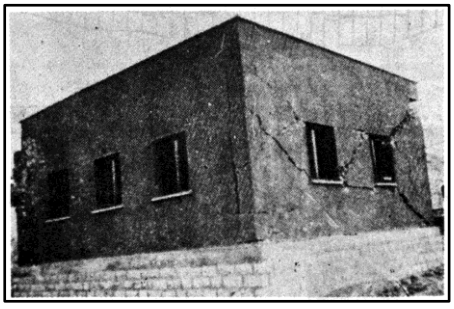

Fig 6 Diagonal cracks in a masonry building

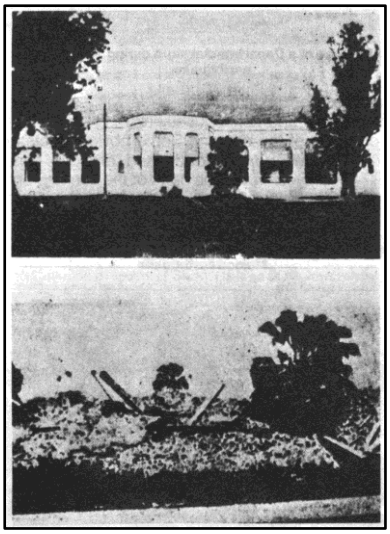

Fig 7 Collapse of judges house at Muzaffarpur during Bihar Earthquake of 1934

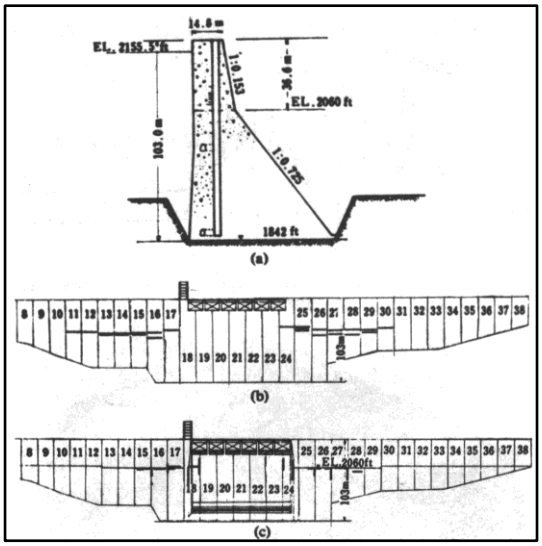

Fig 8 Cracking of Koyna concrete gravity dam during December 11, 1967 earthquake

Fig 9 Failure of a Departmental store during 1948 Fukull earthquake

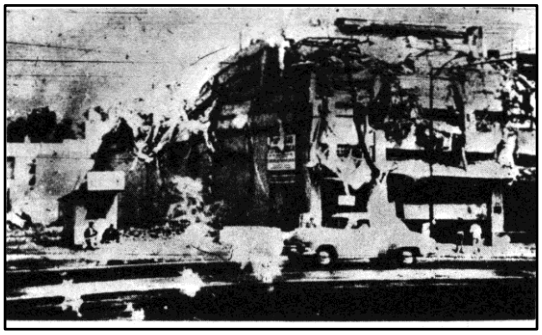

Fig 10 Collapse of multi storeyed concrete building during Mexico earthquake

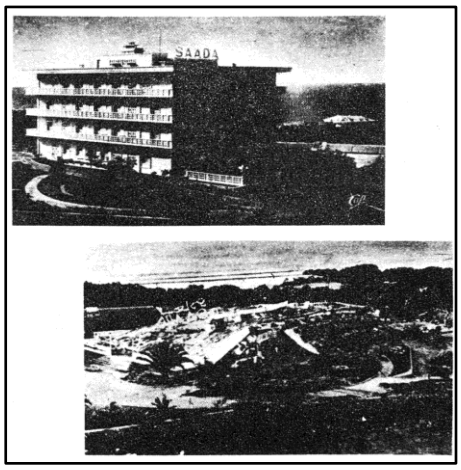

Fig 11 Collapse of SAADA Hotel during Agadir earthquake 1960

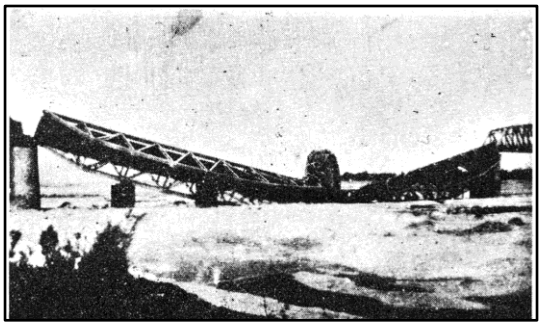

Fig 12 Supper structure of steel girder bridge overthrown due to failure of its bearings (Bihar earthquake 1934)

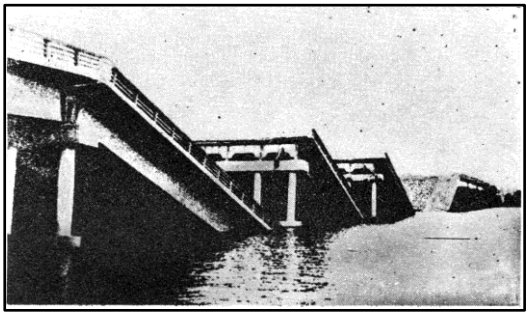

Fig 13 Collapse of spans of Showa bridge in Nigatta earthquake of 1964

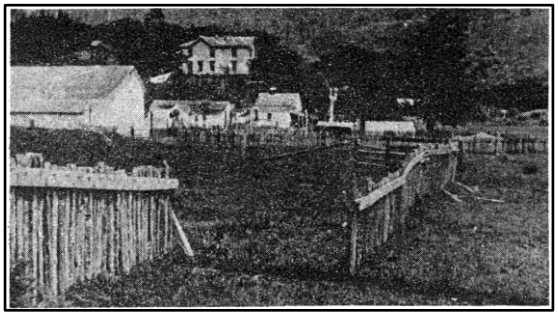

Fig 14 Large movement of ground indicated by shift offencing during an earthquake

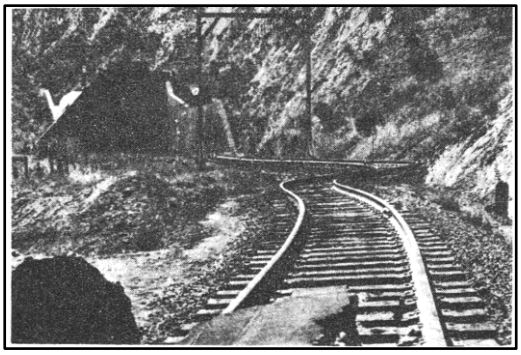

Fig 15 Large movements of ground indicated by deformed railway track

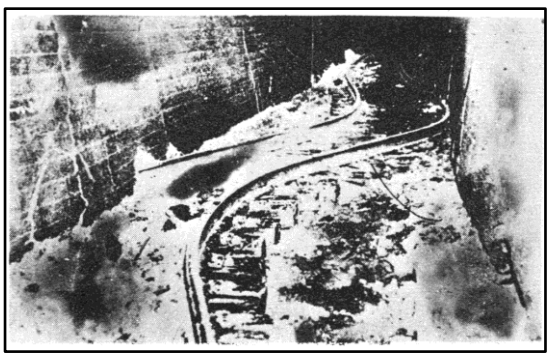

Fig 16 Large deformations of a railway track inside a tunnel

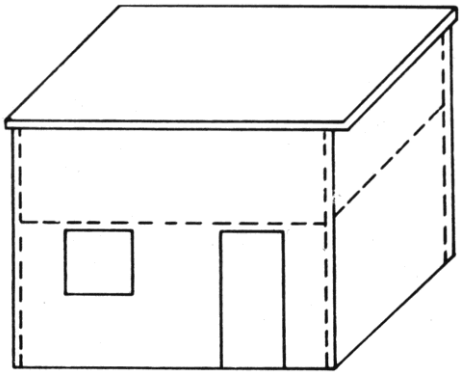

Fig 17 Cracking of Ono Earth Dam in Japan during an earthquake

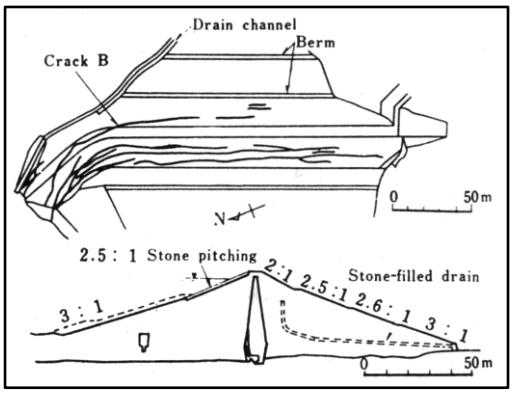

Fig 18 Masonry building reinforced with lintel b~nd and vertical steel at comers and jambs of opemngs

RIVER VALLEY PROJECTS AND ENVIRONMENT

It would perhaps be topical to devote some time to discuss the question of river valley projects and environment-a concern which is delaying execution of many projects and consequently slowing down economic progress of the country. Some obvious facts are:

(i) We suffer from floods and droughts almost every year in various parts of the country, one of the reasons of which is indiscriminate deforestation;

(ii) Rainfall in this country comes only in a few months and water has to be stored for use in dry seasons;

(iii) Coal and oil are depleting sources of energy and also have environmental pollution as a problem, which is far more serious than the pollution due to other resources;

(iv) Nuclear and solar sources of energy are expensive at present and solar energy exploitation requires intensive research for energy storage;

(v) Water is the cleanest source of energy without causing pollution and needs minimum inputs to maintain, although the initial cost is higher than that for coal and oil;

(vi) Energy generation, required to sustain a reasonably comfortable life of one billion people would require all possible resources to be exploited, Thus hydro power could not be ignored whatever the consequences.

Consequently, as many, dams as possible must, be built up and wherever feasible to store water for dmkinq, industry, agriculture and generation of power. The adverse consequences of building dams are:

(i) Displacement of people in the area to be submerged by artificial lakes;

(ii) Submergence of forest and vegetation, dislocation of animals of the region; and

(iii) Small earth tremors in some cases.

There can be no dispute about the fact that these are very serious matters and it is indeed hard on the pople who are displaced from their hearths and homes, where they have been living for generations, and h~ve to s~art life in new surroundings, but no progress IS possible without sacrifices. It is, however, the duty of the owners of the project to ensure rehabilitation of t~e displace? people in such a way that they are able to Improve their standard of living in new places, to compensate the emotional setback. That is, the displaced people should be the first beneficiaries of the project. This task should not be tackled in the usual bureaucratic manner with annoying delays, but entrusted to judicious social workers who have emotional contact with the people displaced. Similarly, forest plantations should be undertaken extensively to make good the loss of forest resources. Displaced animals should also be rehabilitated as far as possible. These remedial measures should be the first charge on the projects.

So far as the earth tremors are concerned, they are usually small and should not be taken seriously. In seismic areas, earth tremors caused by natural features are much bigger than those caused by stored water. People of the area should be educated, and their dwellings strengthened, if necessary.

Even if we have to lose, although reluctantly, some animals and some forest, I think, this country has no escape from developing its water resources for. su~ival of its human population. In all developed countnes, nver valleys and other resources were fully exploite~ providing adequate food, clothing, shelter, education and health care before they bothered about environment. We have 40% of our people, ie, 300 millions below the poverty line.

This number is larger than the population of the USA and also that of the whole of western Europe put together. I do not mean to say that we should neglect environmental considerations, but it must hav~ a priority lower than providing essentials for our population through exploitation of all resources, an~ fi:st .of all 'water'. Fossil fuels are increasing carbon dioxide In the atmosphere and decreasing a zone content. This is a great hazard.

It may be mentioned here that the Bhakara Dam project is among the top 75 projects in the world, ~nd Tehri Dam project will be among the top 25. The United States and Canada alone have 20 projects matching the best 'Ne have, when their population is only one-third of our population. Thus developed countries have qone ahead with developing their river valleys as an essential first step. We are far behind them. ..

The most important environmental concern IS air pollution due to automobiles, chimney exhaust, and radiation. Water and food pollution are the next on the list of priorities. The effect of river vally projects on the environment is minimal, if at all.

If we develop our river valleys in the next one century, it will be a fitting memorial for the great engineers like Dr Visvesvarayya and Dr Khosla, who have worked devotedly towards this objective as pioneers. They ha~e given us a good start and it is our duty to c~~ry tbis important, urgent and inescapable task to fruition.

In the end, I thank the Council of the Institution of Engineers (India) for inviting me to .deliver thi? I~cture and, I hope, the Institution takes It as a mission t.o educate our governments so that the 21st century IS really a comfortable one for the young generations to come.

ACKNOWLEDGMENT

The author acknowledges with thanks the assistance rendered by Dr Brijesh Chandra, Professor of Earthquake Engineering, University of Roorkee, in the compilation of the lecture.

The Second Dr Ajudhia Nath Khosla Memorial Lecture was delivered during the Fourth Indian Engineering Congress, Bhubaneswar, December 30, 1989-January 2, 1990

Railways in Service of the Nation

R K Jain, *Fellow*

Former Chairman, Railway Board &
Principal Secretary, Government of India
Ministry of Railways

I am indeed privileged on being asked to deliver the Second Dr A N Khosla Memorial Lecture and thank the Institution of Engineers (India) for affording me an opportunity to share some thoughts with a distinguished gathering of highly reputed engineers.

Dr A N Khosla was an Engineer par-excellence and admirable administrator. He was the doyen of Indian water resources engineers, the father of river valley projects, the first Indian Vice-chancellor of the University of Roorkee, and the first engineer to be appointed as Governor of a State. His invention of the 'Khosla Disc' for precision levelling across rivers and wide valleys, his theory for design of barrages and weirs on permeable foundation, his close association with several major river valley projects like Hirakud, Bhakra-Nangal and Ram Ganga and his leading role in expansion, modernisation and stimulation of research at the University of Roorkee will be remembered for a long time to come. Despite his exacting duties as Member of Planning Commission and as Governor, he continued to take active interest in engineering.

I know Dr A N Khosla personally as a colleague of my father-in-law and as Chairman of the Committee of Engineers (1957) for determining maximum discharge to design waterway for bridges and for ensuring safety of railway bridges against failure of Railway affecting works. He was analytical in his outlook and had a zest for modernisation. While holding the post of Vice-chancellor at the University of Roorkee for a little over five years, he donated his own personal earnings, from which a research fund of Rs 1.15 lakh was created to stimulate research at the University.

He was closely involved with the upliftment of the society and in recognition of his humane and philanthropic approach. He was nominated as Member of Rajya Sabha and appointed as Governor of Orissa. He was always dedicated in service to the society and that is why we remember him. I, therefore, consider appropriate to deal with this subject, which is most dear to Dr A N Khosla and confine myself to the role of Railways in service of the nanon.

Transportation plays a vital role in the economic and social development of a country. It provides necessary linkages between the sources of raw material, the manufacturing units and the consumption centres arid thereby enables mass production. The economy, industrial and agricultural development of a country is closely inter-related with the development of transport structure. It also enables social interaction, commercial activities and cultural bondage- so essential for human survival. Besides immediate benefits to the areas served, it has a multiplier effect on the economy as a whole.

Railway Sector

Railways are the dominant mode of transport sector and therefore acquire a new dimension. This network unifies the country, plays a vital role in economic development and industrialisation, maintains supply lines even to remote and inaccessible areas, connects ports to hinterland and influences the culture of the nation. Indian Railways are thus the lifeline of the nation and the wheels of economy.

Railways are the ideal mode for haulage of materials and essential commodities in bulk over long distance. They are also the cheapest transport for the middle- and lower-income groups, which constitute the bulk of Railway users. Indian Railways with approximately 62000 route km account for about 64% of the total surface transport effort in terms of net tonne km. Indian Railways have slowly gravitated to the movement of long distance bulk commodities, of which 11 commodities alone constitute 93% of the total tonnage lifted and 90% of the tonne km registered.

Profile of the Railways

Today, Indian Railways are the world's second largest State-owned railway system under a single management. Served by 7000 stations with a fleet of about 4400 steam locomotives, 3300 diesel locomotives, 1500 electric locomotives, 30000 coaches and 350000 wagons, every day it handles over 10 million passengers and loads a million tonne of freight.

Unlike other modes of transport, Railways bear the infrastructure cost. Another unique feature in respect of Railways is that the assets-both fixed and moveable - have a long life span. Track, bridges, locomotives and rolling stock constitute 75% of their capital assets. While track and bridges have a life of 40 and 100 years, respectively, locos and rolling stock have a reasonable expectancy of life of 35/40 years. Any major investment for rehabilitation, modernisation and improvement carries with them the implications well over into the next century. Consequently, a wrong choice of a new asset or technological innovation will be perpetuated in the system for several years. This is specially so in view of the high cost of these assets which cannot be thrown away when newer technology becomes available.

Role of the Railways

The role played by the railways in the service of the society is pervasive. Indian Railways transgress barriers of region, religion, caste and creed and are unique in bringing about national integration of people living in different regions with diverse physical features and under vastly different climates. The Railways bridge distance, cut across geographical and political barriers and enable people to intermix freely, blurring the regional boundaries. They help people of different regions to understand one other, thereby promoting oneness. They also bring the producer and consumer closer and allow free interplay of competition, and innovativeness by providing transportation at a low cost, thereby serving the cause of national integration.

The social development of the country is inextricably interwoven with the railway's development and performance.

Railways have, therefore, a distinct part to play in moulding Indian society. Railways have also paved the way in development of heavy industries. The ushering in of an era of planned economy called for a major thrust in the area of freight transport to cater for movement of newly exploited mineral wealth for rapid industrialisation. Growth of agriculture had received full support from the rail network. Railways have enabled trade and commerce to proliferate and motivated labour and capital to discover new frontiers.

Railways have also admirably risen up to the occasion in meeting the national calamities, thanks to the competence and flexibility of the system. By prompt transport of foodgrains from surplus to deficit areas with a remarkable speed, railways have ensured eradication of famines in independent India.

The support given by the railways in maintaining security of the country is significant. During any conflict affecting the nation's prestige, Railways rushed troops, arms, ammunition and stores at top speed to war front and gave the country's armed forces the necessary logistic support. Equally vital is Railways' role in preservation of law and order within the country. When trouble brews in any part of the country, Railways rush the personnel of Central Reserve Police, Border Security Force and other auxiliary formations to the danger spots to reinforce machinery of law and order.

When hit by floods and breaches, Railways have a unique record of restoration unparallelled by the only comparable mode in highways.

Areas of Strength

The environment and resources used in transportation have an economic impact. Surface transport uses resources - land and fuel - which are limited and not easily replaceable. Besides it has a bearing on the environment and quality of life - whether in cities or on country side. It is seldom recognised that amongst various modes of transport, Railways provide not only the safest means of transportation, but also the most economic, energy-efficient and pollution-free system. They are also ideal for carriage of dangerous and toxic goods. While making a choice of transport, these aspects should not be forgotten.

Safety is a strong aspect for Rail transport. Safety record of Indian Railways has improved considerably over the years with a total train accidents touching the lowest figure of 545 in 1988-89, despite increased traffic density and output. Arising out of the train accidents, 140 passengers lost their lives and 547 were injured during 1988-89. As a comparison, road users killed per annum are about 40000. In road accidents at Delhi alone, tile record of 1983 reveals that there were 1156 road users killed and 5463 injured. This indicates clearly why rail travel is considered much safer than other means of transport, despite much volume of traffic carried.

In energy efficiency, the Railways consume only 30-35% of the energy per tonne km or passenger km, as compared to alternative means of mass transport, and comparison of energy efficiency index is even better than the private or individual transport systems.

In respect of environmental impact, Railways enjoy a strong position compared to other means of transport because they integrate harmoniously with the landscape. They create the least pollution and make the most effective use of land for the same throughput capacity.

Indian Railways have also the maximum interface with the public, handling nearly 10 million passengers every day besides dealing with numerous freight customers. Thus, the policies and programmes undertaken by the Railways have a direct significant impact on nearly 1% of the country's population every day.

Constraints

From being a purely commercial undertaking in the pre-independence era, Railways in India have rightly come to perform a dual role of a public utility service and a commercial undertaking. Because of its size and importance, Railways are also used by the Government as an instrument for implementation of its social and economic policies. Performance of the social role vis-a-vis the. community takes the form of a 'policy of price restraint', coaching services including suburban passenger services run at a loss; some essential commodities are carried at less than the transportation cost; and operation of unremunerative branch lines has to be continued as a social obligation.

This social burden accounts for about Rs 1700 crore per annum. It may not be out of place to mention that in 1986 German, French, Japanese and British Railways got an annual subsidy of about Rs 11000 crore, Rs 8000 crore, Rs 2500 crore, and Rs 2000 crore, respectively for the social costs incurred and still these railway systems-were in the red.

As a Government undertaking, Railways do not have the flexibility to pickup and choose the customer and commodities, offer on-the-spot reduction of rates and quote exceptionally low rate in a particular direction.

I would also like to dwell on some aspects of the railway working which are not commonly appreciated by the public. The rate structure for freight movement provides for different classifications and rates for various commodities. Any commercial transporter would naturally prefer to move first the high-rat.ed commodities offering even to the exclusion of others. The Railways are bound by a preferential schedule whereby it is enjoined on them to allot wagons for certain items/commodities like military traffic, foodgrains, coal and cement and then only to others. Though this cuts across the very principle of commercial operations, it is in the interest of the security and economy of the nation. There is, therefore, a strong case for the Press, the public and Parliament to recognise this when evaluating the financial performance of the railways.

Railways do not enjoy unfettered discretion in fixing freight and fare structure. A commercial organisation would price each service to cover the cost or design explicit subsidisation of certain services. Being a public utility undertaking, Railways do not exercise freedom to adjust their freight and fare rate corresponding to the increase in the price of various inputs used by them. The Railways are also bound to transport supply of materials for relief of distress in the event of natural calamities like floods, cyclones, drought and earthquakes at concessional rates.

So far urban rail system has been provided by the trunk railways, in the absence of adequate transport. With the rapid economic progress and consequent urbanisation, the demand for transport of commuters is rising at a staggering pace. Urban transport projects are highly capital-intensive and the services are not generally remunerative. Consequently, it would be impossible for 'any single agency to take on this responsibility on its own.

Indian Railways have a working force of 1.6 million regular employees with a wage bill amounting to about 51 % of the total working expenses. The present work force on the railways still has a large component of unskilled staff. The average cost per employee on the railway has risen sharply and is 20 times that in 1950-51. Despite this, in nation's interest. the Railways have to remain financially viable. Attempting to be a model employer adds additional responsibilities and expenditure.

Strategies for Better Service

Indian Railways have a major role to play not only because the rail traffic is growing, but also the society is changing. Their approach towards customers has also to change, since customer-oriented service has to be the primary concern of any commercial undertaking. The position of the esteemed customer was succinctly summed up by the Father of Nation, Mahatma Gandhi, when he said:

'A customer is the most important visitor in our premises. He is not dependent on us. We are dependent on him. He is not an outsider to our business. He is a part of it. We are not doing him a favour by serving him. He is doing us a favour by giving us an opportunity to do so.'

The management has to focus its attention on the needs of the customer; it has to react in time, objectively and positively; it has to anticipate and thereafter by proper planning ensure effective implementation of what the Railways promised so as to fulfil the expectations of the customer. This exercise has to be a continuous process. As our late Prime Minister, Pandit Jawahar Lal Nehru said: 'A nation cannot progress, if it merely imitates its ancestors; what builds a nation is creative, inventive and vital activity.'

'Quality of service' is synonymous with customer satisfaction. Customer satisfaction means different things to different customers. Basically it is derived from the personalised response to the specific needs of the customer. Only he can say whether he has derived 'value for the money'.

Railways should believe in the philosophy that people should travel byrall not because they 'have to' but because 'they want to'. Railways are to be concerned not only about the customers 'who use' the railways but also those 'who could use' them. A time has come for the railway management to recognise that there is potential for offer of value-added services and to put a corresponding price tag on such services.

With rising standards of living and expectations, desirable comfort-level would also increase. The dividing line between a necessity and a luxury is transient. Today's luxury is tomorrow's necessity. To illustrate, air-conditioned sleeper coaches introduced in the seventies, once considered a luxury, had turned out to be such a boon and a necessity that the production of first-class coach for upperclass passengers has yielded the pride of place to the second-class air-conditioned sleeper coaches. The offer of services to the passenger has been responsive to the demand.

It is true that in India the demand outstrips the supply and hence the need for achieving customer satisfaction is not a commercial compulsion today. Even then railways have to give adequate attention and thought to customer satisfaction. As Plutarch said:

'To those, who ask for them, we must render reasonable and proper services not at their insistence, but because we choose to do so.

'An adage is that 'quality is ninety percent attitude' aptly applies to railway systems. There is need for seeking to bring attitudinal changes in all echelons in the hierarchy by suitable training and other measures. Quality must become an integral part of corporate philosophy in thought and deed.

Beyond the basic passenger service, Railways have to pay greater efforts to meet the requirements of the contemporary world. These could cover passenger information and guidance system, shopping guide, tourist guide, medical services, car-hire, hotel reservations, encashing of travellers' cheques, luggage lockers, onward connections in inter-modal services and communication while on train.

Punctuality is paramount in both short and long distance traffic. It is said that 'the last mile is the longest' in long distance journeys; therefore the wearied passengers look forward to arriving at their destination on time. Steps have to be further taken to improve punctuality of all trains. Similarly the concept of guaranteed time delivery of goods would have to be substantially extended.

Making available convenient and speedy facilities for reservations on trains by computerisation has gone a long way in ensuring passenger satisfaction. At present, computerisation has been introduced in four metropolitan cities while at five more cities, the work is in progress, which will cover 57% of total reservations on the Indian Railways. It is proposed to extend it to cover 88% reservations by 1994-95. A rough estimate at Delhi alone has revealed that 15 million man-hours are saved annually, as a result of provision of computerised reservations and satellite offices, in addition to the saving in transportation cost by the prospective passengers due to shortening of journeys undertaken for the purpose of reservation. The socio-economic benefits to the community are thus considerable. Although the computerisation is an item of cost for Railways internally, it has helped individuals as also economy by bringing this service to our users. Computerisation of passenger reservation and freight are thus important areas, which will give abundance of benefit to the customers.

To measure the level of satisfaction of the customer, periodic and surprise inspections, the rating system for different facets of the journey, suggestions and complaints from customers and reaction of the Press can be fully used, since they serve as the only barometers. The measurement of customer response should cover all aspects like comfort, punctuality, cleanliness, hygiene, catering, passenger guidance. availability of information and passenger amenities. The management should be geared to know more about the quality level of the service rendered to the customer and should notice the changes in the quality level, well before the customer. Customer complaints must therefore not normally be the basis for quality control, but only an indicatrve supplement to the information system where control has failed. The remedial action is more important than diagnosis and hence measures to take corrective action in time require greater emphasis.

Tangible improvement in the areas of inherent strength of railway system as mentioned earlier has to be undertaken, to enable the railways to serve the nation better. Safety in operation is the biggest preoccupation of the Indian Railways. Since the share of human element is over 60% in railway mishaps despite the increase in level of automation, there is a greater need to control lapses on the part of human beings. The vulnerability of 'man' becomes more conspicuous, when he works in configuration of man-machine system. It is proposed to control the fallibility by adopting a number of strategies covering assessment and control. Towards this objective, job placement programme, job-oriented training, counselling services, employees' motivation, sustaining programme and scientific designing of workplaces and procedures have been introduced.

Psychological testing of candidates at the time of recruitment, at the time of promotion and periodical psychological check up for some sensitive categories above 45 years of age have been introduced, to monitor quickness of reaction and perceptual abilities, which are likely to get affected due to ageing process. Continued efforts are being made for creating greater safety consciousness amongst the railwaymen and a number of safety devices are being progressively installed. Even though the index of safety performance in terms of accidents per million train km has improved from 1.50 in 1984 to 0.9 in 1988-89, no complacency should be allowed to creep in. Safety is an area of paramount concern, where no compromise can be struck and no shortcuts taken.

Energy bill of Indian Railways accounts for more than one-fifth of the working expenses. Energy conservation has, therefore, been an area of concern especially when 90% to 95% of the consumption of energy of the Indian Railways are on traction. Apart from accelerated phasing out of steam locomotives, several energy conservation measures have been initiated like design of more energy efficient locomotives, reduction in the tare weight of wagons and coaches, lubrication of rails, provision of chopper control and regeneration in dc EMUs, improved training of drivers and fitment of fuel-efficient kits. R&D programmes have been launched for fitment of flanged lubricators on locos, use of steered bogies on sections with sharp curves, provision of roller bearings in all wagons, aerodynamic profiling of rolling stock, use of high efficiency turbochargers, fitment of low idling feature in locos, use of multigrade oil and provision of high speed turnouts. Against a target of 5% improvements in two years covering 1987 to 1989, Indian Railways achieved this conservation in one year itself. A further energy conservation of 20% has been kept as a target to be achieved in the Eighth Plan.

Conservation of forest wealth is a national programme and is receiving the wholehearted support of Indian Railways. 88000 ha of vacant railway land are being speedily a forested with 10 crore of trees. This will improve ecological balance, environmental condition, reduce noise level, enhance the aesthetic value, beautify the landscape and protect the railway land from erosive effect of rains and storms. Railways have also drastically reduced the intake of wooden sleepers by switching over to concrete sleepers, which has already crossed the 3 million mark annual production in 1988-89. The lead taken by the railways is expected to result in development of sound environmental management methodologies.

With the greatest interface with the public, Railways are to be alive to the tremendous responsibility reposed on them. They are to make determined efforts to make the railways as an efficient transport mode to meet the country's need to serve the society in the best possible manner. They should like to fully abide by the observations of our the then Prime Minister when he said 'A responsive administration is tested most at the point of interface between the administration and the people. Therefore, it is essential to hone the cutting edge of the administration'.

The fruits of independence in the last four decades have brought a new generation of customers with different aspirations and diverse requirements. The improved economic conditions of the society and the change in social attitudes will place a different pattern of demand in future and this aspect is being borne in mind in their perspective planning.

With the lifespan becoming longer due to improved medical standards and health care, the future clientele would be of a larger percentage older people. The requirements for such people will have to be catered for. Similarly handicapped persons would like to travel and move about freely without taking assistance from other fellow human beings. With the spread of educational centres, there will be a new requirement of students for commuting to educational institutions. Government policy towards providing a well earned rest and recuperation has given a further encouragement for travel to have relaxation and holidaying. Adequate facilities both at the stations and in trains to meet these needs will have to be provided for.

Witl1 the transformation of traditional society into a modern society in the years to come, railways have perforce to modify themselves to the changes in the attitude and expectations of the people. Introduction of non-srnokino compartments, improving the bedroll service to inculcate the habit of travelling light and opening of Yatri Niwas are some of the measures being undertaken in this direction. The gap between the expectations and fulfilment is also planned to be kept as narrow as possible. Our then Prime Minister has rightly observed 'As growth and development proceed, as our society changes, as our economy becomes stronger, our socialism must adapt to that. We must go back to the basic postulates and re-apply them to the changed situation. A responsive administration recognises these evolving changes and evolves appropriate answers.'

With the society gradually becoming more time conscious, the distance is being increasingly measured in 'time units'. A location may be distant or close depending on 'how soon' it can be reached. The railways have, therefore, planned to shorten the travel time, since it has become an element of cost. Towards this objective, Shatabdi expresses have been introduced and they augur a new era in pointto- point passenger traffic. They are also considering electric multiple unit train sets and diesel train sets for introduction on Indian Railways in near future.

Railway technology encompasses all disciplines of engineering. Indian Railways have drawn up an integrated plan for modernisation, which would help in generating the much needed additional transport capacity both for freight and passenger traffic. The key future technological areas have also been identified. Elements of improvement are programmed in different technological areas simultaneously over the core network of the system, taking due care to ensure that no Single field is left uncovered as to delay the overall benefits of introducing the new technology.

Reliability is an important parameter towards better service and customer satisfaction. Each failure, be it of an engine or spring or rail or signalling, causes serious repercussions and the cumulative effect is much more severe today because of increased frequency of trains. Service reliability is therefore given a major thrust in all fields of railway working. The equipment inducted and the maintenance procedure have been so evolved as to reduce the maintenance cycle and to improve the reliability in operation. Quality assurance in maintenance and production procedures must become a part of habit and duty. The setting up of quality circles in various production areas including workshops, sheds and offices will bring the cooperative effort to bear on this aspect. The Indian industry, which is now sufficiently mature, has an important contributory role to play in it.

During the last 40 years, while the traffic has gone by about 400%, the growth of the railway network has been only 16.7%. Against 884 route km added per year during British period, only 178 km have been added per year since Independence, in an attempt to make optimal use of the system. There is a great need to reshape the network to rectify this weakness to meet the requirements of planned development. A stage has now come when emphasis will have to be laid on the expansion of the network to serve as links to form alternative route for relieving congestion on the existing saturated rail routes, provide links to shorten the distance, meet the strategic needs, give access to remote areas and meet the project-oriented links for tapping mineral and other resources.

The work force of Indian Railways needs necessary motivation and training to enrich their jobs and to utilise their latent skills and talents. The men are made to feel happy at their work and have more pride in the organisation for which they are working. In an age of continuous change, human resource development and management has become a continuous organised process. Training institutions and programmes are being upgraded and modernised for meeting the new requirements and aspirations of this work force, so that they rise up to the challenges of new technology and are equipped adequately.

Organisational changes are being brought about steadily and firmly with the support of social and political systems in the country. Because of the mass contact with the public, a change from the bureaucratic to a commercial role has been found necessary to fulfil the aspirations of the customer. There is also no point in making massive investments in modernisation in machines and equipment. if the man behind machines is going to do merely a routine day's work without any element of motivation in his attitude. Inculcation of team spirit is therefore to be given due importance for the success of the exercise. Being an important infrastructure for the development of our nation, the new environment, work ethos and culture are bound to have ripple effect both in the railways and in the society. As Benjamin Disraeli observed 'Individuals may form communities, but it is institutions alone that can create a nation'.

Obligations of Society

Investment in the transport structure not only ensures the development of capacity, but also has a multiplier effect on the economy in that it helps industrial and economic growth of the entire community: Measured as a percentage of total plan expenditure, the investment in the transport sector has halved over the successive Five-Year Plans, while investment on the Railways has steadily declined. There is a need to avoid duplication of investment in different modes and to invest in areas, which will help catching on the strength of the each mode, enabling development of all modes of transport so that they play an economic and meaningful role in the areas where they are best suited. Since Railways have to provide more capacity for movement of freight and people and they have little resources, the investment issue becomes important. Rail transport is playing a significant role in tlie Indian economy and this is fully recognised by the Government and also by the industry. It is, therefore, essential that adequate support is given for the investment on the Railways and the society must prevail on the Government for greater allocation. As our then Prime Minister has observed 'When the community realises that it is itself contributing to the development process, the chances are that tile accent will remain on balanced development with long-run advantages rather than only populist short-term measures pursued at the cost of long-term development'.

The cooperation of the customers is essential for the success of the organisation in improving better service. Their valuable support will enable prevention of thefts and pilferages of railway assets and public consignments, nabbing of anti-social elements, rooting out corruption and improving tile image of the railways. Through the Press and other media and Public Relation Organisation, Railways convey to the customers as to what they are doing, what they are striving to do and what they are not able to do, so that the public are in a position to understand and appreciate the problems. It is equally necessary that the feedback from the customers is promptly given to enable them to improve further.

The obligation of public rests in maintaining a civic and responsible behaviour and in respect of its own and other people's health, conveniences and rights by observation of some' elementary principles and practices. Throwing of objects outside the windows of running train, boarding a running train, carrying of offensive and prohibited articles in a train, pulling of alarm chain indiscriminately, making the Railway premises dirty and insanitary, vandalism, etc should be eschewed. The feeling that assets of Indian Railways are a national property in which every citizen has got a rightful role to protect and maintain them has to be inculcated in the minds of people, and the society can definitely playa significant role to achieve this objective and thereby reduce unit cost of service.

The cooperation of rail users in maintaining the standard of cleanliness and upkeep of railway assets will enable better service to the valued customers. The example of Metro, Calcutta convinces that mutual efforts and involvement of Railways and the users as a team can ensure that the premises can always be kept clean and pleasing, so that the tired commuter is relieved of his tension and can relax in an invigorating atmosphere and surroundings. Such a citizen can definite.ly bring better productivity at his workplace and more happiness at his home.

For supply of essential commodities to farflung areas, mobility of the railways is important. Indian Railways have been running essential services in Punjab and Assam under very adverse conditions. Terrorist and anti-social activities of bandh, rail (aka agitation, etc for issues not connected with the railway affect drastically the rail movement and deprive people of getting their normal share of entitlements. I would urge for the abundant support of the community to this vital aspect. Such agitations, bandhs, etc affecting rail movement must receive full condemnation from all sections of the society and persons or groups indulging in them ostracised.

Scientific determination of the price which a customer is willing to pay for regularity or speed is essential. It will enable formulation of a rational approach in meeting such demands. While the Railways should know at all times what the customer thinks of the service offered and set up a competent machinery to take adequate remedial measures in real time, the society should be equally responsive for accepting the price tag towards such special services.

Railways influence the society and the same are being influenced by the social changes. Railways and society have thus a complementary role to play. It will be, therefore, necessary that the society should be willing to adapt themselves to the changes brought out by the Railways from time to time. Change in travel habits, computer culture, new work ethos and improved civic sense are some of the areas where Railways can pave the way for bringing a radical change in the behaviour of the Railway users. Adapting an age-Old saying, one may say that 'people get the Railways they deserve'.

Conclusion

Indian Railways have recently displayed a remarkable resilience in meeting the challenge of the past, successfully fulfilling the needs of the country at present and also planning and organising to meet the transport needs of the future. In the present economic scenario, Railways have a crucial role to play in the planned economic development of the country and they fully realise the enormity of their task and have therefore evolved appropriate strategies to tackle the challenges successfully.

Emboldened by the success achieved, encouraged by the able support of the customers and endowed with the ability to innovate, improvise and improve with ingenuity and imagination, Indian Railways are poised for a quantum jump and are confident in establishing an efficient Railway system to meet the country's need and to serve the society in the best possible manner. Our late Prime Minister, Smt Indira Gandhi aptly said:

'The Railways are our largest State Undertaking. Their functioning has a crucial impact on national life. Any significant enhancement in their efficiency would have far-reaching benefits'.

The Third Dr Ajudhia Nath Khosla Memorial Lecture was delivered during the Fifth Indian Engineering Congress, Kanpur, December 16, 1990

Development of India's River Basins

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HISTORY OF TECHNOLOGICAL DEVELOPMENTS

The early irrigation ventures in India were concerned largely with impounding rain water in tanks, and taking canals, from these tanks or from the diversion weirs across the streams to the farms. These efforts were supplemented by wells dug by the farmers. The widespread suffering caused by successive famines in the closing decades of the 19th century led to the setting up of the first famine commission in 1878 and then again the second famine commission after the drought of 1896-87 which recommended the first priority for works of irrigation amongst the various measures adopted for giving protection from drought. But the emphasis was still on digging of new tanks and the repair of existing tanks. It was only after the appointment of the irrigation commission in 1901 that some ambitious construction programmes were taken up to control, conserve and utilise the water wealth of the rivers by means of storages. But still the approach was essentially location specific and project oriented.

After all, the State of technology is bound to have a profound bearing on the nature of basin's development. In the past when large works and safe structures across the river channels were not structurally possible, the water management essentially revolved around the development of tanks. But those were essentially shallow structures constructed on small streams and tributaries of the rivers. It was difficult to work in the river channels of the large rivers.

Later, with the development of engineering technology for construction of weirs and gates, diversion schemes from large rivers like Sone, Mahanadi, Godavari & Krishna became feasible. Developments in bridge-engineering also made extensive canal schemes commanding lakhs of hectares feasible, because of the possibility of putting large aquaducts on the rivers and drainage channels being crossed by the canal on its way. In fact the period from 1850 to 1900 was essentially the period of construction of canal schemes with barrages and weirs across the river source. The diversion canals from the barrages across the rivers Krishna, Godavari and Mahanadi newly brought under systematic irrigation lakhs of hectares from their delta areas. Similarly the diversion canals from Ganga & Yamuna in their upper reaches brought irrigation to large areas.

In the 20th century, such schemes got a further boost when Dr Khosla propounded the theory for designs of weirs on permeable foundations. The construction of diversion structures across the river channels not having rocky foundations thereby became feasible. Much of the subsequent rapid developments on the Northern rivers has been on account of this technological breakthrough made possible by Dr Khosla's theory.

Impact of Dam-Engineering

It was also after the dawn of the 20th century and with the development of hydro-power technology that the subject of dam engineering picked up globally. Commencing from the beginning of the 20th Century, higher and higher dams were built across the major rivers and in the deep valleys progressively with larger and larger storage capacities initially mainly for the purposes of generating hydro-electric power. But this revolutionised the whole approach to the development and management of the river valleys. In the past, conservation and regulation of the large volume of river flows was not possible through the development of tanks weirs or even gated barrages across the river channels. With the advent of dam engineering, this became feasible. Morever, in addition to the generation of power, the large reservoirs behind the dams made it possible to have regulated releases of water into the river and thereby enhance the flow even during dry period of the year making the river almost perennial. This was a very welcome feature as it considerably improved the ecology of the valley. Where the natural advantage from snow-melt was not available, as in Ganga, Yamuna, Ghagra, Gandak or Kosi the regulated releases from the storages could make the river a living entity even during the dry summer months also.

The construction of dams with large storages also helped to modify the monsoon hydrology of the river by arresting peak flood flows. Hence large dams came to occupy a critical position in the development and management of the basins. In fact nobody could think of basin's management at large till the dam engineering reached its full potential. That is why, there is no mention about the concept of basin management in the earlier reports of the famine commissions. With the level of technology available in the 19th century one could not think in terms of a basin but had to be content with small local storages in tanks or with diversion of only natural flows available in the rivers.

DR KHOSLA'S PIONEERING EFFORTS

In India, the concept of basin as a unit of development was first propounded by Dr A N Khosla in 1945 when he was the Chairman of the Central Water Irrigation and Navigation Commission of Government of India. (That was the earlier name of the present Central Water Commission). In a broadcast to the nation in 1945, he said: 'Planning should be on a regional basis and the drainage basins should be treated as units In so doing, account should be taken of other social benefits as well as economic, general benefits as well as special and potential benefits. For the purpose of preparing comprehensive and integrated water plans for the various river basins in India, the Government of India have set up the Central Waterways, Irrigation, and Navigation Commission to deal with the problems of flood control, soil erosion, drainage and land reclamation, Irrigation and navigation and the Central Technical Power Board to deal with power including water power. The Central Waterways, Irrigation and Navigation Commission will be a central fact finding, planning and coordinating organisation which will examine the potentialities of Indian Rivers from all relevant aspects and will assist in the coordinated and integrated development of rivers passing through more than one province or State.'

In this context, one of the first problems that attracted the attention of Dr Khosla was of the floods in Orissa. After field investigations, Dr Khosla came to the conclusion that the only cure for the many problems of Orissa,namely floods, drought, poverty and diseases, lay in the control, conservation, and utilisation of the enormous water wealth of its rivers by means of storage dams. Investigation of the Mahanadi for multi-purpose development was immediately taken up and Hirakud Dam Project Was constructed as a multi-purpose project to provide flood control, irrigation, hydro-power and navigation in the river below Hirakud.

Dr Khosla is rightly called the father of the river valley projects in India. He not only propagated the concept of the river valley development but also undertook the implementation of this concept through the planning and construction of the projects on the desired lines. Hirakud Dam on the Mahanadi river was conceived by him in May 1945 soon after assuming charge as a Chairman of the Central Waterways, Irrigation and Navigation Commission. He also directed its implementation phase upto 1953. The project was completed by 1957, in a record time of just 12 years between conceptualisation and completion.

Dr Khosla delivered the Sixth Sri M Visesvarayya Lecture at the 43rd Annual Conference of the Institution held at Bangalore in 1963. Naturally, that the subject chosen by him for the lecture was the one very dear to his heart. It is interesting to note that the lecture was titled 'Orissa's Decade of Destiny-1963 to 1973 i e, a Plan for the Integrated Development of River Basins in Orissa'. In his lecture, he said that Orissa is destined to be the most advanced State in India but the foundation of its development was based on the conservation of flood water during the monsoon through storages and the utilisation through regulated release during the dry part of the year for irrigation, power generation, navigation, fish culture and tourism. His plan for the unified development of the Mahanadi basin comprised a set of river valley projects, thermal projects and other industrial development activities. But he was firmly of the opinion that the river valley projects have necessarily to be developed first as they provide the essential foundation for the other developmental programmes.

THE ROLE OF GOVERNMENT OF INDIA

The Government of India act 1935 which became operative from April 18. 1937, had entrusted the responsibility for irrigation development to the provinces. But the framers of the constitution of independent India were aware of the need for a more comprehensive approach to the development of the rivers to arrest the menaceof the floods, generage large blocks of hydro-power, and provide navigational support in addition to waters for irrigation. Hence they made the entry on 'water' in the state list, 'water that is to say, water supplies, irrigation and canals, drainage and embankments, water storage and water power' subject to the provision of entry 56 of the Union list. The latter provides for the 'regulation and development of inter-State rivers and river valleys' by the Central Government 'to the extent to which such regulation and development under the control of the Union is declared by Parliament by law to be expedient in the public interest'.

The wording of the entries in Schedule VII of our Constitution under the States' list and under the Union's List is interesting. While the States List uses the word 'Water' which means use of water in irrigation, etc; the word 'water' is not used in the Union List; but the Union List mentions about "the river and the river valley'. The use of the word 'river valley' is particularly significant, because it clearly aims at dealing with a geographic entity like a basin rather than only the physical resource material like water. The basin aspect was made the responsibility of the Union while the local handling of water was kept with the States but within the framework of the development and regulation of an inter-State river as may be determined by the Parliament. Almost 77.67% of India's geographical area falls within the inter-State river valleys. The Union Government will have to playa very crucial role in their development and management.

DR AMBEDKAR'S CONTRIBUTION

Dr Ambedkar considered it a mistake that 'waterways' (i.e. rivers) were not made a central subject under the Government of India Act of 1935. This defect was however removed when as Chairman of the Drafting Committee he incorporated it in the Central list also. Water was not left entirely under the state list as was the case under the Government of India Act 1934. Dr. Ambedkar was also instrumental in ushering in the coordinated development of the Damodar Basin by the Central Government-As a Minister of Labour, in the pre-Independence Cabinet, he pursued vigorously the question of Damodar Valley's development, held four/five meetings hemself and gave directions to have its development modelled on the lines of the TVA. That is why immediately after independence, the first river valley development agency in India, namely, the Damodar Valley Corporation could get established by an act of the Parliament without any loss of time.

INTER-STATE DEVELOPMENTS

The need for coordinated basin development was felt immediately after independence when planned development was taken up in hand. It led to the enactment of the River Boards Act by the Parliament in 1956, paving the way for the establishment of the River Boards for the inter-State rivers by the Union Government. But the country was mostly in the project oriented phase of development in the last four decades. Hence no river Board came to be established under this Act. But the States through mutual negotiations reached agreements on either their shares in the river water for the projects within the state or on the nature of inter-State project they should jointly take up. Where such agreements could not take place, such as for Krishna, Godavari and Narmada rivers, the matter was referred to the inter-State tribunals. In Godavari, after reference was made to the tribunal, a series of agreements took place between the five basin States; which were finally placed before the tribunal. Hence the Godavari award by the Tribunal essentially comprise of the set of such agreements only. Recently issues associated with sharing of Ravi-Beas Waters and Cauvery waters have also been required to be referred to the Tribunals.

RECOMMENDATIONS OF THE IRRIGATION COMMISSION (1972)

In the meanwhile the Irrigation Commission which went into the question of planned development of water resources of the country as a whole for the first time, noted in its report of 1972 that the absence of coordinated strategy or faulty planning can lead to waste of resources and impose a severe limitations on the benefits. An integrated policy calls for attention to irrigation drainage, navigation, flood control, thermal power generation, water supply land reclamation, control of water pollution and control of ground water levels. They therefore recommended formulation of a well defined strategy for development of water resources considering the river basin or a sub-basin as a natural unit.

The Irrigation Commission recommended that,

(a) The basin pian should present a comprehensive outline of the development possibilities of land and water resources to meet the anticipated regional and local needs.

(b) The plan should:

(i) indicate a broad frame-work of various engineering works to be taken up in the basin, the reasons why they are preferred to alternatives and the inter-relationship between them;

(ii) establish priorities in respect of water use for various purposes;

(iii) indicate inter se priority of projects;

(vi) indicate the need for earmarking water for any specific future purposes.

(c) The plan should be periodically reviewed and revised as required in the light of changing needs and supplies.

NATIONAL FLOOD COMMISSION'S VIEWS

Subsequently, the Rashtriya Badh Ayog in its Report in 1980 also observed that as a 'flood plan' forms the part of 'water plan', the basin is an apt unit for planning for flood works also. It also pointed out that a river basin has been universally accepted as the most suitable and proper unit in the preparation of a water plan.

PROVISIONS IN THE NATIONAL WATER POLICY

On this background, the National Water Policy adopted in September, 1987 laid down that resource planning in the case of water has to be done for a hydrological unit such as a drainage basin and appropriate organisation should be established for comprehensive planned development and management of the river basin as a whole. All individual developmental projects and proposals should be formulated by the states and considered within the framework of such an overall plan for a basin or a sub-basin, so that the best possible combination of options can be made.

HYDROLOGICAL CLASSIFICATION OF INDIAN RIVERS

On the basis of hydrological characteristics, the river systems of India can be classified into four Groups, viz,

1. Himalayan Rivers
2. Deccan Rivers
3. Coastal Rivers
4. Rivers of the inland drainage basin

The strategies for the development of each class will differ on account of the different pattern of water availability. The role of the dams and the storages behind them, the diversion weirs, the ground water and the inland navigation will also, therefore, be different in each case.

The Himalayan rivers are snow fed and therefore have continuous flow through out the year. During monsoon months these rivers swell due to heavy rainfall and cause frequent floods. The main rivers are the Indus and those of the Ganga Brahmaputra-Meghna system. The important tributaries of the Indus are the Sutlej, the Beas the Ravi, the Chenab and the Jhelum. Important Himalayan tributaries of the Ganga are the Yamuna, the Rarnqanqa.the Ghagra, the Kosi and the Mahananda. These rivers cover a drainage area of about one million km". They generally have a good ground water potential.

The deccan rivers are rainfed and therefore, fluctuate in volume. Many of these are non-perennial. The important rivers are the Narmada and the Tapi which flow westward and the Brahmni, the Mahanadi, the Godavari, the Krishna, the Pennar and the Cauveri which are east flowing. These rivers together cover a drainage area of 1.10 million Sq. Km. Hydrologically, at the southern tributaries of Ganga also fall in the same category, and contribute a drainage area of 5,96,204 Sq. Km. which for all practical purposes will have to be dealt with on similar lines as per the deccan rivers. Thus in the Indian context, this is the most dominant hydrological class of river valleys, accounting for nearly half of the India's geographical area. Most of these basins are fairly rocky and undulating have a relatively poor ground water holding capacity. Large storages will, therefore, have a critical role in their development.

The costal Rivers are short in length and have limited catchment areas. Most of them are non parennial. There are only a few rivers in the eastern coast but there are about 600 such rivers-small and large on the western cost; though the important sizeable basins from the point of planning and development are about 45 only. The west cost rivers contain about 14% of our water resource although they drain only 3% of the land.

The streams of inland drainage basins of western Rajasthan are few and far between. Most of them are of ephemeral nature. These rivers drain into the salt lakes or get lost in sands with no clear outlet to sea. Desert Rivers flow only for some distance and are lost in desert. Only 99.433 Km2 of Indian territory falls under this category.

CLASSIFICATION ON THE BASIS OF AVAILABILITY OF RESOURCE

From the point of planning, however, the basins can be better classified on the basis of availability of water per capita for the population in the basin or on the basis of availability of water per ha. of the cultivable land. The former is the more comprehensive criteria because it takes into account not only the agricultural need of the society but also industrial and domestic requirements. For food requirements alone it has been estimated that every individual needs about 360 cu. met. of water annually, for a good living. Added to this will be the requirements for drinking water, domestic hygene, municipal services and industrial development. If we classify the basin with reference to the requirements of the human society it is seen that Pennar, Cauvery, east flowing Rivers between Pennar and Kanyakumari, and west flowing rivers of Kutch and Saurashtra basins already stand below the level minimum requirements, i e 1000 m^3 per capita. Hence planning and development of these basins will have to follow a different critical path. The basins which are having the availability between 1000 to 2000 m^3 of water per capita are Ganga, Krishna, east flowing rivers between Mahanadi and Pennar, Tapi and Mahi. In these basins with systematic management it should be possible to support a thriving economy. On the other hand there are basins having more than 2000 m^3 of water per head, they are Indus, Brahmaputra, Barak, Narmada and west flowing Rivers from Tapi to Tadri and from Tadri to Kanyakumari. These basins will be able to afford water intensive crops like rice and sugarcane or highly water consuming industries. Water rich basins are those having more than 4000 m^3 of water available per head. Our efforts will have to be to bring the liberal quantities of water available in nature in the favourably placed regions to the drier areas so as to help the handicapped regions in managing their growth and sustainance in a smoother fashion.

Because of the growth of population every individual's share in the available water is fast shrinking. At the time of independence every Indian had 5 150 m^3 of water which has now shrunk to 3 200 m^3 of water per head only. In comparison the availability of water for an American, the Japanese and the Soviet is of the order of 6 200 m^3,

6 500 m^3 and 17 536 m^3, respectively. It is, therefore, clear that we will have to be considerably more vigilant in the planning and development of the country's water resources.

CLASSIFICATION ON THE BASIS OF DRAINAGE AREA

From the organisational point of view, the river basins of India could be divided into three groups on the basis of size of drainage area as below.

Large River Basins

These are the river basins having a drainage area of 20 000 km2 and above. Indian territory basically comprises of large size basins. There are 12 such basins in India, namely Indus, Ganga-Brahmaputra- Meghna, Sabarmati, Mahi, Narmada, Tapi, Brahmani, Mahanadi, Godavari, Krishna, Pennar and Cauvery (Annexure I). Most of these are inter-State in nature and will need inter-State organizations. Of these, five basins-namely Indus, Ganga-Brahmaputra, Mahanadi, Godavari and Krishna are very large basins with a drainage area of more than 100,000 krn". They will need a hierarchically structured set up for dealing with the sub-basins also separately in an effective manner.

Medium River Basins

These are the River Basins having a catchment area from 2 000 km^2 to 20 000 km, There are 46 such river basins of which 22 are west flowing and 24 are east flowing. They together represent about 7.47% of India's geographical area. Scientific and systematic development of these basins should not pose much of a technical or organisational problem.

Minor river basins comprise of the basins with drainage area below 2 000 km, They together represent 3.63% of Indian territory but account for 8% of the country's run off. A coordinated and integrated management of such smaller units will very much depend upon the capacity of the local leadership in self-governance and in technical management. Even the small size coastal basins have a very large variation in their set up, because of which a standardised package of treatment is not possible for all of them. The basins of Kerala are faced with high intensity of rainfall and problems of coastal erosion while at the other extreme the basins of Saurashtra are faced with problems of salinity intrusion as a consequence of the increased pumping of ground water. They do not have enough flushing potential because of poor rainfall.

BREAK DOWN OF LARGE BASINS INTO SUBBASINS

Some of the river basins in the country are so large, wide spread and covering widely different regional characteristics that it is convenient to break them into sub-basins for convenience of planning and development. Sub basinwise division of Ganga basin on the basis of hydrometrological and catchment characteristics shows the break up as below. It will be seen therefrom, that even the sub-basins are large or very large in their size. These will, therefore, need to be handled by separate will-structured organizations.

TABLE 1 SUB-BASINWISE DRAINAGE AREA OF THE GANGA BASIN IN INDIA

Sub-basin	Drainage Area, km^2	Proportions to the Ganga basin area, %
Banga Main Stem	68 687	7.97
Ramganga	32 493	3.77
Yamuna (excluding Chambal)	226 755	26.32
Chambal	139 468	16.19
Tons-Karamnasa	32 998	3.83
Gomati-Ghaghara	103 728	12.04
Son-East of Son	107 322	12.46
Gandak-Burhi Gandak	21 929	2.55
Kosi-Mahananda	38 410	4.46
Ganga d/w Farakka	89 661	10.41
The Ganga Basin	861 451	100.00

The Krishna tribunal divided the Krishna River Basin for its study and examination into 12 subbasins; namely, Upper Krishna, Middle Krishna, Ghataprabha, Malaprabha, Upper Bhima, Lower Bhima, Lower Krishna, Tungabhadra, Vedavathi, Musi, Paaleru, and Muneru, The Godavari Tribunal had also to drivide the Godavari River Basin for its consideration into 12 sub-basins; namely, Upper Godavari, Pravara, Purna, Manjra, Middle Godavari, Maner, Penganga, Wardha, Pranhita, Lower Godavari, Indravati, and Sabari. It, therefore, looks that each of these sub-units will need an organisational entity of its own for the optimisation process.

AGRO CLIMATIC REGIONS

From the agricultural point of view, the country has been divided into 15 Agro Climatic Zones keeping in view the rainfall, temperature, soil type, topography, water resources and irrigation facilities to enable a more scientific utilisation of available resources for optimum output and employment in agriculture.

If we super-impose the map of India with basinwise division over the map with Agro climatic regions, it will be seen that each river basin has more than one agro-climatic region and also each agro-climatic region has more than one river basin as a P~Htof it. The considerations on the basis of the agro-climatic regions are good enough for planning the strategy about the rainfall dependent crops. But the consideration on the basis of such regions does not remain fully relevant when irrigation is to be planned either through ground water or by canal irrigation from the storages utilising the rainfall surpluses. Hence in the planning of the water resources, the natural drainage system as reflected by the configuration of the valleys and the sub-valleys as well as the agro-climatic divisions will have to be considered together. Agro-climatic regional considerations would help a great deal in the study of cropping patterns and crop specialisations, productivity levels and inputs required in the different parts of the basin.

The regions are:

	Percentage of geographical area
1. Western Himalayan Region	7.67
2. Eastern Himalayan Region	8.58
3. Lower Gangetic Plains Region	2.16
4. Middle Gangetic Plains Region	5.13
5. Upper Gangetic Plains Region	4.48
6. Trans Gangetic Plains Region	3.63
7. Eastern Plateau & Hills Region	12.36
8. Central Plateau & Hills Region	11.58
9. Western Plateau & Hills Region	10.36
10. Southern Plateau & Hills Region	12.36
11. East Coast Plains & Hills Region	6.17
12. West Coast Plains & Ghats Region	3.66
13. Gujarat Plains & Hills Region	6.13
14. Western Dry Region	5.48
15. The Islands Region	0.25

In this respect, the Godavari basin presents a typical interesting case where high rainfall areas of the Sabri & Indravati form an important part of the basin along with the very dry areas of Telengana, both of which are distinctly different from the coastal detlaic region of Godavari. Hence planning of a basin like Godavari stretching over different agroclimatic regions is a very complex exercise and the best course to deal with it will be by looking at the development of sub-basins and tributaries.

INTER BASIN TRANSFERS

Inter basin water transfer is one of the controversial topic of water resources planning. An important consideration for undertaking water transfer is the one of inter-regional equity in respect of socioeconomic well-being. But in practice, equity in respect of water use has been very difficult to work out because of the differences in the agro-climatic regions, people's food habits and consequential differences in their preferences for the crops. Hence, the application of principle of equity is always beset with many disputed claims.

But in India, there have been alrelady many excellent examples of inter-basin transfers of water for irrigation, hydro-power or for urban water supply. The Periyar Project provided for the transfer of water from a west flowing river to the water short eastern region. On the other hand, the Koyana Hydroelectric Project and the Tata's Hydro-Electric Stations provided for the western diversion of the east fiowing waters to generate hydro-power by taking advantage of the deep escarpment. Bombay island and its over flowing urban and industrial compiex on the main land are situated strictly speaking, within the Ulhas basin. But the largest supplies of water for these developments have been secured from the neighbouring Vaitarna basin.

Interestingly enough, the awards given by the tribunals on river sharing allow the States to transfer water, from their share, out of the basin. But at the same time, the tribunals do not allow transfer of water from the other basins to the river basin for which allocations have been decided by the tribunal. This is because the additional input of water from outside the river basin immediately raises claims for adjustment of the share earlier decided on the basis of the availability of water from within the basin itself. The result is that the basin for which water allocation award has l:ieen made, can get depleted of its natural availability but cannot get supplemented without entering into a water sharing exercise again. This is one of the hurdles in free transfer of water from one basin to the other. In the case of Krishna basin, water diverted from Godavari is to be shared between basin States in Krishna according to an agreement reached between these states.

Many suggestions have been made from time to time for interlinking the Indian rivers. After carefully examining all such suggestions for transferring water for irrigation and other purposes from well placed areas to deficit areas in the country for the optimum development of water resources, the Ministry of Irrigation (now Water Resources) and the Central Water Commission formulated in 1980 a national Perspective for Water Development keeping existing agreements and awards in view, retaining the existing uses undisturbed and providing for the reasonable needs of the basin States for the foreseeable future. The perspective comprises of two components-Himalayan Rivers Development and Peninsular Rivers Development. The National Water Development Agency has been set up in July 1982 to investigate into the matter further and give a concrete shape to the Peninsular Rivers Development Component of the National Perspective.

NEED FOR LARGE STORAGE

Due to the peculiar characteristics of the India's monsoon season, about 80% of the river flows occur in the four monsoon months of the year. During this period only limited water can be made available for the farms direct from the run of the river, because the farm area does not need much water in this period having received it directly from the rain. It is' in the post monsoon period that the agricultural demand for water is greatest. Hence storing of the water available in the flood season for use in the subsequent part of the year is an in-escapable part of our development process.

But it is not that large storages are required for hydro-power or irrigation purposes only. In modern times, they are required for urban and industrial requirements also. The requirements of drinking and municipal water supply to metropolitan and other important towns in the country have already become critical. The entire water supply of Bombay is dependent on a series of large dams like Vaitarana, Tansa and Bhatsa. In fact, there is now a proposal to construct another large dam on the Vaitarana to meet the increasing needs of Bombay's water supply from Nizamsagar and Singur dams. Delhi, which is situated on the banks of the Yamuna gets hardly 25% of its needs directly from Yamuna. The balance needs are met by releases from Bhakra Dam on the West, and Ramganga Dam on the East. For the future needs of Delhi, it is proposed to obtain water from the Tehri Dam being constructed in the Northern stretches of Ganga. This is in addition to a number of tubewells, which contribute hardly 10% of Delhi's water supply. The acute scarcity of water supply in Madras is too well known. Since there was no other possibility of augmenting the water supply, the States of Andhra Pradesh, Maharashtra and Karnataka agreed to part with their allocated share of Krishna waters to provide 15 TMC of water supply to Madras city which will be through the stored waters at Srisailam Reservoir in Andhra Pradesh and carried through 430 km long canal to reach Madras City.

Although the industrial requirements of water constitute only a small per cent of the total consumption of water, it again cannot be met with without the construction of storage dams. For example, for the needs of Bokaro Steel Plant, another dam at Tenughgat in the Damodar River Basin had to be constructed. Similarly, a cluster of thermal and superthermal stations in U.P. are entirely dependent on the waters stored in Rihand Dam on a tributary of the Sone river in UP. Similarly, for the Vishakapatnam Steel Plant, the water is to be supplied from Yeleru Reservoir under construction in Andhra Pradesh.

It is significant to note that the available water resources in India and in the United States of America are almost identical. However, the storage capacity alrealdy created in the United States is about six times that of India. Does that also explain the difference in the prosperity of the two countries?

Before Independence, there were thousands of small tanks constructed in the States of Andhra Pradesh, Tamil Nadu, Rajasthan, and other. There were very few major dams like Mettur, Krishnarajasagar. After independence, till now more than 2900 large dams have been constructed. The dams constructed so far have a live storage of 16.2 Mha-m out of 69 Mha-m of utilisable water resource in India. The dams under construction have a live storage of about 7.7 Mha-m and about 13 Mha-m still remains to be harnessed. Thus, the total storage capacity likely to be created by large dams in India is about 36.5Mha-m which is about 53% of the utilisable surface water resources, and only about 20% of the available annual surface water resources. The total storage capacity of the thousands of tanks constructed aggregate to only 3 Mha-m or only 8% of the storage capacity through major dams. They have an important place in the development of the small sub-basins and

water-sheds and will occupy an important nitch in the total developmental plan of a basin. However, they cannot match with the potential of varied growth and development associated with the large reservoirs.

GATED RESERVOIRS

The large dams however have the disadvantage of extensive submergence of land and consequent dislocation of the population. Particularly in the thickly populated country like ours, this aspect assumes considerable importance. Hence right from the early part of this century, engineers have introduced gated spillway and reduced the flood heights, i e, the maximum water level behind the dams and the barrages thereby saving large areas from submergence. With the superior quality of steel, greater skill in structural engineering and development of dependable hoist mechanism, the sizes of the gates have been continuously on the increase thereby reducing the submergence area drastically. It is interesting to note that many large storages have now more than 50% of their live capacities against the gates-a few important examples are given below.

TABLE 2 LIVE STORAGE AGAINST GATES

Project	Total Live Storage at FRL, Mm^3	Storage behind Gates at FRL, Mm^3	Percen-tage
Srisailam	8 288	5 954	71.84
Ukai	7 100	5 530	77.89
Gandhi Sagar	6 827	4 445	65.11
Tawa	2 049	1 685	82.23

But the series of gated storages in a basin also imply the risk of carryover damages by mal-operation of one of the upstream gated structure. Hence gated reservoirs have to be looked upon not as a project or a structure in isolation, but as an element of a broader system of basin's development to be managed methodically in an integrated manner.

KEY STORAGES

Considering the completed projects in the Basin and those under construction at the moment, Krishna and Mahi happen to be intensively developed basins. Out of the 67.8 krn" of Krishna's average flow, 37.2 km" is to be in the projects already completed or under construction which is more than 50% of the basin's average flow. But the interesting part is that 23.7 krn" of this water is stored in just 7 reservoirs, that is how large dams are more critical in the management of the basins. In the case of Mahi against the total flow of 11.8 krn", 4.5 is already stored of which 2.9 is just in two large storages.

Similar scenerio is expected to develop progressively in the other valleys also. Because of the natural limitations on the availability of good storage sites, the most will have to be made of the available limited sites. They, therefore, assume a critical importance in the development of the basin's resources.. The storages at these sites will have to be treated as key storages from the point of Basin's management. In the case of large inter-State basins, such key storages will have a national importance.

DEVELOPMENT OF NARMADA BASIN

In spite of its plentiful resources the development of the Narmada basin has lagged considerably in comparison with the other basins like Krishna and Godavari. It is one of the basins blessed with large quantities of water and also a favourable bedingredient for developing hydro power stations in cascade right within the heartland of India. By now as many as 900 small surface irrigation works like tanks have been constructed in the basin but less than 1% of the available water of the valley has been utilised through them. Even after their development in such large numbers, the basin is also not considered as an economically developed basin. Because in modern times a meaningful economic thrust can be generated only when extensive agricultural commands get developed, intensive industrialisation is supported and bulk power generated. A" these activities have lagged behind in the Narmada basin.

In the past, on account of the inter-State differences in the approach to development of the basin, a variety of permutations on development came to be proposed and placed before the special committees and the inter-State Tribunal which went into the question of optimum development of the valley. Finally it was seen that the best strategy would lie in having two large key storages, namely, one at Narmada Sagar (Punasa) and other Sardar Sarovar (Navagam) having 34.5 krn" and 5.8 km^3 of live storage capacity respectively. These two together will thus store almost half of the Narmada's annual flow of 3.45 km" at 75% dependability. It is interesting to note

that the availability of water in Narmada is more than that in the eastern rivers of the Indus valley totally allotted to India namely, Ravi, Beas & Sutlej together. Looking to the green revolution that can be ushered in Punjab and Haryana on the basis of development of Beas and Sutlej waters, it can very well be imagined as to what great potential lies in the development of the Narmada waters. The Sardar Sarovar Project with its 460 km long Navagam canal upto Rajasthan Boundary is also a fine example of how the waters of a favourably placed basin can be utilised to provide solace to the needy areas of the water short basins like Sabarmati & Banas, and some of the chronic drought prone areas of Saurashtra, Kutch and Rajasthan.

Dr Khosla had headed a Committee in the Sixties which had suggested the desired pattern of development of Narmada. It is interesting to note that the award given by the tribunal is close in line with the approach to the development of Narmada waters as was rerlected in the Khosla Committee's Report.

GROUND WATER REGULATIONS

Ground water is an important phase of water in its hydrological cycle. But the correct appraisal of the ground water phase is much more complicated than that the surface water system because unlike surface water ground water is not confined to any defined channel or is not exposed to vision for a direct measurement. The basic information needed for assessing the ground water availability are the type and location of aquifers, their thickness/depth and their characteristics such as hydraulic conductivity and storage coefficient. These are obtained from water level observations in wells, surface geological mappings, test drilling and pumping test data. The most important information required is regarding the annual rate of recharge because in the long-run, the use has to be restricted to the annual rate of recharge. Utilizable ground water is that portion of availvble ground water which can be economically developed and utilised with the available technological know-how. This should be assessed.

In certain areas, over pumping of ground water from aquifers may cause excessive lowering of water table resulting in undesirable adverse effects such as excessively higher cost pumping decrease in available yield, salinity intrusion and ground subsidence. Such areas should be identified and appropriate remedial measures and preventive actions incorporated in the basins development plans.

FLOOD PLAIN ZONING

Increasing pressure of population has resulted in greater encroachment of flood zones. This has necessitated introducing flood plain zoning measures. These measures envisage delineation, classification and demarcation of land with reference to relative risks of flood and to prohibit activities which will cause obstructions in the flood plains. In the model bill; recommended to the State by Government of India, it has been recommended that Defence installations, Industries, Public utilities like hospitals, electrical installations, railway stations, commercial centres, etc., are proposed to be located in such a fashion that they are above the flood levels corresponding to a once-in-100 year frequency or the maximum observed flood levels. They would also be above the levels corresponding to a 50 years rainfall and the likely submersion due to drainage congestion. Public institutions, Government offices, Universities, Public libraries and residential areas should be safe for 50 years flood or a 25 year rainfall. The major roads in the area will, however, be at a still higher level so that even in the infrequent occurence of floods/drainage congestion, the communications are not affected. Play grounds and parks can, however, be located in areas vulnerable to frequent floods. Such a zoning plan will have to be a part of the basin's total management plan.

NAVIGATION

Ironically enough, even though the construction of large sized canals was initiated in the modern India by the British engineers who had their roots in the extensive navigational canals developed across Britain during the 17th and 18th centuries, the navigational aspects of water resources development progressively got ignored because of the Indian Railways taking over the transport needs of the country. We do find the impact of the navigational orientation of the earlier British engineers in the design and layout of the early large-sized canals like the Upper Ganga Canal built in the 50s of the 19th century. It had been provided with navigational locks almost at all the masonry structures along the canal. All of them have gone into disuse by now. But with the increasing volume of traffic and congestion on the railway lines running parallel to the river channels, the interest in the navigational potential of the rivers has been recently revived. An inland Water Transport Authority has been established by the Government of India. This is a very encouraging sign. The water resources development programmes of the future will have to accommodate the navigational requirements along the river channels by resorting to large scale river training works and adopting the cascade pattern of development on the lines of the Tennesse Valley.

MANAGEMENT OF DEMAND

Even in the project stage of development the planning was essentially for meeting the demands and fur supporting the crops popularly grown. There was hardly any question of demand management as such. Now

with the realisation that the water resources are finite and limited in comparison with the total demand in most of the basins, considerations of equity will necessitate a greater and critical scrutiny of the demand itself. Hence, it will not only be the question of using water saving devices progressively like drip and sprinkler agriculture but also the question of modifying the crop pattern by encouraging less-water consuming crops in the water short basins. A sort of water-zoning will have also to be introduced in each basin, permitting high water consuming industries only in some parts and less water consuming industries in other parts. A modified strategy for agronomical management and industrial locations will finally dictate the nature of economy that will emerge in a basin.

HYDROLOGY

Because of the natural variability in the existence and availability of water, and the growing demands for water, the subject of hydrology, will assume much greater importance in future. Enough attention was not paid to this subject in the past when "demands" and "drawals" were small compared to the availability of water in Nature. But that is no more the case in many of the India's basins now. Hence correct appreciation of the exact hydrological cycle of the specific region is very much necessary now for the proper planning and management of the regions water resources.

There have been some gaps in our understanding of the hydrology of India's water resources. For example, not much work has been done on the subject of snow hydrology. The Himalayan rivers draw considerable supply during the snow-melt periods. A proper assessment of the availability of water from the snow covered areas will require a much greater insight into the subject of snow hydrology. Recently a small beginning has been made in this direction by establishing a Snow Hydrology Division of the CWC at Shimla. But much still remains to be done. This is going to be an area of challenge for many scientists and explorers. Our knowledge about the costal aquifers is also not yet well developed. With the increasing extraction of ground water even in the coastal are as there had been many of ingress of saline water in the ground water acquifers. For the proper management of the coastal areas, a thorough understanding of the ground waters aline water inter-face will be necessary. Very extensive observational field work and experimental work will be necessary on this problem.

Our knowledge about the self-purifying properties of the river system is also limited. Considerable research and field observational work will be necessary before we will be able to confidently managed the quality of the river water by utilising its self-purifying properties in its different reaches. On the one" hand efforts will be required to close the gaps in our knowledge on the other hand conscious efforts will be required for developing the necessary skilled personnel for utilising the available knowledge.

In the past, the pleasing river flows that were seen in the dry months were essentially contributed by the surcharged ground water during monsoon that used to get released into the river channel in the subsequent months. Ground water recharge has been affected in many areas because of excessive deforestation and urban sprawls. At the same time, with the excessive pumping that has developed in most of the sub-basins, there is hardly any opportunity for the ground water to re-emerge into the river channel. Hence, while effective steps will have to be taken for regulating the drawals of ground water, and improving the natural recharge system through planned afforestation and watershed development the river flows will have to be artificially augmented by releases from the reservoirs to maintain the desired life supporting character of the river.

LAKE MANAGEMENT

Apart from over 50,000 small water tanks a number of large lakes have been added in the last few decades after the construction of storage dams. These lakes are faced with the problems of evaporation, accumulation of pollutants, consequent cutrophication and growth of weeds, the possibility of increase in mosquitoes and other micro-organisms and changes in the shore profiles by sedimentation. The self purifying property of the flowing water is not available for the lake waters. They, therefore, tend to deteriorate faster than the flowing river st etches.

In the past much attention was not required for the management of the tanks and the lakes as the quantum of effluents from the cities and the industries was relatively negligible. The only problem was that of silting. Hence soil conservation measures in the upstream catchments were encouraged right since our Independence. The Central Water Commission had established a Directorate of Soil Conservation back as in the fifties. The constitution of the Central Water Commission formulated in 1945 also envisaged a part time member for looking after the soil conservation measures in the valleys. In the seventies, Indian standards on soil conservation measures were also formulated. But still much remains to be done in respect of development of a sound strategy and a systematic follow up on these measures. In any case, soil conservation measures, afforestation, and water treatment works will always constitute an important elements of the Basins Management plan; if not of the individual projects.

RIVER WATER QUALITY

The deterioration of stream water quality due to industrial and domestic effluents has increased the need for greater attention to the aspect Basin's total management. Water quality modelling techniques can be used to determine the degree of treatment required, the relocation of waste discharge points and the amount of low flow augmentation required. It is not enough to plan on scientific lines, it is also necessary to monitor the system continuously. A well laid out system for measurements of the quality of the rivers water will have, therefore, to be an essential part of the basins management plan. Many stretches of the Indian rivers are already considerably polluted such as the stretch of Ganga near Kanpur on the one of Yumuna between Delhi and Agra. Future development plans of these basins will have to provide for the necessary clean up activities.

As water has an opportunity cost in agricultural produce or other industrial and domestic uses it will be very expensive to release large quantities of water just to maintain the river channels clean on for digesting the effluents released into the river channels. From economic considerations, it will be desirable to progressively refine our water treatment technologies by moving up the ladder of technologies towards sophisticated high value technology to make the effluents cleaner rather than depending on the water being available for dilution. The growth of water treatment technologies will, therefore, assume special importance particularly for the low rainfall areas if they have not to have their rivers converted into sewerage channels and the lakes and tanks used as sinks for the pollutants carried by the sewerage system. In the past the development of the river basin essentially revolved around construction of storages or diversion of river waters. But now treatment of water and the treatment of the effluents of the cities and the industries will be progressively an essential element in the total management set up for the basin. Great Britain does not have Irrigation projects as in India. But still it needed the set up of a river authority-essentially to manage the quality of the river's waters.

Because of the industrial development in the country and the urban growth, the quantities of centralised effluents put into the rivers have been on the increase resulting into points of high pollution on the river lengths and also leading to accumulation of pollutants in the lakes and reservoirs on the down stream. As the problem has already attracted our attention well in time, and as the supportive Water Pollution Prevention and Control Act and Environmental Protection Act have already been introduced in the contrary, it should be possible to manage the quality of the river water and the lake waters in good shape. The growing modern technological activities in the basin can have some adverse effects on the ecology, but the technological strength developed in the society should also enable us to remedy the situation and take up effective clean up operations also.

Considering the complexities in integrating the different features of the basin it is not only the planning that is going to be very difficult and challenging, but the operational management of the basins particularly of those having a large number of gated reservoirs is also going to be a very challenging task. It is not the technology of development alone but the technology or management utilising the modern tools like telecommunication, computerisation will, therefore, hereafter playa decisive role in sustaining the prosperity or the country. Tennessee valley is the world's most fully regulated river system. Using a computer to calculate coming stream flows from rainfall readings, engineers control these flows at and across its 33 dams much as a dispatcher controls train movements.

Proper handling of water through its different phases, over a large aerial extent also requires continuous collection and analysis of a large volume of data from the basin. Data management by itself is going to be a challenging operation in the water resources sector. Data are required not only for the long range of historical perspectives and projections, but also for the real time operations over a large aerial extent such as for flood forecasting and flood regulation. This complex task is possible only by taking resources to the computer's capabilities, to the telemetry and the wireless communication system. The nature and the magnitude of surpirese events like the floods can be best comprehended and sensed in advance only if it is possible to collect and transmit the real time data. Hydrological observational sensors, the data transmission network and computers will have hereafter to be an integral part of basin's management plan.

MANAGEMENT THROUGH ELECTRONICS

Like dam engineering the next most powerful technological development that is going to revolutionise the Society's capacity and approach to the development and management of the basin is the subject of telemetery. It is only through the advance intimation about the storms now facilitated by remote sensing thorugh satellite communication and transmission of messages about the impending flood through a network of wireless stations, the Central Water Commission has been able to give flood warnings at the critical points in the various river basins of our country with an accuracy of ±15 cm. in flood levels. 95% of the flood messages (about 6000 are required to be given every year) transmitted by the flood forecasting network, have been found to be within this level of accuracy. Hereafter this system will have to be utilised for the low flow management also which will progressively become critical for the needs of clean environment along the river channels. Automation and computerisation is going to strengthen the managerial capacity tremendously. Whether it is the opening and closing of the flood gates, the canal gates or the power stations an optimised control will be possible through a

complex system of automation and computerisation. In Narmada basin such a system has been planned and is under development. Progressively similar systems will have to be introduced in the other basins also.

Hydraulic engineering of the 18th and 19th centuries was mostly revolving around river training works, ports and harbours. This was followed by the age of dam building and hydra power stations but it essentially remained the domain of civil engineering and particularly that of structural engineering. But with the demands for drought management and flood management, the subject of hydrology grew in importance and provided the basic foundation for the approach to the basin as a unit of management. The actual management will now stand facilitated greatly through the capabilities developed through remote sensing, automation and computerisation. These sciences and related technologies are. therefore, going to be an integral part of the future operation plans of the water sector.

PLANNING AND MANAGEMENT SKILLS

The pre-independence river valley projects were mostly single purpose. But the urge to derive the maximum benefit from the water resources of rivers inevitably led to the concept of multi-purpose projects. Such projects not only provide maximum service but also reduce costs. For example a flood control or storage irrigation scheme which by itself may be too expensive, can become economical if combined with schemes for industrial or municipal water supply or hydro-power generation. The concept of multipurpose river valley projects was well established by projects like Bhakhra Nangal, Hirakud, Tungabnadra, Chambal, which were taken up soon after independence. Although the concept of multi-purpose development had taken roots, the planning was still essentially limited to the project as a unit of development and not directed towards the overe!t needs of the basin or the sub-basin. But with th "1creasing demands for water from the various grow .•.J sectors of economy, in many regions of the country we are quickly moving from the situation of plenty to the one of scarcity of water. From a project-oriented phase, country as a whole, with limited resources of water we are now entering into a river management phase. We must, therefore, learn to think about the river and the river valley and not about "water" in isolation.

In terms of total annual availability of water, availability of storage sites, monthly pattern of flows in the river, availability from sonow-melts, ground water regimes and the availability of dam sites, each basin stands on a different footing. Hence the strategy for the development of each basin will have to be different from the other. In a basin like Cauvery, deficient in water compared to the growing needs but with good storage sites available in nature, progressively there will have to be greater attention to the repetitive uses of the water through re-cycling and to the development of hydro stations in cascade. At the other extreme is the case of Ganga basin particularly its northern tributaries who have plenty of water from the plentiful of rainfall and substantial flows from the snow-melt during the summer months. But compared to the available annual quantity of water, the reservoir sites on these tributaries are limited, and are available only in the upper reaches many of which lie in the neighbouring countries like Nepal and Bhutan. But a large part of the basin has quite a favourable ground water position. Hence some of the water requirements could be substantially met from ground water also provided cheap electricity is available in plenty. Thus the package of development measures will depend on the peculiarities of the basin.

River basins differ in their size and potentialities. As no two basins are alike, each will have its own distinctive plan of development. No standard package of development for the basins is possible. What is possible at best is to have some guidelines for the planners, developers and the managers. Recently, these have been published by the Central Water Commission under its publication titled "Guidelines for the preparation of River Basin Master Plan" (1990).

There is competition for river water not only between the States and between the various uses within a State but also between the different regions and districts of the State. Hence even when a river basin is confined to a single State, coordination of the various needs and uses has to be secured through an integrated approach to the management of the basin by the State concerned.

Realising the importance and complexities involved in the planning and management of the basins, Central Water Commission has already developed a separate organization in the name of Basin Planning and Management Organisation at its headquarters. In addition, a central training unit has been established in the campus of the Central Water & Power Engineering Research Station (CWPRS), Khadakwasala (Pune) for intensive training in the subject of basin planning and management. This Wing is expected to be a permanent Wing of the Central Water Engineering Academy that would be coming up at Nagpur shortly.

Some of the India's river basins are international in character and we will, therefore, need not only greater technological and management skills but also close cooperation with the neighbouring countries. Particularly in the eastern parts of India, the development of the river basin will depend considerably on the goodwill and cooperation between the neighbouring countries. Some of the associated considerations have been recently

analysed by Shri B G Vergese, an eminent journalist and a scholar, in his book titled "Water of Hope" released by the Centre for Policy Research.

Because of the desired orientation towards the river valley as a geographical unit of development and acceptance of the multi-purpose nature of the use of waters, behind the dams, right from the earlier decades after independence, the irrigation and hydro power projects came to be mentioned as "river valley projects". Even today the Divisional Council of the Bureau of Indian Standards is named as the River Valley Divisional Council. Many Indian standards also carry the words "river valley" in their title. Dr. Khosla initially introduced the use of the words River Valley Projects. It is heartening to see that it has found acceptance and has come to stay.

Greater the intensity of water related activities greater, the urgency for a basin oriented organisation. The basins with intensive water development programmes will, therefore, need them early. Damodar Valley Corporation was the earliest of such set ups. Even though it was modelled on the lines of TVA, it had the important element "Irrigation" in addition. TVA was essentially flood control, Power & Navigation oriented and does not have an irrigation component. In the Indian context, Irrigation will be not only an important part of the Basin's Plan-and many situations it will even be the most dominent one. Hence pattern of Indian basin Organisations is likely to be quite different from the TVA-which was globally the forerunner of the valley oriented set ups.

RIVER BASIN ORGANIZATIONS

It is not that we do not have any river basin organisations at all. Some project oriented organisations and some subject oriented organisations have been already set up which work on the basis of basin as a unit, but they do not have the comprehensive mandate. Organisations like the Damodar Valley Corporation, Bhakra Beas Management Board, Tungabhadra Board, Mahi Control Board, Betwa River Board and Bansagar Control Board have remained confined to construction and operation of the specified projects rather than looking at the basin in totality. The subject oriented organisations like the Brahmaputra Board, Ganga Flood Control Commission have their principal focus only on the management of the Floods. The Narmada Control Authority in its present forms has the mandate of implementing the Tribinals award which is essentially project oriented.

The issue of setting up of comprehensive River Basin Organisations has however received the attention of Parliamentary Consultative Committee of the Ministry of Water Resources who have recommended setting up of River Basins Organisations in the seven basins of Narmada, Brahmaputra, Ganga, Mahanadi, Godavari, Cauvery and Krishna by either reconstituting the existing set up or by creating a fresh set up as may be required.

ADMINISTRATIVE TRANSFORMATION

Dr Khosla was a visionary. He had realised the need for basin approach in the management and the development of India's rivers well ahead of others. Now the challenge would be to bring about this change by arranging the ground level activities on this pattern by integrating the different programmes associated with the water, basin-wise and subbasinwise. This would involve considerable administrative and organisational restructuring in the field set up.

From the point of resource mobilisation (one of the important themes of this Congress) the basin concept has been sponsored long back. From the point of proper flood management and hazard mitigation (another important theme of this Congress) the basin management approach has been supported by the National Flood Commission (Rashtriya Badh Ayog) also. But the technological management of the basin in an optimised manner and in an integrated fashion would involve considerable administrative restructuring and political goodwill amongst the States & amongst the districts in the State. The pattern of present administrative set up in India has not been 'resource oriented' but essentially evolved in the early years of the British Raj from the point of political and administrative requirements for law and order purposes. Later in the context of Local Self Government and decentralisation of developmental administration, the same set up got utilised further.

But now with the changing times and pressing requirements of a more comprehensive basin/subbasin's managements, integration of the earlier set up with the new technological needs of basin management, will be necessary. It is hoped that given the countrywide urge for a systematic development of the basins the various departments involved in the management of the basin should be able to bring about the necessary transformation in mutual consultation and good will. When that happens it will be a great tribute to the visionary like Dr Khosla who propagated the need for such a change as back as two generations ago.

ANNEXURE 1

BASIN-WISE STORAGES IN INDIA

Basin	**Annual Flow (Average)	Completed Projects	Ongoing Projects	Total	Project under consideration, km³
		Live Storage	Live Storage	Live Storage	Live Storage
Indus	73.305	14.515	2.441	16.957	0.050
(a) Ganga*	501.643	33.200	14.729	57.218	6.471
(b) Brahmaputra including Barak etc.	627.867	0.475	0.842	1.318	46.332***
Godavari	118.962	18.553	11.955	30.508	2.763
Krishna	67.790	30.186	6.099	26.286	0.423
Cauvery	20.957	7.181	0.297	2.578	0.482
East flowing rivers between Krishna and Pennar including Pennar & between Mahanadi and Godavari	23.806	1.042	3.659	4.701	0.898
East flowing rivers between Pennar and Kanyakumari	17.725	1.329	0.077	1.407	0.023
Mahanadi	66.879	8.310	4.914	13.224	11.665
Brahmani & Baitarni	36.227	1.077	3.324	4.401	6.505
Subaranrekha	10.756	0.328	1.329	1.657	3.332
Sabarmati	3.812	1.196	0.331	0.152	0.023
Mahi	11.829	2.312	2.192	4.505	0.166
West flowing rivers of Kutch, Kathiawar including Luni	15.098	2.579	1.630	4.209	1.752
Narmada	40.950	2.806	14.106	16.913	0.463
Tapi	18.000	8.167	0.897	0.906	0.169
West flowing rivers from Tapi to Tadri including Tadri	108.618	0.856	2.181	3.037	0.476
West flowing rivers from Tadri to Kanyakumari	89.250	8.895	7.942	16.838	0.100
TOTAL	1853.494	143.018	79.054	222.072	82.102

*Including tributaries downstream of Farakka.

**The figures include the observed flow and corrected for surface utilisation and the effect of actual utilisation of ground water draft not included.

***Only Dihang and Subansiri projects considered.

(Source: Water Resources of India (A CWC Publication, 1988)

The Fourth Dr Ajudhia Nath Khosla Memorial Lecture was delivered during the Sixth Indian Engineering Congress, Pune , December 22, 1991

Status of Construction Sector in India

A Nagabhushana Rau

Former Chief Executive and Joint Managing Director of the Hindusthan Construction Company Ltd.
Former Honorary Executive Director, National Institute of Construction Management and Research

My grateful thanks to the Institution of Engineers (India) for giving me this opportunity to deliver the Fourth DrA N Khosla Memorial Lecture, I consider it a great honour. I am happy that the Institution has recognized the importance of the construction sector in national development and has asked me, a construction engineer, to share' the thoughts with distinguished engineers,

Dr A N KHOSLA'S CONTRIBUTION TO THE NATION

Dr Ajudhia Nath Khosla was born in 1892, graduated at Thomson College of Civil Engineering, Roorkee, in 1916, During 1918-1920 he was with Mesopotomia Expediency in Iraq, as a Commissioned Officer, He invented the Khosla Disc for precision levelling across rivers and wide valleys, During 1921:25, he evolved precast concrete units for - construction of barrages, During 1935, after long research on flow of water through sub-soils in relation to stability of hydraulic structures, he published his treaties on 'Design of Weirs on Permeable Foundations'. This was his most outstanding contribution to engineering, This is being used even now in the design of barrages over permeable foundations. The basin as a unit of development was first propagated by Dr A N Khosla in 1945. He also saw that this proposition was implemented in Orissa by construction of the Hirakud Dam, as a multipurpose project to provide flood control, irrigation , hydro-power and navigation in the Mahanadi River,

In 1945, he became the first Chairman of the Central Electricity, Irrigation & Navigation Commission and Additional Secretary to the Government of India in the ministry of orks, Mines & Power, He was with Hirakud Project which was completed in a record time of 12 years in 1957, even though he retired in 1953. During his Chairman tenure he was with the Khadakavasala Research Organisation which was reorganized and properly developed. Dr Khosla was also responsible for development of Bhakra, Chambal, Damodar Valley, Kosi, Narmada and Tapti. All these contributions to the nation made him the Father of River Valley Projects in India.

Dr Khosla became the Vice-Chancellor of the University of Roorkee in 1954, In 1959, he became a member of the Planning Commission, In 1962 he became the Governor of the State of Orissa, One cannot forget Engineer Khosla becoming a Governor as this was the first time that an engineer was appointed as the Governor of a State, He was a consultant to the Narmada River Valley Projects. Dr Khosla was analytical in his outlook. He was for rnoderruzation. He donated his personal earnings to start a Research Fund in Roorkee University, He was, throughout his life, involved in the uplift of society. He had a humane and a philanthrophic approach. I am connected right from 1950 with many river valley developments and projects in India and construction of projects particularly the barrages of Sone, Farakka, Sharda, Gogra, Mahanadi, Tista and Godavari on permeable foundations,

CONSTRUCTION SECTOR

Construction sector covers a vast area of operation from the beginning of surveys to architecture design to complete structure, alongwith operation and maintenance during its life. Construction covers various forms of activity ranging from small mud home construction to high-rise buildings, from rural works to industrial structures, from village roads to, expressways, tiny irrigations tanks to major dams, power houses, thermal, hydel, gas, nuclear, runways, ports, overhead drilling to platform and all other civil infrastructures.

Construction technology exhibits all kinds of technology from medieval to the most modern, It includes production, supply and transport of all kinds of construction materials. It includes the construction activity undertaken by individuals themselves to those executed by the organized sector, government owned firms, government departments directly, corporations and co-operative societies. It is mobile, seasonal and more labour intensive than other industries.

Its products range from multimollion dollar projects to simple structures costing a few thousand rupees.

Head load carrying women workers, animals and computer controlted heavy machine work side-by-side in perfect harmony.

In construction the elasticity of demand has more profound influence on decisions regarding size of the organisation, investment on technology and compliance of legal framework than any other industry,

The Government has an important role to play in construction as it acts both as legislative authority and an active participant. Most of the financing of works is from the Government.

The construction section assumes much larger conceptual role than just building or construction, It becomes synonymous with the project site activity, which involves management of construction, materials, equipment, human resources, financial resources, information systems, environmental management, contract management and other interconnected aspects of development. It also involves co-ordination between various direct and indirect participants.

Indirect participants approach and decisions affect construction activity to a large extent.

Construction is carried out by contract system to a great extent. Competitive bidding is universally accepted as best and economic method, Of course, there are many problems in bidding and acceptance of lowest financial bid.

Construction sector is full of individuals, family oriented teams, small petty 'piece workers, very small contractors, special tradesmen working on their own, This sector almost forms 80% -85%of the construction.

Construction sector provides a buffer to rural agricultural workers migrating to urban areas for occupations. It helps them to absorb the shock of migration but does not involve them completely in this sector,

An important matter to be observed about Indian construction sector is that it has grown on its own to a great extent. It did not have overseas collaborators or contractors to assist them as happened in many developing countries. Quite an amount of equipment and technology comes in from bilateral aids from developing countries, but it was not continuous and similar. This closed the doors to outside contractors and to a great extent has given enough confidence to Indian construction industry. Many a number of concrete dams, barrages, industrial structures, marine structures, bridges and atomic stations have been built entirely by Indians. But it had its own other effects or not making the Indian sector aware of new technological developments and construction equipment. But, how far joint ventures have helped transfer of technology is another problem. The entry of World Bank, Asian Development Bank, and the open policy of the Government of India has brought in new technology and construction equipment management. The Indian constructors going overseas in 1975 and onwards have awareness of the technological development and acquisition of new construction equipment.

Particularly in small towns, rural areas and villages entire construction is handled by small unorganized contractors, the Government departments or Zilla Parishads work gangs. Unfortunately, there is no data - available on these as there is no licensing of contractors, but registration by different departments or organizations undertaking construction.

Even on technology, there is not much assimilation. The old methods continue in rural infrastructure and housing. In major projects like dams, airports, high-rise buildings, bridges, powerhouses, atomic stations, industrial structures, most modern technology is tried to be employed. Again, lack of planning and management has its effect on these projects. There are long delays that cost increases, disputes, quality at stake on almost all the projects.

Once a construction project is completed and a structure of infrastructure is built and starts rendering service to society, the maintenance of its through its economic life has a substantially special construction methodology. Unfortunately, this is the most neglected subject both in private as well as Government.

Construction is the most unorganized sector in the country. The contractors and construction workers are most unorganized. In spite of so many labour laws and acts present, implementation is always a problem. The contractors do not form effective organization. There is no training of workers and tradesmen. Anyone with finances and entrepreneurship can enter construction without any organization or equipment. He can manage by sub-contracting, piece working and sub-letting. He can get out also with least botheration or any fear. Even in Government departments no efforts are made to train the employees to be productive.

The problems relating to all construction activities are varied and diverse. It needs continued study to understand the problems and find solutions and bring about reduction in construction time, cost and better quality which are the objectives of construction sector.

ROLE OF CONSTRUCTION IN NATIONAL DEVELOPMENT

Construction is basic to the development of any national activity like agriculture, industry, economic infrastructures, water, power, transportation and communication. It also forms a part of commerce, special infrastructures, education, health and cultural activities. It provides housing to the people. Construction acts as a stepping stone in all industrial activities. Construction is active in entertainment, tourism, wild life and environmental upgradation.

Construction sector accounts for almost 50% of the capital outlay in National Plans. It forms up to 9% of GNP.

It provides higher employment. The construction sector provides 7% per annum against 2% per annum overall. A 10% of value added to construction increases the employment by 10%. It is also estimated that this sector adds 75 paise to gross domestic production for every rupee that is invested.

In any country, developing or developed, construct: activity is vital to the national groW1h. It provides a means of transforming aspirations for social and economic well-being of a nation to reality by providing housing, industrial and infrastructural facilities etc. The construction sector offers an environment to raise the standard of living of the people of a country.

Construction sector has the single objective of production of products, that serve its users needs. The aims of this sector is to produce and deliver a quality product with imagination, with integrity, with economy and with an eye on the environment. It may be that this sector has not been able to satisfy society in achieving this objectives fully, but on many major projects in earlier days this aim was achieved. The aim of all concerned whether Government, contractor or consultant should be to achieve this for benefit of society.

The Asian Productivity Organisation, Tokyo, in its survey of the construction sector in member countries during 1981-83, made out that construction activity is not a 'trade' or a 'service' activity but a 'productive activity'. Whatever activity construction sector takes up, the end result is a 'product' - a building a dam, a road, etc. The construction sector deals with all the resources and manages the activity, which results in a product.

There is a need to improve productivity in the construction sector. If the sector can be made even a little more efficient through improved designs, construction methods, technology and man-power, planning and training, tools and equipment, a little better coordination between the constructor and the owner and ultimately by use of better management, the result of such an effort will be a boon to the country's economy.

It has been estimated that the component of construction in different sectors of the economy is as given in Table 1. The gross fixed capital formation in India at current prices is indicated in Table 2.

TABLE 1 ESTIMATED COMPONENT OF CONSTRUCTION IN DIFFERENT SECTORS OF ECONOMY

Sector	Construction Component as a Percentage of Outlay	
Agriculture and allied sector	34	
Irrigation and flood control	80	
Power	75	
Small industries	25	
Organized industry	30	
Transport and communication	40	(excluding Railways)
Education	20	
Scientific research	10	
Health	37	
Housing	100	
Welfare of backward classes	12	
Social welfare	21	
Labour welfare and craftsmen training	45	

TABLE 2 THE GROSS FIXED CAPITAL FORMATION IN INDA

(in Rupees million)

Year	Construction	Machinery and Equipment	Total
1950–51	6330(72%)	2410	8740
1955–56	8100(66%)	4730	12830
1960–61	13370(62%)	8190	21560
1965–66	23600(57%)	17720	41320
1970–71	39600(63%)	23450	63050
1975–76	73400(55%)	59900	133300
1980–81	136490(52%)	126270	262760
1985–86	270340(49%)	279710	550050
1986–87	297470(47%)	337140	634610
1987–88	336660(48%)	365880	7025140

(Figures in bracket indicate percentage to the total)

It is also seen that the construction component in the National Plan of construction sector in the capital formation is about 40%-50% (Table 3).

Hence, the construction sector has a very important role to play in the National Development and National Economy.

The Deputy Chairman of the Planning Commission stated in 199QDonyention:

"As regards rural development, the Government is already committed to 50% investment in agriculture and rural sector A major part of this outlay is expected to be in the manner of minor works, including activities on the farm which are not part organized construction activity, but still defined as construction in the national accounting sector. This shows the view and extent of construction activity in the country, of which we need to be fully aware."

It must be mentioned that there is no data available on different types of works done, the labour employed, the number of contractors, the number of consultants and designers and other relevant data pertaining to the construction sector. This lack of data puts one into difficulties.

TABLE 3 CONSTRUCTION CONTENT BY HEADS OF DEVELOPMENT

(in Rupees million)

Heads of Development	First Plan (Actual)	Second Plan (Actual)	Third Plan (Actual)	Fourth Plan 1969–74 (Actual)	Fifth Plan 1974–79 (Actual)	Annual Plan 1979–80 (Actual)	Sixth Plan 1980–85	Seventh Plan 1985–90
Agriculture and allied sectors	990	1870	3700	7890	16540	6790	45140	77500
Irrigation and flood control	3470	3440	5320	10830	31020	10300	119490	101870
Power	1120	3390	5390	22000	55490	16810	14490	257050
Small industry	110	470	600	610	1480	640	4450	6880
Organized industry	170	2810	5180	8590	20610	7150	61220	119210
Transport and communication	2070	5040	8450	12320	27480	8180	61490	117770
Education	300	550	1180	1550	0	530	5050	12770
Scientific reasearch	0	0	70	130	170	90	920	2470
Health	360	840	840	1240	2820	830	6740	12550
Housing and urban development	1290	1490	1280	2700	11500	3690	23700	107820
Welfare of backward classes								
Social welfare	0	0	20	80	110	40	330	2940
Labour welfare and craftsman	0	0	40	130	180	70	570	2130
training and other services	0	0	250	140	3680	1060	9140	33020
Sub-total	9880	19900	32320	68210	1710800	56180	353180	853980
Approximate construction content as percentage of total outlay	50.4	42.6	42.3	43.2	43.4	46.1	36.2	47.4

It is necessary that the Government should consider how best to evolve a reliable data. It helps the Government itself in evolving solutions in connection with construction sector.

CONSTRUCTION SECTOR GENERATES EMPLOYMENT

It is well known that the construction sector is next to agriculture in generating employment. Unfortunately, reliable data on how many workers are employed is not known. Perhaps an idea of the labour situation may be obtained from the 1990 census. All figures are estimated. The Deputy Chairman of the Planning Commission said during the National Seminar on 'Construction' in 1990: 'According to currently available estimates, there is as of now a backlog of about 27 million unemployed people in the country. The labour force is projected to increase by about 37 millions during 1990-95 and 41 millions during 1995 - 2000. Thus, the total number of persons requiring employment during the Eighth Plan would be around 64 millions and as much as 105 millions during the period 1990 - 2000. If employment is to be provided to all these persons during this decade, employment will have to grow at an annual rate of 3% and above and some 300 million persons are estimated to be employed in 1990. On the other hand, the growth rate in employment achieved during the 15-year period, 1972-73 to 1987-88, was of 2% per annum. In more recent years, the overall employment elasticity with respect to value added during the period 1983-1987 is estimated at 0.38. The employment elasticity in the construction sector is estimated at 1. This implies that for an increase of 10%, say, in value added in the construction sector, in the increase in employment is 10% of the highest among all the sectors. This is indicative of the importance of the construction sector in employment generation which is one of the key objectives of the Eighth Five –Year Plan'.

It is also said that 10%-12% of the people employed are in construction sector. The National Building Organisation (N B 0) has estimated that Rs one million invested in construction generates 3 000 man-days of skilled and semiskilled and 1 300 man-days of managerial and technological employment.

The growth of the construction sector leads to the growth of associated sectors such as construction materials like cement, sand, glass, wood, paint, pipes, electrical and sanitary fitting. It is estimated that employment in cement -1.6 million jobs, bricks - 2 million jobs, paints and varnishes-0.1 million jobs, glazed tiles - 0.132 million jobs which generate employment.

Housing has high employment generation potential. It is stated that employment rose from 1.27 millions in 1961 to 2.18 millions in 1981. It is estimated that investment of Rs 10 millions in housing will generate a totalof565-mm-years direct and 904 years of indirect employment on urban pucca structures at the 1983-84 wage level.

During floods and droughts, employment generation schemes take up maximum number of employees in construction. Thus, it is observed that construction generates both direct and indirect employment.

But, in the construction sector, employment is seasonal, temporary and casual. It depends on the duration of the work load. The place of work changes very frequently. Continuity of work and service exist in Government and

well-known firms, that too for technical people. 'So, the training, productivity and improvement in methods are at stake.

But, unfortunately, there is no proper analysis or data on systematic approach to improve continuity of employment or productivity. This definitely needs attention of the Government and others associated with the construction sector.

PLANNING COMMISSION AND CONSTRUCTION SECTOR

During 1960-68, the Planning Commission did a great job for the construction sector. It set up various committees to go into the details about the status of the sector and make recommendations. It must be said that even though none of the recommendations are implemented even now most of them are valid and apt to be applied. There were Committees to develop a standard contract form, to examine Public Works' administration, to review construction labour position, to go into the details of economics in the construction sector and to review project management. But later on no efforts have been made. The National Institute of Construction Management & Research (NICMAR) took up with the members of the Planning Commission that each page of the document of Planning Commission refers to construction but there is no separate chapter to deal with the problems of the construction sector, the strategies and action plans. Hence, some recommendations are made on the construction sector. It is difficult to understand why this is so. In May 1990, the Deputy Chairman of the Planning Commission said: 'I assure you, there will be a separate chapter on the construction industry in the Eighth Five-Year Plan document because construction is an ever expanding field and we would like to give due importance to it so that more job opportunities are created'.

Some of the recommendations made in 1960s are even now being asked: Ministry of Construction, Construction Finance Corporation, Standard Contract Document, Building Materials Assessment & Development Board, Training in Building Trades, Board of Engineers and Architects for each State: on labour laws, national registration of contractors and many other technological upgradation problems. These are as valid today as they were then.

The Ministry of Labour in 1954 and the National Commission on Labour in 1960 have gone through workers problems and made recommendations. But none of them are implemented. They spoke on enactment of proper labour legislation for construction, training of technicians, safety, problems of unorganized employers and employees, proper contract system, minimum y.ages, welfare of construction workers and other aspects. But the situation is same.

A tripartite working group on building and construction industry was constituted in 1985 by the Ministry of Labour. The Ministry also organized in 1990 a National Seminar on 'Construction Workers'. But no consensus was evolved.

Again, the Department of Science & Technology has done some' good work on the construction sector, building materials, etc. But they are all in files.

The Builders' Association of India in January 1989 made an exhaustive memorandum to the Planning Commission, but nothing has happened. It asked in the memorandum for a fair contract document, price adjudication, National Safety Code and Standards, National Construction Boards at the Centre and the States, eliminate price preferences given to public sector undertakings, sales tax. excise duty training in trades, etc.

Again, the National Institute of Construction Management & Research and the Planning Commission had a National Conference on 'Construction in Eighth Five-Year Plan' where pollcies, performance and programmes were discussed in May 1990 at Delhi. The Conference recommended:

'The Planning Commission Documents to include a chapter on the construction sector, economic completion of projects in time, increasing productivity, management development, fair contract document, setting up of Construction Industry Development Councils at the Centre and the States, Building Materials Development Board, Construction Welfare Fund, Construction Industry Training Board, establilshment of Construction Finance Corporation to bring in uniform labour code, develop proper administrative system suitable to the practices, action to be taken to improve exports, development of technology and care of environment, and a Ministry of Construction'.

Again the Planning Commission set up a working group on improvement of methodology and technology in construction in 1989 and the Committee made its recommendations in April 1990. This working group also said about the same as the National Conference. It wanted again a separate chapter on the construction sector, a central agency for coordination, national policy on construction industry, national housing policy, construction management, management of major projects, contract management, work management, safety codes and standards, technology, setting up of a construction development bank, workers safety, health, welfare, productivity, a ministry of construction, construction Industry Development Board and other matters. But what will happen to these recommendations is to be seen.

The Planning Commission has set up working groups under different ministries to evaluate construction equipment and technology development contractors' capability and many other issues. But, what is the result of all these discussions and recommendations are not clear.

It is seen that the recommendations to improve the construction sector in 1960s and again in 1990s are almost same. But, nothing tangible has happened in the Planning Commission or the Central or State Governments. Continued efforts of all interested in the construction sector are needed.

ROLE OF THE GOVERNMENT IN CONSTRUCTION SECTOR

The two-fold role of the government-Central and States and local-as policy makers at the macro economic level, and as an originator of demand and executor of works at the micro economic level-stresses their importance for the sector.

Most of the construction work is Government financed. Of late, even industrial and housing gets finance from financial institution and banks regulated by Government. The Government also regulates construction by controlling the finance allotted to different infrastructural execution. Many times projects are stopped abruptly because of finance shortages. Many times finances are cut down on projects which result in delays. The delays on projects are also due to Government not giving prompt decisions and fulfilling its obligations regarding land, forests, roads, electricity, quarrying, drawings, settlement of extra item rates, etc. Several committees of the government have examined these but no effective improvements are discernible. Many drought and famine construction works get financed from the Governments.

Execution of infrastructural facilities is important for the improving the standard of living of the people, but it depends on finances and priorities. Governments, Central as well as States, have their own construction corporations. Even government departments have their cells for construction.

The pre-qualification, registration of contractors, equipment, financing, building material manufacture and management, land for buildings, quarrying and other matters are all controlled by Government laws and acts and executive orders. In labour laws and acts, sales tax, excise duty, rent act, urban land controls, management of labour, management of equipment, etc, the governments have a significant say.

Contract conditions, specifications, designs and many other related aspects are controlled by construction departments of the governments. Even on research and development (R&D) there are few private organizations. But most of R&D are in government hands. The engineers' training, tradesmen training, technical selection, etc are all controlled by the governments.

On many projects, the delays and cost escalations happen due to non-cooperation and obstruction from other departments of the governments. The government departments have set up a number of committees to go into the problem of various aspects like contracts, rates and costs, construction equipment, project management, project evaluation, etc. But most of the recommendations have not been implemented effectively.

The Government has set up a number of public sector construction organizations. These have a price preference against the private sector construction organizations. .

The Government set up a Tripartite Working Group on Building and Construction Works, but this has not produced any unanimous report. Again in 1990, a National Seminar on 'National Construction Labour' was organized by the Ministry of Labour, but no consensus was reached.

A Task Force was appointed by the Government of India in 1988. It made very important recommendations. One of them was setting up of a National Institute for Project Management & Research. Unfortunately, this has not been implemented as yet. But, the construction sector itself founded in 1983 in Bombay, the National Institute of Construction Management& Research (NICMAR) which imparts management training.

Even on project design, entire conception, design and contracting is dealt by Government departments. In a few cases, private consultants are allowed for construction of bridges, housing and infrastructural areas. Hence, export promotion cannot happen unless this changes.

Thus, the construction sector needs concerted strategies and action by a number of sectors. These will succeed only if the Government is committed to them and take actions to implement the reforms. Unless the approach and attitudes of the Government changes nothing will happen to this sector.

CONSTRUCTION AS AN INDUSTRY

Whether construction is declared as an 'industry' or not is again a dilemma. There is no definite opinion either by the Government or private contractors and construction organizations. The dilemma faced in this connection is two fold: (i) if the construction sector is organized in the form of an industry, these will necessarily follow legislation to regulate workers employment and conditions of work so that they are not exploited. On the other

hand, the construction sector, may need to have some flexibility in regard to employment since the location of construction activity keeps Changing, it is casual and temporary. Hence, there is no persistent demand for construction labour continuously. It is, therefore, necessary to ensure that construction activities are not hampered by too much regulation and excessive controls which characterizes organized industry. There are again problems created to small contractors about industrial laws and acts. The construction sector is so unorganized and spread even in the interior rural areas also So, a study is needed in detail to decide as to make construction sector an industry or not.

ROLE OF CONTRACTORS AND CONSTRUCTION AGENCIES

In general, contractors and construction agencies in the construction sector in India are not well organized. There are very few organized construction agencies. Most of the contractors are small with no technological or management background. Unfortunately, the number of contractors is not known in the absence of reliable data as in other countries where central licensing of contractors is insisted upon. In India, there is only a registration under different government, public sector and panchayat and local municipalities. Each agency has different criteria for registration.

It is easy for anyone with money and influence to enter into construction and go out without much problem. Even many industrial houses are making construction, particularly the housing as a diversification. But very few construction organizations exist who can handle major projects and who have technological, managerial, organizational set up and possesses the necessary equipment. Most of the contractors, particularly in rural and small towns, are non-technical.

The Builders' Association of India (BAI), which was started about 60 years ago at Poona by a military engineer is the main contractors' organization. It has about 60 centres all over the country, about 20 affiliated associations, and about 10000 direct and 15000affiliated members. It holds seminars once in two years at different centres and discuss technical matters connected with construction. BAI has developed with the assistance of NICMAR a draft contract document and submitted it to the central and state government authorities. Some progress is made in accepting some of the clauses. The members of the BAT are on Schedule Rate Committees, Contract Conditions Committees, Rates and Cost Committees, etc.

In each State as well as the Centre the construction agencies have formed associations for different departments and the departments usually have consultations with these associations. Unfortunately, the construction sector has not built up a political lobby as is done in other countries. This is important if some definite actions are to be taken for improvement of the construction sector.

Public sector construction organizations are also members of some of these associations. For overseas works, the Government has established an Overseas Construction Council, which looks after the overseas interests of Indian contractors.

The BAI and other contractors associations are not putting efforts to train or make aware the members or its employees on technology and management. There are no trade training efforts by the BAI. Of late, it has made efforts to make four test trades approved by the Director of Employment & Training of Labour Department- concrete supervisor, form-work, reinforcement man and mixer operator. But nothing has been done to put it into practice.

There are a number of public sector undertakings in construction. Most of the State also do have these. But very vew of them are doing well. The objective of starting these is to improve the technology, planning and management. But this has not yielded any results. Most of these get works done by the sub-contract system. They get 10%-15% price preference in tenders against private contractors. It is high time some thought is given to make them more efficient and productive and management oriented rather than give subsidies.

The World Bank has said about construction as: 'Construction works also involve grave risks-more so when compared to other types' of economic activity. Unlike the typical manufacturer of farmer. The construction entrepreneurs move from site to site, organize logistics for timely assembly of all the inputs there and follows custom design for each site and jobs are won usual~ by specific bids. Cost transfers have to be estimated for each site in the assumptions made about many variables such as site condition, weather, productivity of labour, equipment, time required for delivery of spares, so on and so forth. For civil works, the risk involved in bidding exceed even these for building because the scope of work is usually larger, use of heavy equipment is greater and susceptibility to the effects of inclement weather and in some cases the remoteness from service and supply centres are more pervasive.

Since a majority of the construction industry output is capital intensive, demands tend to fluctuation considerably more than the other industries. The contractor has to face the risk of sharp fluctuation in his volume of work and hence in the number of employees and the amount of equipment needed. Again the risks tend to be greater and the fluctuation more marked for civil works than for building. It should be said that

contractors do not study any of the laws being enacted by governments. They do not put up their views and influence change in policies. Usually actions are thought of after enactment. This needs better approach. In this context, building up a political lobby is a necessity if the contractors views are to be heard.

LABOUR LEGISLATION

On construction projects as many as 22 to 24 labour laws and acts become applicable. All of them are not same. If there is a strong union of workers, which usually exist on projects, the maximum benefits available under the law will be made applicable to all the workers. This is a costly matter. - The construction work is seasonal, casual and temporary and employment cannot be permanent. Many items of works last for few days or months. These workers cannot be carried on. So, the employment has to be there only as the items of work exists.

Till some years ago, there never used to be minimum wages for construction works. Now almost all States have it. The implementation of the ESI Act, and the Provident Fund Act becomes a problem because of the casualness of employment. The Government has been requested by the BAI that a percentage of contract be levied, 2%, say as welfare fund and let the Government operate it and see that the workers get the benefits. This is because no worker is permanently with any contractor. Nothing has happened. Particularly the employees under small contractors and many Government departments get exploited. There is no enforcement authority to enforce the labour acts and laws.

There are also no proper organizations and unions in this sector except in public sector organizations and organized firms. Almost all other are unorganized. No labour union leader has been able to establish the unions in small construction organizations and enforce a fair treatment. This probably is again due to the workers not being politically of any use to the union leaders.

The latest Planning Commission Group says, 'A comprehensive labour code should be enacted to replace all the existing statutes applicable to it. The principle of 'one law, one inspector and one code' should be observed. The code may regulate minimum wages, conditions of employment, working conditions, living conditions at sites and safety'.

'In large projects of more than five years duration, employment should be continuous. They should have a comprehensive scheme of training and restructuring for ensured continued employment'.

With the states bringing labour acts, enforcement being not effective, the construction sector not getting continuous work; non-existence of unions, unorganized nature of the sector, and inefficient implementation of the laws, it is doubtful, if any unified code or a fair and equitable labour act could be adopted for the construction sector.

ENGINEERING EDUCATION

Present engineering education, either in civil, mechanical or electrical degree or diploma, does not orient the engineers to the many aspects of the construction sector. It does not touch any of the management subject such as management of resources, general management or construction equipment management, etc. The management of resources is one of the important factors that an engineer faces. Even in mechanical engineering or electrical engineering, the question of construction equipment, methodology, operation, maintenance, etc are not included in the college curiculum. There is a great need to change this situation.

Introduction of information system technology, communication technology, computer technology in the colleges or technical institutions is necessary.

The BAI in collaboration with the Overseas Construction Council of India, right from 1981 tried to establish an Institution of Construction Management. In 1981 society was formed with a trust and the National Institute of Construction Management & Research (NICMAR) was established. This institute is the only one of its kind in this part of the world. The NICMAR has started a postgraduate course in construction management and the fifth Course is on. It has also started in-house training programmes and also correspondence course in construction management for the benefit of people engaged in construction projects. The UNDP and ILO have helped the institute by sanctioning a project for upgradation. The Department of Science & Technology, HUDCO and other government departments as well as private construction sector helped NICMAR. It is felt that more institutes of this type are started all over the country. It is also desirable to have construction management courses in almost all engineering colleges to upgrade the construction sector which takes about 70% of the civil engineers and diploma holders coming out of the colleges. It should be mentioned that the Madhav Institute of Technological Sciences, Gwalior, and the Manipal Institute of Technology, Manipal, have post-graduate courses in construction management. It is also suggested that owners ar Government Department engineers are given training construction management, contract management, project management, management of resources, communication and information system management. The World Bank, wherever it has financed the projects, is insisting on training of the engineers and the project 'authorities, in these subjects, Some projects have started

training programmes. The Madhya Pradesh Narmada Dam Project has a three-year programme on the subject. NICMAR is helping in this. The Central Water Commission has programmes on different projects in construction technology and construction project management. Public Works Department and the Irrigation Department of Karnataka have also started this. Many other departments are also moving on these lines.

CONSTRUCTION TRADE AND SKILL DEVELOPMENT

Construction technology has developed so vast in recent years. Cement production has increased and the production of concrete, prestressed concrete and pre-fabricated concrete all having increased almost by 100%.None of the polytechnics and technical institutions teach anything regarding concreting, reinforcement, form-work, scaffolding, masonary, flooring, painting, finishing, joining, etc. These are all important trades for proper training in polytechnics.

In the earlier days, the Central Water Commission and some of the manufacturers were training people in operation and maintenance of construction equipment. But, unfortunately, this is stopped. Since so much of equipment is being manufactured in India and the cost being so high it is necessary that properly trained operators, mechanics are available in the country.

The Indian Concrete Institute, the Builders' Association of India and the Government departments have evolved syllabus for the concrete supervisor, reinforcement-men, mixer operator and formwork men on concrete technology. These courses are to be taken up in the polytechnics along with other trades like boring, drilling, heavy equipment operation, etc.

There should be a Construction Industry Training Board at Centre and State levels. These can be semi-autonomous bodies. Actual training course may be given by the private agencies, .industry associations, project authorities, trade unions and government bodies.

Nirmathi Kendras and Jawahar Rozgar Yojana schemes have started some training programmes in low cost technology and low cost housing. But they are not yet very effective except in some centres.

CONSTRUCTION EQUIPMENT

It is said that 'India has some construction equipment or others, mostly imported since 1990's. During the last ten years, the Indian manufacturing industry has gone into development of many modern construction equipment with overseas collaboration. But what is the need of the country, what equipment is needed for mechanization, what servicing is needed and what training is needed have not yet been analyzed and proper action taken.

It is to be noted that cement production, which is the index of construction in the country, has gone up by almost 100%. This has an effect on construction sector. Unless concrete is done by weigh-batching of cement and aggregates by mechanized means, no quality and economy could be achieved. There is need to develop smaller weigh-batching equipment with electronic weigh-batching system that could be used by small and medium contractors.

NICMAR under the Department of Science & Technology has published two volumes on construction equipment manufactured in India. The Roads Congress has also published a book on this subject

The entry of the World Bank and the Asian Development 'Bank and the entry of some countries' aid in construction has allowed the construction industry to import the technology and construction equipment and many projects have done so. But, the main problem is the operators and mechanics to look after the operations and maintenance. There is not much effort in this direction.

Very few Indian manufacturers publish operation and maintenance manuals in local languages. Spares and servicing by Indian manufacturers is another problem. Construction equipment or use forms only about 10%-15% of the equipment made by heavy earthmoving equipment manufacturers. Tables 4-9 show the equipment position in India.

TABLE 4 CAPACITY AND PRODUCTION OF EARTH MOVING MACHINES AND EQUIPMENT INDIA, 1970–1984

Description	1970		1975		1980		1984	
	C	P	C	P	C	P	C	P
Excavators	100	90	305	116	380	234	380	321
Dozers	700	211	600	395	1177	286	1177	449
Scrapers	60	33	50	22	118	65	118	7
Graders	60	21	60	32	60	20	60	48
Loaders	60	46	112	87	590	310	590	360
Road rollers	1620	340	2220	740	2220	870	2220	270
Cranes	1235	355	2325	800	1765	900	2765	1070
Mobile cranes	188	70	264	152	1784	216	NA	NA
Dumpers	156	105	460	313	685	477	685	516
Air compressors	8700	6800	13500	5900	13700	15900	13700	4250.

C = Licenced Capacity; P = Actual Production

TABLE 5 CAPACITY UTILIZATION OF FEW SELECTED CONSTRUCTION EQUIPMENT IN 1986

Type of Equipment	Mfg. Co, No	Annual Licenced Capacity, No	Production, No	Capacity Utilization %
Excavator–hydraulic and tracked (backhoe and shovel)	4	927	397	46
Dozer	4	2120	456	31
Scraper–motorized	2	296	7	3
Grader	2	90	46	51
Loader–wheeled	4	931	304	47
Jack hammer	5	21480	3537	15
Drifter–blast hole drill	3	2950	504	20
Compressors	5	7268	3916	50
Vibratory compactor	75	829	638	62
Roller (smooth wheeled, vibratory, pneumatic tyred, sheepfoot)	9	4213	996	34
Tower crane	4	147	25	17
Mobile crane	11	870	531	61
Tower hoist	5	20	40	240
Crusher (jaw, granulator, hammer, impact, cone roll and gyratory)	6	452	270	108
Mixer (tilting, non-tilting, drum, pan and transit)	9	3197	871	36
Concrete pump	2	50	6	12
Vibrator (Immersion, shutter, screed)	10	5700	2510	40
Prestressing equipment	3	20	12	60
Dumper	6	1204	542	54
Asphalt mixing plant	5	225	83	52
Paver finisher	4	109	26	29

TABLE 6 POPULATION VALUE AND ORIGIN (IMPORTED/INDIGENOUS OF CONSTRUCTION EQUIPMENT OWNED BY IRRIGATION SECTOR IN 1979)

Equipment	Total		Imported	
	No	value, Rs million	No	Value, Rs million
Excavators	866	614.1	635	443.767
Tractors (Cr)	4459	728.790	3720	579.015
Tractors (Wh)	749	38.843	545	32.594
Dumpers	2569	601.987	2337	542.388
Scrapers (M)	1035	251.501	923	191.985
Scrapers (T)	294	23.035	248	16.686
Motor graders	382	34.299	364	30.043
Front end loaders (Cr)	140	22.625	131	20.808
Front end loaders (Wh)	NA	NA	NA	NA
Cranes (all types)	957	272.048	775	207.882
Batching and mixing plant	16	14.667	16	14.667
Air compressors (all types)	1998	108.488	286	16.194
Drills and drilling equipment	588	74.762	172	29.950
Crushing screening and Aggregate processing plant	771	45.176	48	15.746
Locomotives	133	24.509	126	22.616
Agitating cars	4	0.534	4	0.531
Cable ways	4	7.179	4	7.179
Belt conveyors	112	12.707	81	2.130
Tractors trailors	372	10.105	258	13.651
Vibratory rollers	28	1.989	20	1.625
Mobile workshop	18	1.498	12	0.556
Water tankers	25	1.585	Nil	Nil
Muckers and rockers shovels	25	8.848	25	8.848
Fork lifts	136	6.709	108	5.600
Ditchers and trenchers	26	0.805	26	0.805
Mini car loaders	4	0.029	4	0.029
Pile driving equipment	53	5.519	49	5.246
Tugs and barges	63	19.110	Nil	Nil
Asphalt distributors and paver finisher	25	2.142	25	2.142
Spreaders	3	10.034	3	10.034
Ore loading plants	1	1.440	1	1.440
Total	16 048	2 986.808	10 928	2 224.160

TABLE 7 PRODUCTION AND SHORTFALL IN BUILDING MATERIALS

Materials	Year 1988–89		Year 2000 AD	
	Production	Shortfall	Production	Shortfall
Bricks, million	63 000	17 000	1 00 000	25 000
Cement, Mt	46	0.00	100	0.0
Coarse aggregate, Mm^3	100	15	150	30
Lime products, Mt	4	2	7	3
Ply wood, Mm^2	66	60	100	65
Particle board, t	80 000	28 000	90 000	33 000
Fibre board, t	1 00 000	30 000	1 10 000	33 000
Plastic building materials, t	1 59 400	42 000	4 26 200	–

TABLE 8 APPLICATION-WISE CONSUMPTION OF PLASTICS IN BUILDING AND CONSTRUCTION SECTOR IN INDIA

Component	Materials	Consumption, Mt	
		1983–84	1989–90
Wires and cables	PVC	25 000	58 000
	LDPF	2 000	10 000
Electrical fittings	Phenolics/PP	760	1350
Toilet seats	PP, HIPS	200	450
Water proofing	LDPE	30	150
Roof sheets	GRP	120	240
Various profiles like handrails, step nosing, expansion joints, etc	PVC	385	760
Pipes and conduits	PVC	34 000	100 000
Sanitary appliances			
(a) Flushing cistern	PP/HIPS	50	600
(b) Toilet pots	PVC	–	700
(c) Plumbing fixture	PVC	70	500
Overhead water tank	LDPE	500	1 500
Floors tiles and skirting	PVC	3 000	5 900
Wall paper	PVC	180	360
Partitions	PVC	500	1 900
Thermoformed false ceiling and wall panels	HIPS	30	70
Heat insulating film	Polyester	25	100
Sound and heat insulation	PS and PUR foam	220	350
Others		50	500
Total		76 120	201 430

TABLE 9 TOTAL DEMAND, PRESENT PRODUCTION AND SHORTFALL IN AVAILABILITY OF CONVENTIONAL BUILDING MATERIALS

Building Materials	Total Demand (Annual)	Present Production	Shortfall
Bricks, million	70 000	55 000	15 000
Lime, Mt	7.00	4.00	3.00
Timber, Mm^3	5.5	4.00	1.5
Aggregates			
Coarse aggregate, Mm^3	115	95	20
Sand, Mm^3	140	100	40
Building boards			
Particles board, t	1 00 000	75 000	25 000
Fibre board, t	1 14 000	90 000	24 000
Asbestos cement products, t	8 00 000	7 00 000	1 00 000

The major works are in the public sector. Construction equipment can be used on big projects and major works, but these are divided into small parts to get more contractors. So, the small contractor uses manual labour or some outdated second-hand equipment. Since even major construction agencies, public or private, use subcontracting, use of updated new equipment becomes a problem.

There is so much change in construction equipment technology overseas. But, in India the construction sector has no say. Equipment is selected and forced on the Indian manufacturers. There is no coordination among them to consider the supplementary equipment needed with each major equipment. Nobody knows what is the demand of equipment in the country for irrigation, transport, tunnels, housing and other infrastructure sectors. It is high time some action is taken on this. It is difficult to get any correct data as long as construction sector remains unorganized and not recognized as an industry.

The construction equipment manufacturers have to plan their policies and management to develop technology, upgradation, development auxilliary industries to get it with quality parts and components, increase production, improve quality to suit overseas competition and be ready to face the challenges of growing construction sector in India. The National Highways have brought in more equipment manufactured in India.

Another problem is the human resources development plans to go along with needs of the construction equipment manufacture and management sectors, use, selection, operation, maintenance and development. This is very much lacking.

CONSTRUCTION MATERIALS

Construction materials form about 45%-65% of construction sector investment. It is not seriously considered for development at the national level. There used to be shortage of cement, steel, timber and other materials. But, now the position has changed and there is improvement in the availability of these materials. But, items like brick, aggregates, sand, earth and other connected materials which need great attention for price control and quality control. If an analysis is made of the requirement of materials during the Plan period and proper assistance is given to the manufacturers of building materials through the financial institution proposed to be set up for the construction sector, it will do a great service to the country. This will not only improve the quality of construction but also bring down the cost.

A great deal of attention is now being paid by HUDCO and state Housing Boards on soil-cement and mud technology. Another aspect is the use of local materials and building materials manufactured by waste and natural resources of the area. But even though the research stations of the Government of India and State Governments do a lot of work, the implementation is a problem. The State Governments do not include these in their schedules. The specifications do not change as it should.

Another problem is energy saving in the manufacture of cement and burnt bricks.

CONSTRUCTION TECHNOLOGY DEVELOPMENT

Unfortunately, except for the small exposure that India has got in oversea markets, there is not much of inflow of modern technology in construction. The arrival of the World Bank has brought in some overseas construction organization into the country and brought in some new technology. There is no organization within the country which is making any research or analysis of the type of technology required for the country taking into consideration that it should blend properly with the employment potential also. Small contractors and rural construction agencies are the real back-bone of the construction sector in the country. They do not have access to the technology development which may be highly relevant to the operations at this scale. It may be worthwhile to consider setting up of a special cell for R&D in technology development.

The new technology involves mechanization. But, great care has to be taken about employment generation, the advantage of speed, quality, productivity and use of machines. But use of high technology and mechanization gives the infrastructure a faster growth and in cost benefit manner it is worth considering. Even on manual work, mode of technology could be improved so as to get better quality and productivity.

India, about 10 years ago was not using cement pumps, belt conveyors, canal lining, road making equipment, tunnel equipment and other sophisticated technological developments. Construction equipment is capital intensive. It needs a great planning and management and steady and continuous work. On concrete dams, the Indian construction sector has been using sophisticated equipment since long. On marine works also there is improvement. On bridge construction and prestressed concrete works there is development.

Hence, technology development has to take many sound economic and political decisions as indigenously developed or imported. But, the technology improvement is needed for the Indian construction sector to compete in overseas projects. There is still lot to be done on this aspect of cost effectiveness and management.

MANAGEMENT OF MAJOR PROJECTS

It is observed that most of the projects are delayed, costs go up, quality assurances lacking and problems arise during execution. This matter has received enough attention of the various departments and a number of committees have gone into the details.

Recently, a Working Group of the Planning Commission also went into the details and recommendations on the study of the existing practice and problems on projects.

01. Investment decisions should be taken only after thorough investigation, data collection, analysis, preliminary evaluation of alternative technologies, detailed evaluation of the selected technology, estimation of time and cost based on factual data rather than optimism.

02. These investigations must lead to a realistic assessment of local resources, materials, plant and machinery, supporting engineering infrastructure, unskilled and skilled labour, training needs, geographical distance of the project site from the resource centres, facility for transportation of men, materials and machines, climate, day-long hours, working season, etc.

03. Besides its primary objective, a major project must enrich the environment by creating better sanitation and health facilities (health centres/hospitals), drinking water, good housing, education and training centres, community centres, shopping complexes, parks, etc. It must not discharge harmful effluents or exhausts.

04. After the first stage of clearance, the following advance actions should be taken by the project and administrative authorities:

Land acquisition, resettlement plans, securing all , clearances including financial, environmental/ecological for resolving environmental, ecological and resettlement issues public debate, if, considered necessary, clearance and scheduling of interlinked projects, identification of and tie-up with the main technology consultant, identification and positioning of the core project team; preliminary design and engineering, inviting tenders for main long-lead materials inputs, creating/augmenting preliminary infrastructure facilities for construction (power, water, roads, railways, etc).

05. Detailed technical and financial planning must be complete and availability of resources and allocation of funds should be ensured before commencement of the work.

06. Some of the projects staff may require training, which must be organized in advance. Continuity of staff should be ensured. Project leader and key staff must not be changed mid-stream.

07. Technology consultants should be associated with formulation and planning from the earliest possible stage.

08. Time cost quality (TCO) balancing techniques should be used to optimize the total execution plan.

09. Bids major projects should be invited in two or three envelopes.

(i) Technical bid

(ii) Commercial comments about the contract conditions, special conditions desired to be incorporated, etc.

(iii) Price

10. A central decision-making body on construction should constitute a broad-based committee to study various departmental procedures and accounting manuals and bring out a model standard procedure manual for general use. There should be separate chapters for major construction sectors like irrigation, road, power projects, etc. The procedure should be fair, objective and simple. The manual should be revised every three years.

11. The new manual should include special or modified (simple) procedures for execution of construction works in rural areas permitting/encouraging less experienced local contractors and workers cooperatives to execute small, simple works with increased technical input in the form of design and supervision from Government engineering departments

12. Handbooks incorporating the latest developments in the field of concrete, steel structures, road works, embankments, bridges construction, etc should be brought out.

13 Technology: For every large project, selection of technology should be based on a judicious balance between employment generation on one side and automation and mechanization for quality on the other. A total system cost-benefit analysis should include:

(i) All inputs and activities. direct and indirect;

(ii) realistic assessment of social and environmental costs;

(iii) making the quantum and timing of production of the project facilities with other related facilities existing or under development and construction;

(iv) opportunity cost and benefit:

(v) safety and health aspects.

These have been studied in some detail, as the project management is very much low and the result is that almost all projects are delayed, cost going up and quality and environmental aspects at stake. The owners and the Government who start these projects have to manage projects well fromInitial stages.

SAFETY, HEALTH AND WELFARE OF CONSTRUCTION WORKERS

Safety, health and welfare of the construction workers need greater attention as most of the construction workers suffer from lack of these.

01. Construction continues to be an accident and injury prone sector due to the nature of work, but also due to the difficulty in. implementing the safety regulations at scattered, sometimes remote construction sites, the nature of work, temporary or seasonal employment and changing work sites also make it difficult for the construction workers to get full benefits of health schemes. A separate, carefully drafted legislation and scheme will be required for ensuring proper safety and health benefits reach the construction workers.

02. The legislation on construction safety and health should grant mandatory status to the Bureau of Indian Standards and Safety Standards for Construction Works.

03. It should provide for the appointment of safety officers with recognized qualifications.

04. Schemes like provident fund and gratuity or bonus will have to be designed to take care of employment in broken periods and at different sites.

05. Broken periods with one employer, even if it is on different projects must be' aggregated as continuous service for counting of leave entitlement and welfare benefits. A new system of record keeping with provision of at least one cross check will have to be designed and implemented by the Government, as the private contracting sector is very unorganized.

06. If hygienic living conditions with minimum protection against weather cannot be arranged near the construction site, transportation between the work site and workers' camp should be catered for.

07. Productivity should never be divorced from welfare. Besides welfare and man management, training and skill development must be taken care of

08. On the job training should be available to promising unskilled workers for upgrading their level of employment.

09. At least for some of the construction trades, on the job training will have to be supplemented by more formal skill development in the training institutes/apprentice schools.

10. There should be a Construction Industry Training Board (on the UK model) under the DGET in the Ministry of Labour.

11. For trades training construction companies must not look up to the Government, though guidance, coordination and some assistance in setting up the institutes may be provided by the proposed CIDB. Construction trades training institutes should be at large projects and elsewhere near load centres of construction activity or tradesmen recruiting areas.

12. There will have to be a few other training institutes for the training of trainers.

13. Private construction companies, institutions like BAIOCCI, etc manufacturers of construction material banks and trades union-all should Join together to create trades training institutions.

CONSTRUCTION PROJECTS EXPORTS

Unfortunately, the construction sector is not able to export as it did a few years ago. Competition has increased in almost all countries. Very few countries in the Gulf region are open to Indian exports even where there exists stiff competition. Our productivity levels and management of projects need greater improvement if we have to be economical and face competition. Further, there are problems of financing. There is also the problem of trained personnel. Indian construction equipment and materials should be made available at better quality control and price control to assist the construction sector to be more competitive. The task force set up by the Government of India has recommended that it is necessary that the domestic construction sector need to improve to be competitive.

Further, the Conference and the Working Group of the Planning Commission recommended: 'The construction sector has to give much greater attention to the marketing of projects, improving competitive abilities of the exporters an making bid prices competitive. The data and the information systems to be improved. Indian companies should form consortiums, joint ventures with over sea construction firms.

. Technology development is to be made aware to the officers and workers. Rationalization of fiscal, financial and taxation measures to make Indian bids more competitive. The overseas Construction Council needs support and strengthening. The pros and cons of permitting new estate business in foreign countries are also to be examined.

It is expected that the Indian construction sector would get the opportunity of working in the USA and the UK firms in Kuwart and other Gulf countries. Russia has given some work to Indian construction industry. Far East, Indonesia, Thailand, Malaysia also are open to the Indian construction sector. So with more efforts and initiatives, Indian exports in construction should improve.

CONSTRUCTION SECTOR TO BE PREPARED TO FACE FUTURE

The changes in the environmental conditions of the country in political, economical, social and other matters make different demands on the construction sector. Construction sector being of importance to improve the standard of living of the people, there is a demand on this sector to be more active, faster, quality work and

timely execution. People will not accept the way the construction sector is performing now. There are vast changes in the country in areas of natural resources, energy, decentralization of planning and authority. urbanization, uplift of villages, literacy drives, rehabilitation and environmental problems on projects, equity and project exports.

Further, the people are made aware of changes and developments all over the world by communication and information systems, Doordarshan and other media. All these will have an effect on this sector's performance.

There is shortage of land and water and clean air. Increasing scarcity of these natural resources will require large projects on selective basis. These will be capital intensive, hiqh-tech and high skill and higher quality.

Due to decentralized planning and Government authority going to district, Zilla Parishads, and village c..uncus, the construction works taken up by these will be many, but smaller in volume. The construction sector has to make itself ready to tackle these in a better manner.

Urbanization is increasing. The housing, water supply electricity, transport and other infrastructures will need a hanged approach.

Many of the housing structures, bridges, dams, roads, etc are in distress and need rehabilitation, reconstruction and careful maintenance. This needs a much better financial and technological approach than at present by the construction sector.

People from projects need better care and better rehabilitation. The ecology environment and deforestation problems connected with projects are becoming more complex. So, planning and execution has to change.

Projects should consider training of displaced persons for their betterment. This is not yet done, but demands do exist.

The Government should have better political and inter-governmental relations to improve on project exports. The construction sector has to improve its productivity and management to become competitive.

Financial institutions will have to change their approach to the construction sector. This is also coming in.

There has to be awareness and training in technology and management. This is being followed on World Bank projects at its instance. This has an effect on others also.

Trades and skills needed in the construction sector also to change in technology, construction material and equipment is already felt and the department has to take actions to improve this.

These are some of the demands on the construction sector which are to be considered in coming years.

SOME IMPORTANT ACTIONS ESSENTIAL FOR CONSTRUCTION SECTOR

Since 1960, several issues that affect the construction sector have been discussed at Government levels, the Planning Commission, the Institution of Engineers (India), the Builders' Association of India, and other professional organizations. But nothing concrete has happened yet. These have been again pressed recently:

(a) Ministry of Construction

The construction sector is being dealt by many departments and public sector organizations and private, and audited in their own different ways. There should be a standard common guidelines and principles laid down. There should be a national policy and strategy for the construction sector. For these matters a Ministry of Construction is needed. It need not execute the projects, but each department does it, but the policy has to be laid down by the Ministry of Construction.

(b) Construction Industry Development Board at Centre and States

This Board has been tried in other countries. It serves the construction sector well. It acts with the involvement of private sector. The Board would devise multi-pronged strategies connected with the construction sector. Policies including the national housing policy, financial policy, quality, consultancy, transfer of technology, training of skills in trades, etc. The Board could be at Centre and State levels.

(c) Construction Development Bank

As at present, there is no financial institution to finance construction works by private/public bodies. It is desired that there has to be a bank for the construction sector, construction-materials, equipment, advance on contracts, etc should be considered.

(d) Construction to be Declared as an Industry

Construction is managing resources to produce a product. Its share is so great in the country. It is yet to be recognized. A proper licensing of construction contractors is needed. It is desired in some areas that the

construction sector is to be declared as an industry so as to make it more organized and disciplined, even though there are problems as stated earlier.

(e) Construction Industry Training Board

There are no serious efforts made to train the engineers, construction supervisors and technicians in construction trades. It is desired to have a Construction Industry Training Board. This has been tried in other countries and found very effective.

(f) Fair Contract Document

Most of the construction work either in Government, public sector or private is carried out on a contract. So, the contract agreement becomes an important document Contracts also include specifications, designs, plans, schedules, maintenance, workers" welfare and safety, etc. It should also take care of price adjustments due to inflation and government actions. The contract should have a fair dispute settlement arrangement. It should be fair and equal to both sides. After the World Bank entered the construction sector in India, there is considerable improvement in project contracts. But in small works rural construction and other works associated with World Bank projects and other departments, not enough has been done all over India. This needs attention.

(g) Construction Technology and Equipment

There is so much talk about these matters, but not much of interaction between R&D stations, equipment manufacturers and designers, consultants, contractors and Government departments to arrive at proper technology and methodology. This matter is of utmost importance both for domestic construction sector as well as export of construction.

(h) Planning Commission's Role

The Planning Commission has considered the construction sector as an important sector and gave enough attention. It should have a separate chapter in the Plan Document to study the problems and enunciate the strategies and actions to achieve results.

(i) Overall Policy of the Government

The World Bank, after studying the construction sector, has to say: First, the Government needs to be committed to develop the industry, adopt measures that are needed to solve specific problems and constrains and introduce reforms in policy and procedures to improve the business environment of the industry.

Secondly, the inputs of specialized technical assistance required, need to be more comprehensive and apply not only to construction enterprises, but also to administrators and supervisors of Government projects and the banks that provide financial support to the industry.

Third, considerable effort is required, over a protracted period, to achieve the required results, particularly in civil engineering part of the industry.

Fourth and most important, a comprehensive strategy is required to support the construction sector to integrate efforts channelled through the various sections which make use of or contribute construction activities.

Marking the construction industry competitive should be set as an important objective of Government's development policy.

CONCLUSION

It is observed that the construction sector is an important factor in national development. It helps to improve the standard of living of the people of the country by providing infrastructure and facilities. There are many problems but not much attention has been given as necessary. It is desired that all connected with national development give the necessary importance and attention to this sector so that it could act better in the cause of national uplift and the uplift of the standard of living of the people.

The Fifth Dr Ajudhia Nath Khosla Memorial Lecture was delivered during the Seventh Indian Engineering Congress, Bangalore, February 13, 1993

Water Resources Development and Management in 2025 AD — a Perspective

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Formerly Chairman. Central Water Commission and
Ex-officio Secretary to the Government of India

I feel greatly honoured on being invited to deliver the Fifth Dr A N Khosla Memorial Lecture today on the occasion of the Seventh Indian Engineering Congress being held in this beautiful garden city of India. Selection of this city for this occasion is a befitting tribute to a great engineer-statesman of India who delivered the Sixth Sir Mokshagundam Visvesvaraya-another engineer statesman of India-Memorial Lecture at the 43rd Annual Convention of the Institution in 1963. The subject matter of the lecture chosen by Dr A N Khosla was 'Plan for Integrated Development of River Basins with Particular Reference to Orissa', a subject which was very close to his heart. In this context, when the country is stepping into the 21st century requiring to face challenges to provide food and fibre to the growing population, the theme of today's lecture assumes relevance.

INTRODUCTION

Demand creation and supply of any resource for human needs always assume new dimensions with the changing situation. Since these seldom attain fixity, it requires constant re-evaluation and assessment in all these spheres to ensure appropriate use of the resources. The results of such an evalutaion may demand modification or thorough change of technologies deployed in resource enhancement, use and management. In case of water resources, as for that matter for every resource, the goal ultimately is not merely sustaining the life going process, but also to improve the same to desired higher levels. As for evaluation of water resources development and management practices , the parameters chosen comprise (i) the resource generating concept and methods, (ii) current level of demand as emanating from the past and existing pattern of development and management, a! d (iii) future demand patterns as projected from the current situation. This framework is basically based on the comparative assessment; but an element covertly underlies the evaluation and which is also a comparative one between what have been achieved so far and what could have been achieved.

RIVER BASINS

The country which has a geographical area of 3.22 Mkm^2 has 20 broad river basins as shown in Fig 1. Having extremes of climate, the country experiences an average annual rainfall of as low as 310 mm in West Rajasthan and as high as 3 292 mm in coastal Karnataka. The average seasonal rainfall (June to September) in these two regions is 275 mm and 2 886 mm, respectively which accounts for about 88% of the annual average precipitation. Table 1 gives the annual average seasonal rainfall in the different meteorological sub-divisions of the country. Nearly 40% of the area of the country is semi-arid (rainfall between 500 mm and 1000 mm).

WATER RESOURCES

Surface Water

Way back in 1949, Dr A N Khosla estimated the surface water resource for all the liver systems in the country as 167.3 Mha-m. The estimation was based on empirical relationship. Since then. the assessment of the average annual water endowment has been attempted by different authorities and organizations adopting various methods. The variation of 10% of the present day estimation of 185.35 Mha-rn speaks for his vision. It is to be kept in view that all the available surface water potential cannot be utilized from consideration of economic viability, variation in space and time, dependability of occurrence, etc. A maximum of about 70 Mha-m of the available flow can be usefully utilized.

Ground Water

Equally important is the ground water resource in supplementing surface water resource. Ground water utilization apart from controlling waterlogging, salinity and alkalinity, also helps to meet shortfall in irrigation demands, municipal water supply and industrial requirements substantially. The ground water potential has been estimated as 45.23 Mha-m. Ground water is a dynamic resource and, therefore, regular updating of the potential and monitoring the quality of water is necessary.

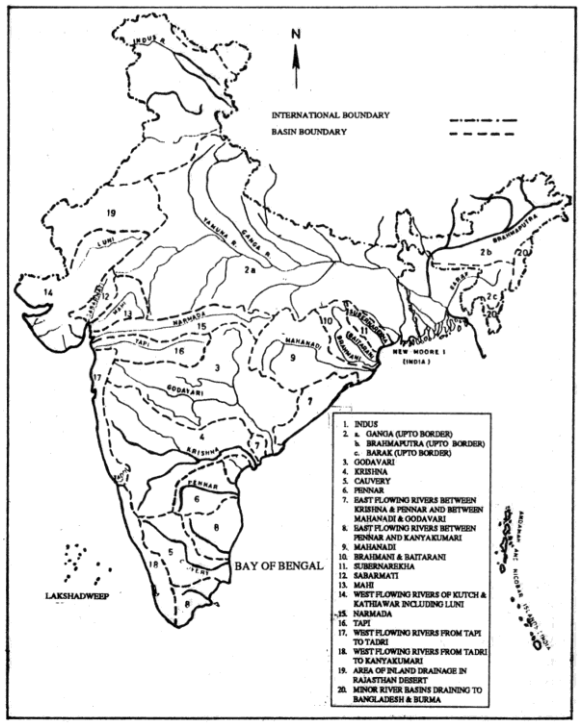

Fig 1 River basins of India

TABLE 1
AVERAGE ANNUAL AND SEASONAL RAINFALL IN DIFFERENT METEOROLOGICAL SUB-DIVISIONS OF THE COUNTRY

Sub-Divisions	Average Annual Rainfall, mm	Average Seasonal Rainfall, mm (June – September)
Arunachal Pradesh	2 997	2 085
Assam & Meghalaya	2 497	1 624
Nagaland, Manipur, Mizoram and Tripura	2 314	2 092
Sub-Himalayan West Bengal and Sikkim	2 779	2 172
Gangetic West Bengal	1 429	1 079
Orissa	1 484	1 143
Bihar Plateau	1 371	1 125
Bihar Plains	1 204	1 023
Uttar Pradesh East	1 014	893
Uttar Pradesh West	836	726
Hills of West Uttar Pradesh	1 750	1 409
Haryana	556	463
Punjab	611	467
Himachal Pradesh	1 518	993
Jammu and Kashmir	997	458
Rajasthan West	310	275
Rajasthan East	700	647
Madhya Pradesh West	1 043	945
Madhya Pradesh East	1 398	1 227
Gujarat Region	967	920
Saurashtra and Kutch	515	479
Konkan	2 881	2 705
Madhya Maharashtra	940	788
Marathwada	794	660
Vidarbha	1 102	960
Coastal Andhra Pradesh	1 008	572
Telengana	931	759
Rayalseema	676	367
Tamil Nadu	1 007	301
Coastal Karnataka	3 292	2 886
Interior Karnataka North	685	447
Interior Karnataka South	1 271	868
Kerala	2 978	1 958

Source : India Meteorological Department, New Delhi
Note : Does not include the islands of Andaman and Nicobar and Lakshadweep

Other Sources

There are relatively insignificant quantity of lake waters which can be beneficially harnessed to meet local demands. Systematic investigations will be necessary to quantify the contributions of snow-melt to the annual surface flow in the Indo-Gangetic rivers.

The basis on which the utilization quantities have been estimated, needs to be reviewed with the availability and advancement of knowledge in hydro engineering and hydrometeorological services.' Innovative application of technology for enhancing the utilizable resources needs be evolved through research and experimentation.

CURRENT LEVEL OF DEVELOPMENT

Development of water resources in a large scale was taken up in the post independence period. Prior to this, during the pre-independence period, the emphasis used to be given for developing water resource only as a protective measure against crop failure and famine. In the post-independence era, emphasis was changed to develop water resources as one of the main productive inputs in agriculture, hydro power and industries, in addition to meeting the human and livestock requirements.

A reference to Table 2 indicates that the live storage capacity of the existing and under construction reservoirs would be about 23.92 Mha-m (assuming that reservoirs under construction would be completed by 2000 AD). Adding about 3.2 Mha-m, which is available from medium reservoirs of less than 10 Mm^3 capacity and minor irrigation tanks, the total storage would be about 27.12 Mha-m. Accounting for evaporation loss of about 7.12 Mha-m, the net storage available would be 20 Mha-m.

In course of only four and half decades, the amount of cumulative storage that could be created by projects completed and under construction is only 12.9% of the average annual flow. When envisaged storage is achieved, the total would stand at 20% of the average annual flow of the country. This points to the efforts, technology, finance, manpower, etc to be required to develop the water resources to the desired level. Therefore, there is urgent need for a review and preparation of a perspective plan for sustained irrigation needs to about 80 Mha to grow food grains to the time of about 200 million towns by 2000 AD, besides domestic and industrial water supply and energy requirement.

Similarly, Table 3 provides the picture of basinwise ground water resources and development. Ground water exploitation also has remained much lower; only 23.6% of the total resource of the country, though sectoral development has gone upto 79.3 % as in the Indus basin. As in the case of surface water, whose development is

constrained by topographical factors, exploitation of ground water is also conditioned by the geographical, geomorphological hydrogeological constraints, since favourable aquifers holding exploitable ground water are not uniformly distributed throughout the basin. Also, due to inadequate legal provision regarding exploitation of this precious resource, there is disturbing trend of over exploitation (over 85% of the potential) in some areas termed as 'dark areas'. The usual classification being exploitation below 65% is termed as 'white areas' and that between 65% to 85% is termed as 'grey areas.' The situation becomes very critical in drought years due to scanty re-charge of aquifers. Therefore, careful studies and micro-level investigations would be necessary before exploitation of ground water in grey and dark areas are taken up. Modem tools of ground water modelling studies are very helpful to ascertain the ground water table rise/depletion particularly in dealing with multiple layer aquifers, their characteristics, leakages and infiltration behaviour not only due to precipitation but also due to introduction of canal irrigation resulting in different soil-moisture regime.

TABLE 2
SURFACE WATER RESOURCE

Name of the Basin	Average Annual Flow	LIVE STORAGE CAPACITIES			
		Completed Projects	Project Under Construction	Total	Projects Under Consideration
Indus	73 305	14 523.80	2 453.55	16 977.38	14.95
Ganga	501 643	37 405.57	16 790.07	54 195.64	28 613.68
Brahmaputra and Barak	596 867	1 094.46	2 711.80	3 806.26	63 347.84
Godavari	118 982	17 270.10	11 549.04	28 819.14	7 428.66
Krishna	67 790	32 232.66	4 470.20	36 702.86	526.99
Cauvery	20 957	7 253.21	420.72	7 673.93	342.69
Pennar	6 858	2 374.34	139.69	2 514.03	–
East flowing rivers from Mahanadi to Godavari and Krishna to Pennar	169 48	1 248.95	1 448.18	2 697.13	1 137.14
East flowing rivers between Pennar and Kanyakumari	17 725	1 416.71	24.25	1 440.96	—
Mahanadi	66 879	8 926.26	4 623.91	13 550.17	11 723.91
Brahmani and Baitarni	36 227	4 287.86	120.09	4 407.95	8 721.19
Subernarekha	10 756	475.55	1 671.15	2 146.70	1 658.86
Sabarmati	3 812	1 300.22	121.99	1 422.21	23.22
Mahi	11 829	4 157.31	365.81	4 523.12	11.33
West Flowing Rivers of Kutch, Saurashtra including Luni	15 098	3 585.79	5 265.59	4 111.38	1 726.25
Narmada	40 950	3 022.79	19 942.64	22 965.43	236.56
Tapi	18 000	8 683.46	395.61	9 079.07	2 013.59
West Flowing Rivers from Tapi to Tadri	108 618	2 947.01	6 625.20	9 572.21	704.63
West Flowing Rivers from Tadri to Kanyakumari	89 250	10 257.46	2 310.79	12 568.25	1 702.57
Area of Inland Drainage of Rajasthan	—	—	—	—	—
Minor River Basins Draining into Burma and Bangladesh	31 000	—	—	—	—
Total, Mm^3/s	1 853 494	162 463.51	76 710.28	239 173.79	130 964.06
Mha–m	185.35	16.25	7.67	23.92	13.10
Reservoirs with live storage capacity of	Mcm	8 800	1800	10600	
less than 10 Mm^3	Mha–m	0.88	0.18	1.06	—
Minor Irrigation	Mcm	21 400	—	21400	
Tanks	Mha–m	2.14		2.14	—
Grand Total, Mm^3	192 663.51	78 510.28	271 173.79	130 964.06	
Mha–m	19.27	7.85	27.12	13.10	

Source : 'Water and Related Statistics'. Central Water Commission, 1990.

TABLE 3
BASIN-WISE GROUN DWATER RESOURCES POTENTIAL

Basin	Total Replenishable Ground Water Reservoirs, Mha-m	Provision for Drinking, Industrial and Other Uses, Mha-m	Utilizable Ground Water Resources for Irrigation, Mha-m	Net Draft	Balance Ground Water Potential Available, Mha-m	Level of Ground Water Development, %
Indus	2.55	0.39	2.16	1.72	0.44	79.3
Ganga	17.17	2.58	14.59	4.49	10.10	30.8
Kutch Composite & Saurashtra Composite	1.39	0.25	1.14	0.45	0.69	39.7
Cambai Composite	0.79	0.12	0.67	0.20	0.47	30.2
Narmada	1.19	0.18	1.01	0.16	0.85	15.4
Tapi	0.82	0.14	0.68	0.18	0.50	26.2
Subernarekha	0.22	0.03	0.19	0.02	0.17	8.9
Brahmani with Baitarni	0.59	0.09	0.50	0.03	0.47	5.2
Mahanadi	2.13	0.32	1.81	0.08	1.73	4.3
North East Composite	2.28	0.34	1.94	0.26	1.68	13.5
Godavari	4.68	0.73	3.95	0.59	3.36	15.0
Krishna	2.66	0.43	2.23	0.65	1.58	29.1
Pennar	0.50	0.08	0.42	0.14	0.28	31.6
Madras Composite and Tamilnadu Composite	2.09	0.31	1.78	0.82	0.96	45.9
Cauvery	1.36	0.20	1.16	0.52	0.64	44.7
Western Ghat Composite	1.83	0.29	1.54	0.30	1.24	19.6
Brahmaputra	2.79	0.42	2.37	0.05	2.32	2.1
Meghna	0.18	0.03	0.15	0.05	0.15	3.2
Total	45.22	6.93	38.29	10.68	27.63	

Two more aspects are also vital in connection with water resources development. These are: (i) hydro power, and (ii) flood control. While the former is directly derivable from water, the latter is related to control and appropriate management. The latter is also directly related to the mode of development of water resources. In Indian situation, where intensity and spread of rainfall are concentrated in three to four months only, creation of flood cushioning in storage reservoirs becomes a primary method of abating hazards of floods.

Development of hydro power rose from an almost insignificant quantity in the post-independence period to as much as 8 500 MW at about 60% load factor (total installed capacity being 18 700 MW). This is about 28.8% of the total aggregate installed capacity from hydro, thermal, nuclear and non-conventional, sources. The achievement is quite formidable, but the task ahead to harness more hydro power is still uphill. For, the untapped sources are located mainly in the Brahmaputra and Ganga basins and their development is beset with difficult geographical constraints, besides the problem of long distance transmission. Most of the multipurpose projects of the country were designed with hydro power as one of the components. This is borne out by the fact that intensity of regional development of hydro power corresponds to regional surface water development. With the growing demand of power, the Eighth Plan has laid more emphasis on the development of hydro power. The aim is to bring the power scenario a 40:60 mix of hydro power and thermal power generation including nuclear and other power sources.

One of the aspects of successful water management lies in abating the negative influence of overland flow which causes land erosion, silting up of river channels, and water bodies resulting in the process widespread bank overflow and floods. Flood control and moderation requires creation of large scale flood cushioning in reservoirs, diminishing flood left by routing. Such management besides other measures are required to protect

40 Mha of land which are flood prone. The measures taken so far have been able to benefit only, 13 Mha, though flood propensity and intensities having upward trend require much more efforts for mitigation.

PATTERN OF WATER DEMANDS-EXISTING AND EMERGING

Of the different uses of water, agricultural practice by way of irrigation has the lion's share, being nearly 80% of its cumulative use. Before planned development started in India around 1950, there was hardly any organized supply system to different users, except limited irrigation, a few urban supplies are fewer industrial supplies. Commensurate with the development activities in water resources, the food production recorded a sharp rise from nearly 50 Mt in 1950 to 175 Mt in recent time (1989-90). This rise follows parallely the increase in irrigated areas from about 22.6 Mha to 71 Mha (against a created potential of 79 Mha) by end of the Seventh-Plan. Water supply for human consumption and livestocks could be provided to about 85% of the rural population and 90% to urban population following the developmental activities. Hydro power production increased by about 35 times during the period from mere 500 MW to 18 000 MW.

The present level of water utilization in different sectors is as below:

Category	Surface water, Mha-m	Groundwater, Mha-m	Total, Mha-m
Domestic	1.10	1.40	2.50
Irrigation	30.00	16.00	46.00
Energy	1.90	—	1.90
Industries	1.50	—	1.50
Others	1.70	1.60	3.30
Total	36.20	19.00	55.20

Note : 1. Energy requirement includes thermal and nuclear power stations and evaporation loss from storages of hydro ponds.
2. Other utilization includes navigation, pisciculture and recreation.

A distribution diagram showing how this requirement would be made up is given in Fig 2.

It is clear that the future demand in 2000 AD will be much within the assessed utilizable water resources and will be marginally less in 2025 AD. The demand projection made is almost in linear proportion with respect to the present pattern of demand and may be drastically different in reality. In that event surface water resources availability may not be adequate enough to meet the demands.

The scenarios presented above relate to the utilizable resources as conceived in the perspective of the available technology and mode of their utilization.

Redeemingly the gross resources are much more than the estimated utilizable quantity and in every possibility can be enhanced with improved technology and innovation and changed approach. This takes us into the domain of development and proper management.

FUTURE DEVELOPMENT AND MANAGEMENT

At the outset, the framework for evaluation the developmental activities were putforth, viz, comparative assessment of what has been achieved and what could have been achieved. The data presented and analyzed, in brief, in the foregoing paragraphs unquestionably point out to the tremendous achievements made in the post-independence era in all spheres where water is used as a means to ultimate end. But at the same time these also indicate some very obvious and noticeable gaps in the field of assessment of resources and in the scale and dimension of development. Water resources development, mode of their use and management are beset with variables and uncertainties which are mostly unpredictable and require understanding of the underlying causes of gaps and learn lessons therefrom.

The nature and pattern of availability of water clearly bring out that unless the resource is 'stocked' at the time when it is available in appropriate quantity, it looses the very meaning of resource and utility. The concept of storing and conserving water in large reservoirs sprang from this fact and rightly so. The demand pattern in time frame and space strongly supports the unavoidable measure for storage conservation.

Perhaps a little change of approach is necessary at this stage on the basis of lessons learnt. The nature of storage, as propounded by some exponents in the form of artificial recharge of groundwater, small reservoirs, ponds, side channel storage. terminal storage. etc and conservation by proper watershed management. modifying land use pattern. etc assume new meaning. No one method can independently be taken and applied as alternative to others. Other forms of storage or conservation methods suggested as alternative to artificial reservoirs behind dams require a back up system for their success.

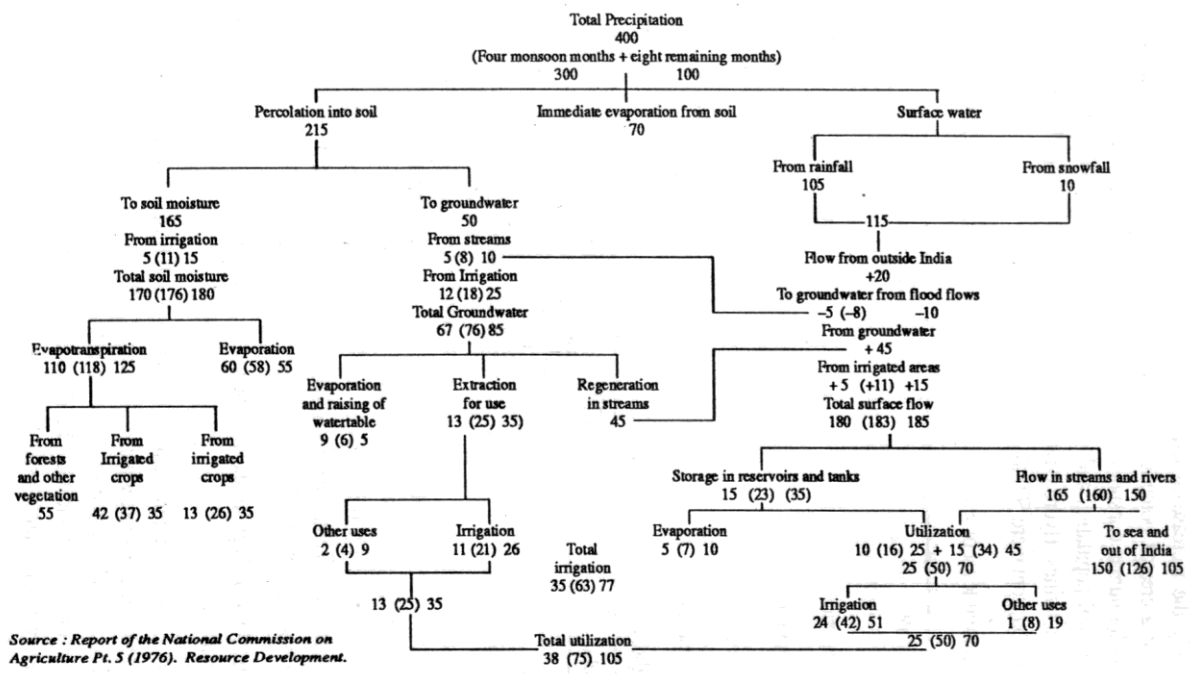

Fig 2 Approximate distribution of average annual resources of India as in 1974 (2000 AD) 2025 AD

Category	2000 AD		2025 AD	
	Surface water, Mha-m	Ground water, Mha-m	Surface water, Mha-m	Ground water, Mha-m
Domestic	1.40	1.90	1.80	3.40
Irrigation	42.00	21.00	51.00	26.00
Energy	2.70	—	7.10	—
Industries	3.00	—	9.00	3.00
Others	0.90	2.10	1.10	2.60
Total	50.00	25.00	70.00	35.00

NATIONAL WATER POLICY

In the context of water resources management perspective. a mention about the National Water Policy adopted in 1987 is relevant. In the planning of operation and management of the water resources. water allocation priorities. viz,

- Drinking water supply
- Irrigation
- Hydropower
- Navigation
- Industrial and other uses

is desirable. However, there could be some modification in the inter-se priority keeping in view regional imbalances.

In this connection, some of the important aspects of national importance for a better water management policy also merit serious consideration.

- Recycling and re-use of water
- Regular monitoring of quality of water (both surface and groundwater)
- Rational water bills
- Rational operation and maintenance cost provision
- Training of in-service engineers (middle and top levels) to bring them abreast with latest advances in science and technology as relevant to water resources management.

CONCLUSIONS

On the question of development and management of water resources as practised some broad conclusions can now be drawn:

- In order to reduce degradation of watershed and increase productivity of land. there is need for accelerated activity in the vulnerable watersheds of all reservoirs in operation and under construction.
- It is difficult to operate a major multipurpose project catering to different priority areas such as municipal and industrial water supply hydro power in addition to meeting irrigation needs. In order to plan optimal operation of the system in deficit flow years, which is the real test of good management, development of computer aided simulation models based on historical flows is essential.
- Review of the concept of large storage approach often propounded on the basis of taking 'gap' as synonymous to 'failure' in favour of alternative or substitution of the existing practice is not generally acceptable. However, a well planned strategy of conjunctive use of surface and ground water will be the right approach.
- Due to over-exploitation of coastal aquifer there is a tendency of salt water ingress. This needs to be checked through proper study and legislation.
- Water table often gets depleted in successive drought years. Studies are necessary to maintain water table at manageable depths by encouraging water harvesting techniques.
- Due to unscientific management of water resources in the past 50 years, the country is facing problems of waterlogging, salinity, and alkalinity of soils, drainge congestion, water pollution and deterioration in the quality of water, besides other environmental hazards. It is imperative to reverse this trend by adopting proper environment management studies.
- The future development plans have, of necessity, to be flexible so that they can induct simultaneously in their schemes such alternatives which will help in closing the gaps by eliminating avoidable losses of the resource and helping in conservation.
- A quantum jump in water resource mobilization in India indicates tremendous efforts in the 'means enhancing' process 'which, to a great extent, has been possible through creation of large storages of water, conserving it from running to waste.
- Pattern, variation and dependability of the main source of water, that is, rainfall, strongly points towards the concept of reservoirs in having carry over storage.
- Evaporation loss from the water surface of the reservoirs is very high. Besides chemical retardants, substantial evaporation loss can be minimized if appropriate reservoir operation rules are developed, as evaporation loss is a function of water spread.
- When analyzed under appropriate framework, it brings out the obvious fact that there exists wide gaps in the desired 'end enhancement' results. The gaps are also pointed to the necessity of bringing about perfect conjunction of development and management practices through active participation of CADA, the agriculture departments, and the beneficiaries, ie, the farmers.
- It is to be admitted that the major problem in basin planning is not where to send the water, but is how much and at what time. This can be achieved by introducing management information system.
- There is need for establishing a network of efficient telecommunication system in major water resources projects which will help in achieving efficient use of water and conserving the same.
- Vast areas of the country is drought prone. Attention is required to be given to these areas so that irrigation facilities are provided to these areas for successful agriculture.
- Last but not the least, a perspective of water development and management is not complete without looking ahead of future planning. Our next generation will be facing a huge task of feeding an estimated population of 1 530 millions by 2025 AD.

It is estimated that the surface water demand would be about 70 Mha-m and the ground water demand about 35 Mha-m by 2025 AD. This goal can be achieved by adequate river basin planning, resorting to inter-basin transfer and establishment of a river basin development authority, as envisaged in the National Water Policy.

Dear friends and technocrats, let us rededicate ourselves to this huge task with firm footsteps in the sands of time in this Centenary Year of Dr A N Khosla.

Thank you.

The Sixth Dr Ajudhia Nath Khosla Memorial Lecture was delivered during the Eighth Indian Engineering Congress, New Delhi, January 03, 1994

Necessity of Caution in Reporting Investigations far Water Resources Projects and their Environmental Impact

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HOMAGE

I feel greatly honoured on being invited by the Institution of Engineers (India) to deliver the Sixth Dr A N Khosla Memorial Lecture today, on the occasion of the Eighth Indian Engineering Congress in the capital city of India. Dr Khosla remained associated with the investigation, research, development and management of water resources from mid-twenties to mid-sixties of this century in different capacities. I came in contact with him when he was the Chairman of the Board of Consultants of projects in the Yamuna valley. We were impressed by his foresight, taking right decisions for technical problems and interpreting investigation results presented to him in the most appropriate and practical manner. He laid great emphasis on correct investigation and applied research, which are the foundation for successful implementation of water resources projects. He verified the practicality of all investigations before reporting them. This is why all his research and investigation work are still a source of guidance to all water resources engineers in the country even today. However, lack of such care in checking investigation results before reporting in technical proceedings has created a lot of problems for project builders in the last two decades. I have therefore chosen this subject of careful reporting of investigation of water resources projects as the topic of my Lecture.

INTRODUCTION

Though the execution of various water resources projects, after Independence, has changed the face of the country and has brought prosperity to the people and contributed to the growth of the irrigation and power sectors, however, during the last over a decade, there has been increasing criticism against water resources projects, so much so that protests, agitations, etc have been held by some so called environmentalists to stop the on-going projects. The various aspects which are severely criticized without proper understanding are: waterlogging and salinity, sedimentation of reservoirs, reservoir induced seismicity, submergence of forest land, displacement of persons in the submerged area, etc.

No doubt, these aspects need detailed studies and proper appraisal before execution of various multipurpose and hydroelectric projects; it is surprising that inadvertently the publishing of some of the investigations has given tool to such project baiters and project bashers in creating 'panic' among laymen against these development works. The research and investigation results are often published without considering in depth the physical interpretation of such findings, with inadequate data, without correlating the work done earlier and sometimes without following any established codes. We will now discuss various aspects of such investigations with examples.

WATERLOGGING AND SALINITY

This is one aspect which has drawn wide criticism from the people. I do not want to plead that irrigation projects have not created waterlogging and salinity in certain areas, but I certainly say that the blame has been – disproportionately assigned. Probably more waterlogging due to obstruction of drainage lines has been caused in the country by road and railway embankments than by irrigation projects.

The extent of waterlogging in measured by: (i) visual survey of blocks of thur and salt appearance (ii) determining depth of water table below ground, (iii) soil survey to determine deterioration of soil condition in different regions upto a depth of 3 m or so, (iv) geological survey to determine the nature of ground water and location of aquifers and clay bands. In practice, when studies are done for localized small regions, all detailed surveys are carried out, but when general investigations are done to define the extent of waterlogging, usually the visual survey and measurement of depth of water table in wells are resorted to. There is no general agreement as to the depth of water table at which the land above should be considered waterlogged. This system gives rise to varying figures of the waterlogged area, depending upon the definition used by the investigating agency in defining waterlogging. This would be clear by some case histories given subsequently.

Waterlogged Area in India due to Irrigation

In India, the first survey of a waterlogged area was done in 1972 by the Irrigation Commission. They collected data through questionnaires and the desirable limit of water table was mentioned as 1.5 m below ground level.

The National Commission of Agriculture (1976) did not propose any such limit of water table depth and the area of waterlogged land worked out by them was 6 Mha. The Commission also estimated that alkaline and saline soils together accounted for an area of 7 Mha.

Various other investigators gave varying figures, depending upon the choice of criteria of waterlogging adopted by them. The different findings are chartered in Table 1.

TABLE 1 WATERLOGGED AREA IN INDIA ACCORDING TO DIFFERENT STUDIES

Year	Agency Undertaking Study	Water-logged Area, Mha	Water-logged Area as Percentage of Irrigated Area, %	Percentage of Mean Figure for Water-logged Area (9.015)	Percentage of Lowest Figure for Water-logged Area (3.423)
1972	Irrigation Commission	4.84	12.2	53.7	141.4
1976	National Commission on Agriculture	6.0	13.2	66.6	17.3
1982	Central Groundwater Board	3.423	6.1	38.0	100.0
1984	Administrative Staff College of India (R Bowander and C Ravi)	10.0	16.9	110.9	292.1
1989	G P Bhargava – Research Scholar	9.826	14.2	109.0	287.1
1989	World Watch Paper No 3	20.0	28.9	221.9	584.3
	Mean	9.015			

It may thus be seen that different agencies, all without proper and precise measurement, have given different figures (varying upto 600%) for waterlogged land in .India. Thus, due to lack of uniformity of the criteria for categorizing an area as waterlogged in a particular agroclimatic condition, the statistics in this regard are questionable both in magnitude and in relevance.

Quite often, the cited statistics are meant for the entire land area met with the waterlogging and salinity, without any distinction of the area affected due to canals and due to other causes like inundation of low lying areas, encroachment/choking up of the natural drainage systems, etc. In such circumstances, it is important to go for uniform criteria to determine a waterlogged area, if we want to avoid wide as well as frequent variations to the extent of waterlogged area in different regions. This could be done only if definitions are developed on the basis of agroclimatic zones.

Having seen how much exaggerated and widely varying figures of a waterlogged area are, a question arises as to how much irrigation is responsible in creating the waterlogged area. It has been estimated that the canal induced waterlogged/saline area may not be more than one-third of the total area under waterlogging or salinity in India. This percentage has been corroborated by digital model studies for suggesting anti-waterlogging measures in Kalyanl-Ghaghra and Jamwari-Chauka doabs of Sharda Sahayak Command in Uttar Pradesh. Similar is the story in other developing countries.

Saline Land Area in India

The figures of saline land area in India given by different investigators show the same picture. (Table 2).

Waterlogging in Sharda Sahayak Command

According to Central Ground Water Board, about 240 000 ha was reported to have been affected by waterlogging in 1982, whereas only 6240 ha remained waterlogged in 1984 (Some drainage measures were adopted, but not so much as to reduce the figure to $^{1}/_{40}$ th in two years). From their district-wise tables for 1982 they showed waterlogged area as 60 000 ha in Allahabad and 68 000 ha in Jaunpur, thouqh the area irrigated in these districts were only 35 000 ha and 13 171 ha, respectively. But they put the whole blame on the Sharda Sahayak Project [Such figures where the waterlogged and saline area was put more or less equal to the area irrigated can be found in figures quoted by 0 P Singh and P S Kumbhare (1991) for Gandak Command (Bihar); area irrigated 1.062 Mha, area waterlogged and saline 0.962 Mha].

For the same command area, the Remote Sensing Application Centre, U P, took satellite imageries in 1983 and after sophisticated computer analyses indicated that 35 266 ha were waterlogged.

TABLE 2 SALINE LAND AREA IN INDIA ACCORDING TO DIFFERENT STUDIES

Year	Agency Undertaking Study	Saline Land Area, Mha	Saline Area as Percentage of Irrigated Area, %	Percentage of Mean Figure for Saline Area (16.5)	Percentage of Lowest Figure for Saline Area (7.0)
1976	National Commission on Agriculture	7.2	15.9	43.6	102.9
1977	FAO (I P Abrol and D R Bhumbia)	7.0	14.9	42.4	100.0
1984	Administrative Staff College of India (R Bowander and C Ravi)	25.0	42.4	151.5	357.2
1988	'Science and the Future' Encyclopaedia Britannica (p 125)	25.0	35.0	151.5	357.2
1990	State of the World (S Postel)	26.0	35.0	157.6	371.4
1990	N T Singh	8.5	11.9	51.5	121.4
	Mean	16.5			

The U P Irrigation Department estimated the waterlogged area in the Sharda Sahayak Command as 17910 ha which reduced to 7400 ha in 1988 due to remedial measures. Table 3 shows these figures of waterlogged area.

It would be seen from Table 3 that two sets of investigators of the same Institute in the same year and for the same conference gave widely varying figures for the Sharda Sahayak Command. Could they not reconcile figures even at the same place of their research?

TABLE 3 WATERLOGGED AREA IN SHARDA SAHAYAK COMMAND ACCORDING TO DIFFERENT STUDIES

Year	Agency Undertaking Study	Water-logged Area, 1000 ha	Water-logged Area as Percentage of Irrigated Area, %	Percentage of Mean (162.825)	Percentage of Lowest (6.24)
1982	Central Ground Water Board	240 (60 in Allahabad District)	15	147.4	3846.2
		68 in Jaunpur District	171 516		
1983	Remote Sensing Application Centre, U P	35.226	2.2	21.6	564.5
1984	Central Ground Water Board	6.24	0.4	3.8	100.0
1984	U P Irrigation Department	17.91	1.1	11.0	287.0
1988	U P Irrigation Department	7.4	0.5	4.5	118.6
1992	Central Soil Salinity Research Institute, Karnal, Haryana (O P Singh and P C Kumbhare). *Eighth Afro-Asian Regional Conference*, ICID	32.6	20.3	200.2	5224.4
1992	Central Soil Salinity Research Institute, Karnal, Haryana (P K Joshi and N T Singh). *Eighth Afro-Asian Regional Conference*, ICID	50.7	31.7	311.4	8125
	Mean	162.825			

TABLE 4 WATERLOGGED AND SALINE AREA FOR SOME PROJECTS IN INDIA

[Figures given by investigators of the same Institute, at the same time and at the same conference (Eighth ICID Regional Conference, Bangkok, 1991)]

Name of Project	Waterlogged and Saline Area According to P K Joshi and N T Singh, 1000 ha	Waterlogged and Saline Area According to O P Singh and P S Kumbhare, 1000 ha			Variation, %
		Water-logged	Saline	Total	
Sharda Sahayak	513.3	326.0	6.2	332.2	156
Gandak Bihar, Uttar Pradesh	611.0	562.0	400.0	962.0	157
		Negligible	Negligible		
Sriramsagar, Andhra Pradesh	61.0	30.0	—	30.0	203
Nagarjunsagar, Left Bank Canal Andhra Pradesh	32.5	33.2	30.0	63.2	194
Tungbhadra, Andhra Pradesh	48.8			33.0	148
Ukai, Kakarpar	25.5			8.3	307
J L N Canal, Haryana	1.6			0.06	2667
Tawa, Madhya Pradesh	6.6	0.46	Negligible	0.46	1438
Mula, Maharashtra	8.0	0.02	0.77	0.79	1013
Purna	5.6	3.1	0.32	3.42	164
Jayakwadi	8.4	2.1	0.49	2.59	324
Nira	10.0	0.2	4.28	4.48	223
Hirakund, Orissa	10.8	3.0	Nil	3.0	360
Ghatprabha	1.6	3.52	Nil	3.52	220

Table 4 gives the different figures quoted by the same investigators of the same institute in India for the same projects and for the same conference.

The variation in their figures is up to 2667%! Does such reporting at international level not require care and caution?

It would thus be seen that in order to get a correct picture of waterlogged areas, we should demarcate zones agroclimate-wise and define the limit of water table below ground level. The areas thus defined would then give a correct figure of waterlogging in different regions.

The question arises whether we can define such a limit as to bring uniformity in assessment of the waterlogged land. This can be attempted by adopting the criterion of effective rooting depth which is more useful than total root development. The effective rooting depth may be defined as the depth or volume at soil in which maximurn proportion of roots of a plant are distributed and which produces the potential yield without restricting the supply of water, nutrient, oxygen and other inputs.

The rooting depths vary widely with soil-crap-climate interrelations. However, generalized data are presented in Table 5 which shows that most of the crops perform well when ground water table is maintained 'at about 1.0-1.5 m below ground level. Table 6 reveals that most of the crops give a 'good' to 'excellent' yield when water table is maintained at 1.2-1.5 m depth below ground surface. This also supports the view of maintaining critical depth of 1.5 m for various crops.

Therefore, it would be worthwhile to define the desirable water depth as 1.5 m for correct assessment of waterlogged areas in arid and semi-arid regions.

TABLE 5 EFFECTIVE ROOTING DEPTH OF MAJOR CROPS

Crop	Effective rooting depth, m
Wheat	1.0-1.5
Maize	1.0-1.7
Cotton	1.0-1.7
Barley	1.0-1.5
Gram	0.9-1.5
Groundnut	0.3-1.0
Lucern	1.0-2.0
Vegetables	0.3-0.6
Mustard	1.0-1.5
Sugarcane	1.2-2.0
Sunflower	0.5-1.5
Potatoes	0.4-0.6
Pulses	0.3-1.0

TABLE 6 YIELD REDUCTION OF CROPS DUE TO VARIATION OF WATER TABLE

Depth of Water Table Below Ground Level, m	Yield reduction, %						
	Mango	Cotton	Oil Seeds	Sugar Cane	Wheat	*Rabi* Fodder	*Kharif* Fodder
< 0.30	100	94	85	85	77	74	71
0.30-0.45	100	71	66	66	49	45	27
0.45-0.60	100	55	54	54	35	30	0
0.60-0.75	100	46	42	42	24	19	0
0.75-0.90	91	37	32	32	15	11	0
0.90-1.0	76	29	22	28	9	5	0
1.0-1.2	61	22	13	13	4	2	0
1.2-1.5	38	15	5	5	1	0	0
1.5-1.8	7	6	1	1	0	0	0
1.8-2.1	0	3	0	0	0	0	0
> 2.1	0	0	0	0	0	0	0

SEDIMENTATION OF RESERVOIRS

This is one subject which has attracted considerable attention from so called project well wishers as a major issue against construction of major storage dams. The main argument is that the sedimentation rate in Indian reservoirs is much more than envisaged earlier, about 3.6 ha-m/100 km^2 year. When sediment load was measured (not on the basis of capacity surveys in each case) in 1950s, it was found to be more than anticipated III most of the cases. Though subsequent capacity surveys in many cases showed decreasing trends, however, our own investigators seemed to enter into a competition in reporting heavier and heavier sediment load, the highest being reported for the Ramganga Dam in U P (on the basis of sediment observations during the period 1958 to 1962) as 19 ha-m/100 km2/year (M S Gupta and H S S Singhal, 1985). Incidentally, due to drought conditions, the reservoir was depleted to lowest water level in 1987, when it was found that sedimentation was actually minimal. Even the roots of trees cut at the time of reservoir filling were fully visible.

Sedimentation is a natural phenomenon. Those who quote heavy sedimentation rates as argument against building lakes and reservoirs behind dams forget that it is only such lakes like Bhakra, Rihand, Tungabhadra, Hirakud, Nagarjunasagar, etc that have changed the face of the country. These reservoirs have added billions of units energy and production of millions of tonnes of foodgrains. The reservoirs by themselves have not accelerated the sedimentation rates. It is the heavy sediment load both as bed and in suspension which is brought by rivers.

Another factor which adds to the sediment load in rivers is the existence of river banks, which are steep and barren. In Alakhnanda and Bhagirathi valleys, practically all slopes facing south are unprotected with forest cover. This situation existed earlier and exists even today when storage schemes have not yet been executed either on the river Ganga or the river Yamuna. These barren slopes add to the fragility and erosion susceptibility of the top soil and weaker rocks. The erosion and landslides become severe in the rainy season.

The topographic flats or benches in river valleys and man-made terraces for agriculture purpose are unconsolidated and are prone to bank-side erosion. The alluvial fans deposited by streams joining main rivers are non-cohesive and made up of boulders, pebbles, shingle and sand. All this adds to the sediment load of rivers in north India.

The problem looks alarming to the critics because the initial projects were designed by engineers taking a sedimentation rate of 0.036 Mm^3 per 100 km^2 of catchment area. This figure was given by Dr A N Khosla on the basis of data from 33 points; foreign reservoirs which have comparatively silt-tree water and very few Indian reservoirs have 5 points. Dr D V Joglekar improved the relationship and suggested an enveloping curve:

y (Silting rate in Mm^3/100 km^2)= $0.597/A^{0.24}$ (A in km^2).

Even this was unrealistic and gave low values. R S Varshney (1971) gave the relationship $y = 1.534/ A^{0.24}$, which is more realistic.

The river Bhagirathi brings a very heavy sediment load right from Gangotri and from comparatively weak river bank slopes. No major dam has been constructed on the river so far. But opposition to the Tehri Dam is being mounted on the plea that the reservoir will be silted soon. Studies have been conducted on Tehri project and the economic life of the reservoir is certainly more than 100 years. Thus, if the economic life of a big reservoir works out to 100 years or so, the heavy sedimentation rate should not be a cause of worry.

Soil erosion and consequent transportation of silt by streams is a natural phenomenon and is a function of soil and or rock strata, country slope, valley shape, natural vegetation and the management of the catchment. The reservoirs by themselves do not and have not accelerated the sedimentation rate. The effect of these projects on siltation, if at all, is nominal.

Some people suggest comprehensive soil conservation measures as a panacea to arrest and control soil erosion and thereby sedimentation of reservoirs. This is neither possible nor practical. First, the cost of treatment would be prohibitive (the present rate of catchment area treatment for the Indus, Ganga and Brahmputra basins works out to about Rs 12540 per ha which, for the Tehri project would mean an investment of over Rs 9000 million at 1994 price level and, if the work takes 12 years, say, the out-turn cost would be abou1 Rs 32.5 billion. Second, the occurrence of big slides like Gohan slide, Bela Kuchi slide, etc in these valleys are natural occurrences, which have not been caused by construction of any water resources project and would not be covered by forest cover.

Thus, a practical and constructive approach in this respect would be to make a comprehensive survey of the catchment in respect of soil erosion, which is a phenomenon to be taker cars of irrespective of the projects proposed in the area, and then evaluate the impact of a particular project. The result of this should be used as input for finalizing remedial measures which will not only mitigate the impact due to the project but go a long way in improving the catchment as a whole.

One more aspect which has been overlooked is the diminishing silting rate noticed on some important reservoirs. That the Indian reservoirs would not be silted up in less than 100 years is substantiated from observations charted in Tables 7 and 8 which have served more than 50 years already and which have come up after Independence.

TABLE 7 SEDIMENTATION RATE IN LARGE RESERVOIRS WHICH HAVE SERVED MORE THAN 50 YEARS OF THEIR USEFUL LIFE *

Name of Reservoir	State	Storage Capacity Mm^3	Year of Impounding	Year of Last Survey	Average Rate of Silting, ha-m/100 km^2/year	Average Annual Loss of Storage, %
Nizamsagar	Andhra Pradesh	841.18	1930	1975	4.891	1.26
Himavatsagar	Andhra Pradesh	107.79	1927	1976	4.467	0.52
Mettur	Tamil Nadu	2708.76	1934	1984	2.520	
Dhukwan	Uttar Pradesh	105.45	1907	1980	0.304	0.61

* A K Shangle. *WAPCOS*, 1991

TABLE 8 SEDIMENTATION RATE IN LARGE RESERVOIRS CONSTRUCTED AFTER INDEPENDENCE

Name of Reservoir	State	Storage Capacity, Mm^3	Year of Impounding	Year of Last Survey	Average Rate of Silting, ha-m/100 km^2/year	Average Annual Loss of Storage, %
Bhakra	Punjab/Himachal Pradesh	9480.0	1958	1973	5.87	0.3
Panchet	Bihar	1975.6	1956	1974	10.00	0.7
Maithon	Bihar	1353.0	1955	1979	12.38	0.5
Mayurakshi	West Bengal	606.4	1955	1971	16.26	0.5
Tungbhadra	Karnataka	3747.8	1953	1972	6.44	0.5
Matatila	Uttar Pradesh	982.7	1956	1974	3.82	0.9
Hirakud	Orissa	8105.0	1957	1982	6.82	0.7
Shivajisagar (Koyna)	Maharashtra	2979.0	1961	1971	15.04	0.8
Gandhisagar	Madhya Pradesh	7746.0	1960	1975	9.04	0.3
Ramganga	Uttar Pradesh	2442.6	1978	1987	Negligible	

Source : 'Sediment Yield from Different Land Uses.' *C B I & P*, Technical Report no 19, 1980.

RESERVOIR INDUCED SEISMICITY

This is one activity which the critics suspect in every storage scheme, whereas the project is in the seismic zone or not, and whereas the increase in seismicity due to creation of a reservoir is a debatable question. The data so far collected on various dams ail over the world indicate that the phenomenon of reservoir induced seismicity (RIS) has been observed in a few cases only.

The world-wise distribution of RIS is as below:

1. There are four site where RIS magnitude was 6 or more.
2. There are six sites where RIS rnaqni.ude was between 5 and 5.9
3. There are 23 sites where RIS magnitude was between 4 and 4.9
4. There are 35 sites where RIS magnitude was less than 4.
5. There are 8 sites where RIS decreased after impounding.

6. There are 16 sites where RIS was suspected but could not be established due to lack of data.

In fact, seismicity has been observed in about 70 cases (Gupta, 1992), although the number of dams constructed is more than 15000, showing a percentage of about 0.48.

Should we stop building dams because 0.48% of them have shown RIS? Even in majority of the 70 cases of reservoirs there were no recorded data of seismic activity in ih& project area before the reservoir was formed, to appreciate the increased or decreased seismic activity to be attributed to the new development, ie, constitution of the reservoir. Therefore, it is nor desirable to put all the blame upon and criticize any high dam, if proposed in a seismic zone. If the fear is that in all cases RIS occur, then it would be difficult to plan any development scheme in future.

Investigators have given the following possibilities to cause RIS:

(i) Favourable tectonic and geologic set up is necessary for RIS. Unless the region is already critically stressed before impounding, RIS cannot occur. But in thrust fault environment, the filling of reservoirs may actually lead to reduction in seismic activity. Thus an 'active seismic status' for which the stage is already set by existing tectonic features for earthquake occurrence in future is an essential requirement for RIS. The reservoir triggers seismic activity by increasing pressure on the ground water in the cracks, fissures and pores in the rocks or by adding to the existing stress.

(ii) The largest RIS event at a given site does not seem to depend upon the time interval between the first filling and its occurrence. At most reservoir sites, major events have occurred following rapid changes in water levels (Gupta, 1992).

(iii) Hydraulic continuity to deeper layers may induce RIS.

(iv) RIS has been observed mainly in cases where the reservoirs are underlain by competent rocks.

It would be interesting to examine if these researches are really true in all cases.

Some attribute induced seismicity due to elastic deformation. If so, it is difficult to reconcile a Cajuru Dam (46 m maximum reservoir depth) in Brazil with a shock of 2.0 magnitude while the 185 m high Almendra Dam in Spain also showing a shock of 2.0 magnitude. On the other hand, the 22 m high Coyote Dam in the USA showed a shock of 5.2 magnitude, but the 185 m high Toktogal Dam in Russia could generate only 2.5 magnitude shock. It is difficult to reconcile the fact that the Hoover Oar" (221 m high with 191 m maximum depth. of reservoir) in the USA has a maximum magnitude of shock of 5.0 while in the same Colorado basin, subsequently built (upstream of the Hoover Dam waterspreaa), Flaming Gorge Dam 139 m high, 176 m high Glan Canyon Dam, and Le Roy Anderson Dam have shown 'decreased micro-seismicity.

Even in case of such reservoirs which have shown seismicity, can it be said that the epicentres of maximum shock is within the waterspread? Are focal depths of 10 to 12 km to be looked upon as shallow? The focal depth at Koyna (the highest MIS recorded in the world though whether the earthquake was reservoir induced is itself questionable) is 12 km deep below the basalts which are 3 to 5 km deep in the Archaeans. Dr Auden, the eminent engineering geologist who surveyed the Koyna site for project preparation and after the major earthquake of December 10, 1967, found no geological defects (from pre- and post- earthquake photographs) or discontinuities extending to great depths through which water can seep.

At 0356 h on September 30, 1993, in eastern Maharashtra, 73 villages of Latur and Osmanabad districts were virtually wiped off the map of the State, with a death toll of over 35 000 people. Incidentally, there was not even a small storage reservoir in the area; otherwise the whole blame would have been assigned to the reservoir. This recent earthquake in Maharashtra stronqly indicates that the December 10,1967, Koyna earthquake was not reservoir induced and seismology of central and southern India is yet to be understood.

It has been said that seismicity is caused by 'deformation and stress readjustments following the loading by reservoirs.' It is then intriguing to find in the case of Bhatsa Dam (1983) that the phenomenon occurred when that dam was half built.

But the phenomenon did not persist nor aggravated when the dam W2S completed to its full height. Here the epicentre was about 8 km away from the waterspread.

In 1979 (10 years after dam construction) shocks were recorded il' the case of the Nagarjunsagar Dam in Andhra Pradesh. Its epicentre was 26 km downstream of the reservoir and to the left of the river where there were no surface manifestations of major lineaments, faults, etc. However, in the same basin, the Srisailam Dam of nearly same height has been constructed on a younger geological Cuddapah sedimentary sequences compared to the Nagarjunsagar Dam founded on granite gneisses of Archaean age. Also the Srisailam Dam is across a deep gorge with an inner eroded gorge with deep joints on either side. Yet no such phenomenon has been observed at this cite.

Then it is said that percolation of water along the fault and fracture zones probably lead to a build up of pore fluid pressures which are then transmitted down to the stress zone with a potential to slip and cause earthquakes. If this were so, then the Giri Bata pressure tunnel (Himachal Pradesh) and the Chibro Khodri tunnel (UP) across the same Nahan and Kroi thrusts at two different places far apart in the Himalayan region should have created seismicity. Serious tunnelling problems were faced due to extraordinary deformation and breaking of steel supports. These tunnels have been running for 10 to 15 years. So far no earthquake has been triggered.

Some say that rapid impoundment of water may induce earth tremors. However, this is also not borne out by facts. The maximum rise in lake level at Koyna was 7.25 m on July 2, 1972. But there was no major shock in 1972. Name of Country Height, Volume of Location with Status of Seismicity After Creation Dam m Reservoir, Respect to of Reservoir 109m^3 Main Thrust it is therefore clear that the phenomenon of seismicity occuring along with formation of lakes cannot be seen with closed eyes,

The aspect of induced earthquake at Tehri Project has been discussed with several authorities on the subject, viz, School of Earthquake Engineering, University of Roorkee; Geological Survey of India and experts from various developed countries who have long association with such projects. They all have opined that no risk is involved in constructing the dam at the proposed site.

Hence it may be concluded that it is desirable for investigators and researchers to fully ascertain all the aspects of site before pronouncing that the site is vulnerable to RiS, Such an attitude has harmed the Tahri project, the proposed first major storage scheme in the Ganges valley. If we cannot develop the Ganges valley, frem where shall we get hydropower for development?

Researchers have also pointed out the following facts which should give confidence to tile investigators.

(i) RIS is confined to an area of about 25 km around the lake.

(ii) RIS decreases with time.

(iii) For reasons inherent to the nature of seismic phenornenon, the maximum values of magnitude and intensities cannot be increased due to reservoir impounding.

(iv) Smooth filling/emptying may be key to reduce the hazard of earthquakes in the vicinity of dams which are known to induce earthquakes.

Table 9 gives data about dams constructed in the Himalayas. All these dams are near to main boundary thrust (MBT) or main central thrust (MCT) The observations show that there has been no increase in seismic activity in the area, rather seismicity is reduced in the case of Tarbela. It can therefore be concluded that reservoir impounding is neither a necessary nor a sufficient cause for earthquake occurrence in future.

TABLE 9 RESERVOIR INDUCED SEISMICITY FROM DAMS CONSTRUCTED IN HIMALAYAS

Name of Dam	Country	Height, m	Volume of Reservoir, 10^9m^3	Location with Respect to Main Thrust	Status of Seismicity After Creation of Reservoir
Mangla	Pakistan	118	7.25	Near to MBT	No increase in seismicity. It is assessed that micro earthquake activity has, on the other hand, decreased due to impoundment.
Tarbela	Pakistan	143	13.70	Close to MCT	Initial filling of reservoir resulted in minor decrease in seismicity with in a distance of up to 100 km from the dam site.
Bhakra	India	226	9.87	Between MBT and MCT	There is no relationship established between seismicity activity and the reservoir created. The level of seismicity is associated with normal seismicity of the region.
Pong	India	133	8.57	Close to MBT	Impoundment of reservoir has not resulted in any change in seismicity level of the region.
Ramganga	India	125	2.37	Close to MBT	No correlation between the reservoir level and local seismicity of the reservoir area.
Tehri	India	261	3.55	Crossed by thrust faults not conducive to RIS	Reservoir not yet created.

MBT Main boundary thrust

MCT Main central thrust

DESIGN FLOOD FOR WATER RESOURCES PROJECTS

Gone are the days when knowledge of hydrology was limited to Dicken's formula, rational method, flood frequency analysis and unit hydrograph. The theoretical knowledge in this field has very much improved and so also are the values of design flood. In 30 years span, the spillway frequency of design flood for major works has increased from 1000 years to PM F of more than 10 000 years [at a rate of increase of 250 years (approx) in frequency value per year]. No doubt, some cases can be cited, with percentage certainly lower than 1, where actually observed flood was marginally higher than designed flood, but the new values now accepted are many a times more, as high as six times though the flood observed was only slightly above the design flood. In other cases where the actually observed flood was only 50% of the design value, the new design flood adopted is now 400% of the previous one, ie, eight times the maximum observed.

Certainly explanations can be given for adopting so high values, which increase the cost of works nearly in direct proportion. However, economy can be achieved if investigations are made to plot flood peaks against damages. It is most likely that the curve would become asymptotic after a flood frequency of 500-1000 years, If such investigations are done along with hydrological studies, much economy can be effected in design of water resources projects. It would be much better if judicious caution is exercised in selecting design flood values and standard norms are laid in this direction. It is desirable to optimize the floods rather than maximize them. In case of dams, dam-break studies should be done and failure proof warning systems installed.

COMPETENCE OF FOUNDATIONS-DEFORMATION MODULES OF ROCKS

Shear strength, compressive strength and modules of elasticity are usually the base parameters which define the acceptability of rocks to serve as dam foundation. Till sixties, the modules of elasticity was usually the criterion for evaluating rock deformability. This concept was acceptable since we were using better available foundations. However, good rock sites are not available for new dams which have been planned now, specially in northern India. In general, rock mass is heterogeneous, anisotropic and discontinuous. As such, the mechanical properties of rock mass at site differ greatly from the laboratory test results carried out on small samples of intact rock. The parameters actually needed in design are the in-situ properties of rock mass and not that of intact rock. Therefore, modulus of deformation, and not modulus of elasticity, was chosen to represent the deform ability of the rock mass. Test procedures and methods of evaluation of deformation modules by using values of stress and strain in plate bearing tests were specified by different codes (Fig 1).

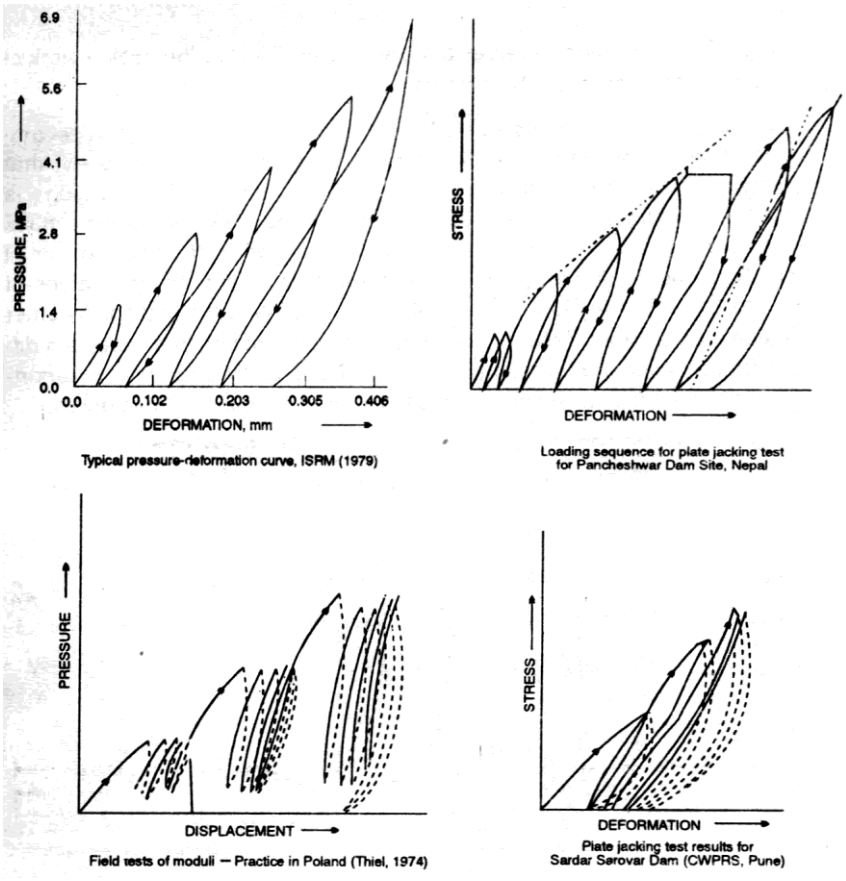

Fig 1 Typical pressure deformation curves

In the Japanese method, used for Pancheshwar Dam studies, the modulus of elasticity/deformation is derived from the slope between two points where the pressure-displacement curve is comparativeiy steep and has lost curvature as a result of repetitive loading. The Bureau of Indian Standards (BIS) recommended evaluation of deformation modulus (IS: 7317-1974) by taking the secant modulus of the unloading curve of second cycle. This code has been revised and the new code (under printing) recommends the loading curve and not the unloading part of the curve for evaluation of deformation modulus, Ed. The recommendations are: 'In the cyclic loading tests, it is usually found that large deformation occurs in the first loading cycle while the recovery of the strain on removal of the load is comparatively very small indicating a permanent set in the rock mass by closing the cracks and joints. The deformations in the second, third, fourth and fifth cycles of loading are used for calculating the deformation moduli at different stress levels. For reporting the average deformation modulus and the elastic modulus, the values corresponding to the last cycle may be considered.'

Actually these recommendations take into account the rock pattern available now for foundations in the Himalayas. If we work out deformation modulus in the manner as recommended by BIS acceptable values would be obtained for competent rocks. But if some other arbitrary method to evaluate E_d is used, like the second loading cycle, the corresponding values of E_d. Specially for Himalayan rocks, would be very low and would create apprehension and fear in the minds of persons taking decision. Such was the actual history of a major project in the Himalayas where very low values of E_d for different rocks were calculated on incorrect basis and that actually put a question mark on the desirability of constructing the dam at all. Table 10 gives values of such wrong calculations for some typical test sites. The correct value as per IS: 7317-1974 and as per recommendations given in the revised code are 2-3 times. These are more acceptable and create confidence. Such an action of reporting wrong values of E_d adversely affected the design work of the project for more than three years.

The same revised IS code (under print) reports a very interesting recommendation, based or some investigations and reported prematureiy, that elastic and deformation moduli are reduced drasticallv (My knowledge is that the investigator showed reduction by 90% to 70%) when rock mass (poor like the Himalayas) gets saturatsu. Well, this will be the condition for all the rocks submerged in reservoir water, h.:mce it means that the values of Ee and E_d will be very low. This result is just contrary to the findings by other foreign investigators. Actua!!y the method of testing in both the cases are different and hence the investigator should have exercised restraint in reporting such investigation which can cause panic in the minds of designers.

TABLE 10 DEFORMATION MODULUS AS PER IS: 7317-1974 Actual Examples in Ganga Yamuna valley

Deformation Modulus. kg/cm^2		
As per IS: 7317-1974	As per Revised IS:7317 under print (calculated by extra-polation	As Actually Quoted wrongly by investigator
52 078 (4.4)	58 941 (5.0)	11 850
28 441 (2.1)	25 964 (1.9)	13 840
47 780 (1.6)	1 08 164 (3.9)	27 950
46 071 (1.6)	34 778 (1.2)	29 200
28 490 (2.1)	46 811 (3.37)	13 870
Average (2.36)	(3.07)	
As Actually Observed for Fifth Cycle		
18 620 (1.8)	17 790 (1.8)	10 080
17 380 (2.6)	11 990 (1.8)	6 750
24 600 (6.5)	45 000 (11.8)	3 800
Average (3.63)	(5.13)	

Values within brackets show the ratio of correct value compared to the reported wrong value.

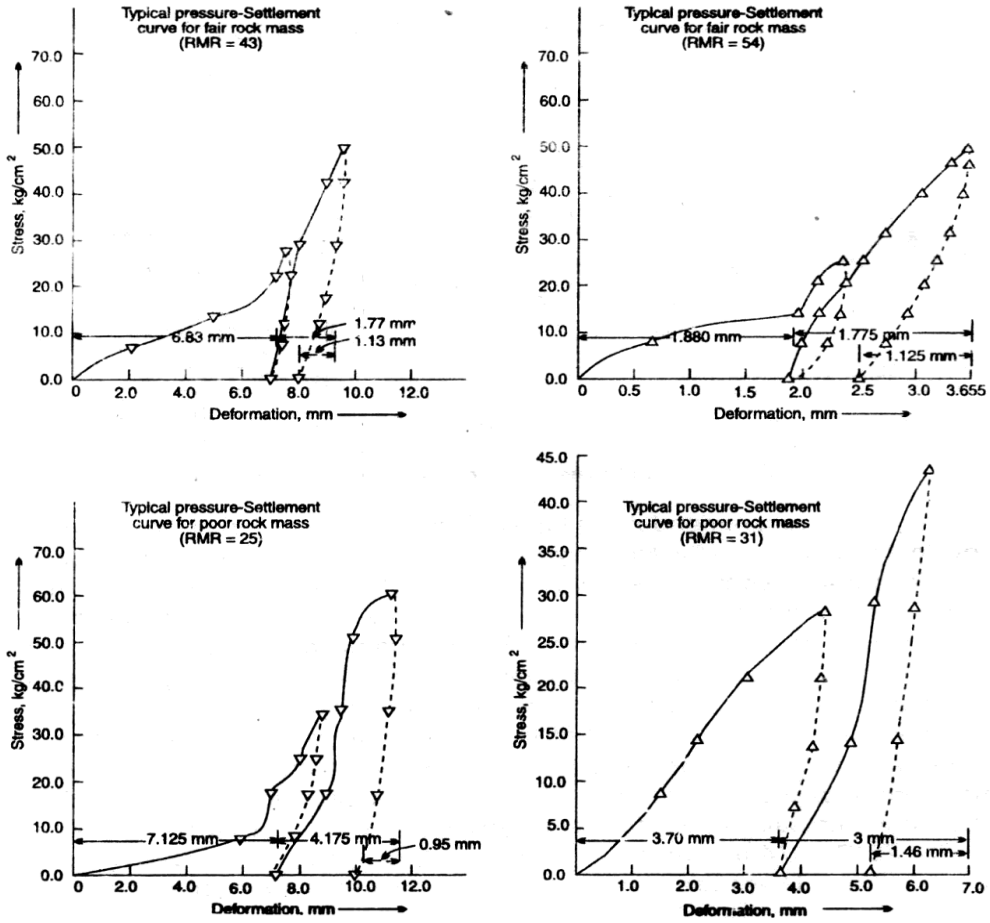

Fig 2 Pressure settlement curves for Himalayan rocks

These actual examples show that lack of care in reporting investigation can create problems in design and execution of water reS()UrCASprojects.

USE OF METHOD FINITE ELEMENT

Every del "de has its mathematical' axiom. Differential equations and finite difference dominated up to the fifties, and matrices up to the midseventies. Since mid-seventies, it is now the finite element method (FEMl, which IS the guiding light in all our researches and studies. The investigators put the name of FEM and try to push the research as gospel truth.

FEM is a versatile tool to solve cur problems; however, its application to water resources project studies. specially the dam along with its foundation, needs care. The extent of foundation on the upstream and downstream, condition cf its boundary foundation nodes, whether fixed, or free or free in one direction, can create substantial difference in the results. The researcher should take care in analyzing the problem and take more care in interoreting and reporting the results. Cases have occurred where the dam was analyzed without taking foundation at all, or it was designed with very little extent of dam foundation on the heel and toe Side. The results were much different than what could be expected in a normal case and were difficult to be explained with reasoning.

In another case, the foundation was taken with all nodes free. The result naturally would be that the mathematical iteration in numerical analysts would not converge and different values of deformation and stresses would result after ths test run is stopped at different intervals.

Tables 11 and 12 give values of vertical and normal stresses for a 1oo-rn high concrete gravity dam, with depth 0: foundation equal to dam height, downstream extent also equal to dam height H, but upstream extent varying from 2H to 0.1 H. It may be seen that variation at heel for o, was 150.6% and for o, 342.7% and while c, at toe changed only 10.8% but o, changed by 272.8%.

When both upstream and downstream extents of foundation wel e chanqsd (Table 13 and Table 14), the variations were more and alarming in case of 0, at toe, which changed from compression to tension and again to compression. These results indicate that the foundation extent plays a major role in the ultimate stress in the dam and foundation.

TABLE 11 NORMAL VERTICAL STRESS σ_y AT HEEL AND TOE*

+ Tension, t/m^2 – Compression, t/m^2
Upstream side all nodes free
Downstream side $U = 0$, V free
Bottom $U = 0$, $V = 0$
Foundation depth, H = 100 m

Up-stream Extent	Down-stream Extent	σ_y At Heel	σ_y At Toe
2 H	H	-53.51	-130.38
1 H	H	-62.55	-131.27
0.9 H	H	-63.49	-131.48
0.5 H	H	-70.60	-132.85
0.3 H	H	-88.14	-134.67
0.1 H	H	-134.09	-144.50
Maximum variation		150.6%	10.8%

*S S Mohanty, 1987

TABLE 12 NORMAL HORIZONTAL STRESS σ_x AT HEEL AND TOE*

+ Tension, t/m^2 – Compression, t/m^2
Upstream side all nodes free
Downstream side $U = 0$, V free
Bottom $U = 0$, $V = 0$
Foundation depth, H = 100 m

Upstream Extent	Downstrem Extent	σ_x At Heel	σ_x At Toe
2 H	H	-26.03	-47.36
1 H	H	-37.56	-149.22
0.9 H	H	-38.31	-150.28
0.5 H	H	-44.41	-154.58
0.3 H	H	-63.59	-158.94
0.1 H	H	-115.24	-176.20
Maximum variation		342.7%	272.8%

*S S Mohanty, 1987

TABLE 13 NORMAL VERTICAL STRESS σ_y AT HEEL AND TOE*

+ Tension, t/m^2 – Compression, t/m^2
Upstream side all nodes free
Downstream side $U = 0$, V free
Bottom $U = 0$, $V = 0$
Foundation depth, H = 100 m

Upstream Extent	Downstrem Extent	σ_y At Heel	σ_y At Toe
H	H	-62.55	-131.27
0.3 H	0.5 H	-86.38	144.97
0.3 H	0	-23.53	-320.92
0.1 H	0.5 H	-133.09	-157.31
0.1 H	0.1 H	-95.37	-366.07
0.1 H	0	-90.89	-355.28
0	0	-94.56	-357.84
Maximum variation		112.8%	178.9%

*S S Mohanty, 1987

TABLE 14 NORMAL HORIZONTAL STRESS σ_x AT HEEL AND TOE*

+ Tension, t/m^2 – Compression, t/m^2
Upstream side all nodes free
Downstream side $U = 0$, V free
Bottom $U = 0$, $V = 0$
Foundation depth, H = 100 m

Upstream Extent	Downstrem Extent	σ_x At Heel	σ_x At Toe
H	H	-37.56	-149.22
0.3 H	0.5 H	-63.22	158.43
0.3 H	0	-45.70	+18.97
0.1 H	0.5 H	-115.24	-175.33
0.1 H	0.1 H	-101.61	-112.88
0.1 H	0	-99.59	+21.40
0	0	-101.38	-21.97
Maximum variation		206.8%	912.8%

*S S Mohanty, 1987

Fig 3 shows two dimensional FEM analysis for the Lakhwar Dam with identical foundation extent, but the side nodes are restrained in one case and roller in another. It is interesting to watch the disappearance of tension zone downstream of tce when side nodes rigidity are changed from fully rigid to roller condition.

Fig 4 shows the effect of foundation depth on stresses. This typical change of stress contours are due to tyorca: foundation rock geometry in Lakhwar, where the trap sandwitched between quartzites and slates, start acting as cantilever with increasing depth of the trap rock. There would have been less effect had there been harder touncation rock in place of slates.

Fig 5 shows similar trend though the values of elastic moduli have beer. taken more realistic. However, the values of tension havs reduced giving greater confidence to the designer and the builder.

It would thus be seen that any FEM result should not be accepted unless proper extent of foundation at least the value of H in depth and 0.5 H on the hep.1and the toe side, better H alround, and boundary mode rostraint conditions are not taken.

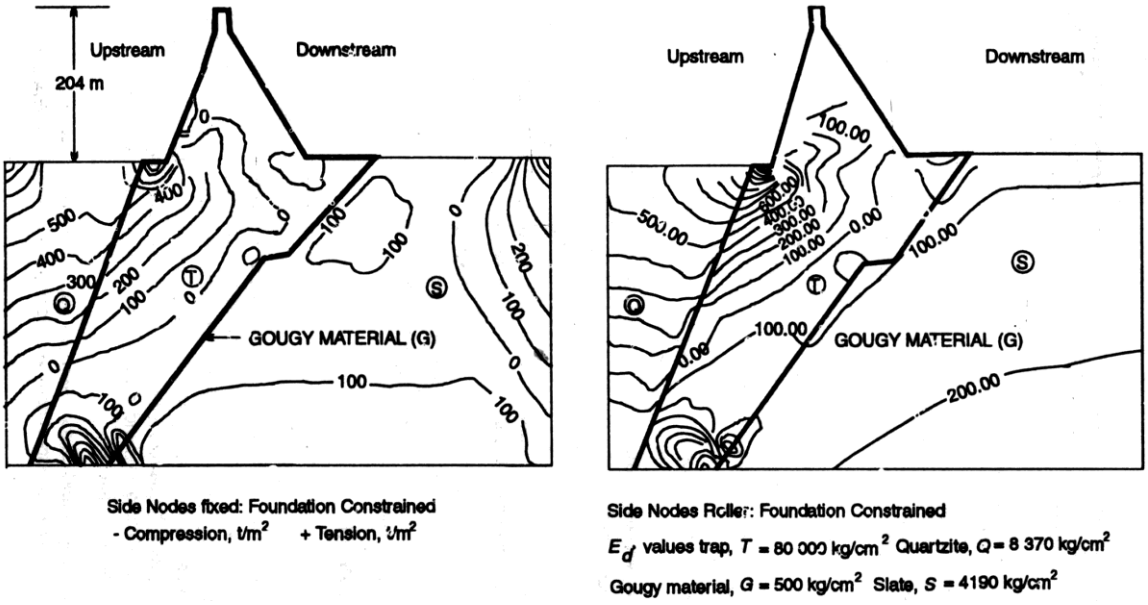

Fig 3 Effect of side constraints on major principal stresses - Lakhwar Dam

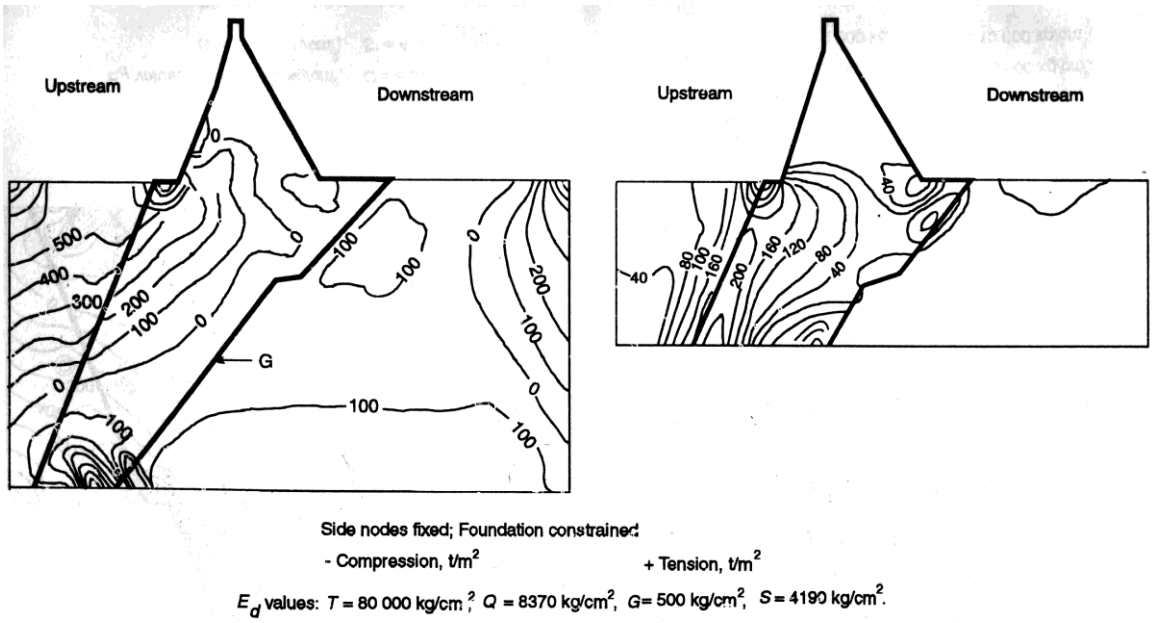

Fig 4 Effect of foundation depth on major principal stresses - Lakhwar Dam

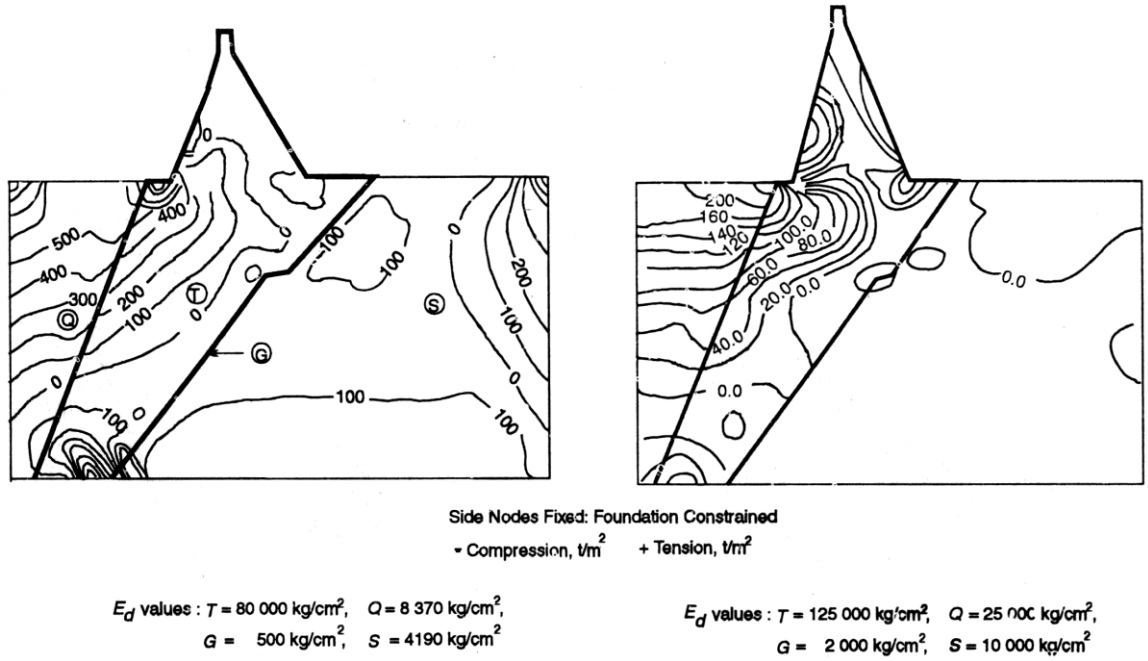

Fig 5 Effect of deformation moduli values on major principal stresses

CONCLUSION

This country has no alternative to developing its water resources for survival of its human population. This is a task to which planners, engineers, finance srs, environmentalists all have to contribute. Stopping the projects on flimsy pleas of environmental degradation without understanding and analyzing the factors would be a great disservice to the country. If the environmentalists who use all their energies in stopping work on projects like the Sardar Sarovar and Tehri devote even 10% of that energy in improving sanitation conditions in all towns and cities in India, the country would turn into a beautiful place to live in.

Our investigators and researchers can help considerably in the development of these projects by reporting their findings in the proper perspective and Tupstream after duly analyzing all the facts. Careless and hasty reporting of results can affect adversely the development plans and help those who wish to stop work on these projects. We should not neglect environmental considerations, but these must have priority after providing essentials for our population through exploitation of all resources - water being the first. The posterity will not excuse us for having allowed continuous loss of precious water flowing to the Bay of Bengal, when storage dams can be constructed to conserve water for irrigation and power. Development of water resources to the maximum possible extent will be a fitting tribute and memory to the great water resources engineer Dr Khosla.

In the end, I thank the Institution of Engineers (India) for inviting me to deliver this Lecture.

Jai Hind

The Seventh Dr Ajudhia Nath Khosla Memorial Lecture was delivered during the Ninth Indian Engineering Congress, Calcutta, January 15-20, 1994

Technical Education and Research in India — Need for Reorientation

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I feel greatly honoured "for being invited to deliver the Seventh A N Khosla Memorial Lecture at the Ninth Indian Engineering Congress being organized in this great city of Calcutta. It is heartening to note that thir happens to be the Platinum Jubilee year for the Institution of Engineers (India). I would like to express my gratitude to Shri P M Chacko, President, the Institution of Engineers (India) for affording me this wonderful opportunity of addressing such a galaxy of engineers and scientists through this lecture instituted in the memory of that great engineer, statesman and educationist Dr A N Khosla. Dr Khosla had many creditable achievements. He was considered to be the father of river valley projects and a doyen of Indian Water Resources Engineers. He had the credit of being the first Indian Vice-Chancellor of the University of Roorkee and the first engineer to be appointed as the Governor of a State. His engineering achievements were remarkable. His closed association with several major river valley projects like Hirakud, Bhakra Nangal and Ram Ganga will be remembered for a long time to come. The invention of Khosla Disc for Precision Levelling across rivers and wide valleys, his theory for design of Barrages and Weirs on permeable foundations are important contributions to civil engineering. I draw great pleasure l111dpride in that he was a Member of the Planning Commission too. I am delighted to note that he was also dealing with the subject of education in the Planning Commission as I am doing now, of course, confining myself to higher and technical education. I must be the second person with engineering background to become a Member of the Planning Commission after Dr Khosla. I could see that he made valuable contributions to education while being in the Planning Commission. He commanded high respect from Pandit Nehru who was the Chairman of the Planning Commission at that time. I am told that Dr Khosla prepared a scheme of providing loan scholarships to the poor but meritorious students for pursuing higher education and sent it to Pandit Nehru in 1962. It was the time of the Chinese aggression. Even amidst such a situation, Nehru appreciated Dr Khosla's proposal and it was cleared in the meeting of the Planning Commission held soon after the Chinese aggression. Perhaps the realization that the real defence of the country could be ensured through the promotion of higher education, making it available to all meritorious students irrespective of their income, might have weighed in favour of its approval even under such an extraordinary situation. Such was the far-sight of that great engineer-cum-educationist, who felt that the boundaries of the country could be made safe through excellence in higher technical education and research.

Keeping in view Dr Khosla's association with the subject of education (including technical education), in the Planning Commission and also the theme of the Ninth Engineering Congress: technology for a Better Tomorrow, I have selected tbe topic of my lecture as 'Technical Education and Research in India - Need for Reorientation.'

INTRODUCTION

Technical education (which includes engineering and management education as well) is one of the most potent means for creating skilled and technical manpower required for the developmental tasks of various sectors of the economy. It forms one of the most important and crucial components of human resources development with great potential for adding value to products and services, for contributing to national economy and for improving the quality of life of the people. It incorporates a technological dimension which is a vehicle for development. Technical education may itself imply high costs, but such high costs, being directly related I to development, should be viewed as an essential productive investment, yielding valuable returns to society and contributing to socio-economic development. The Scientific Policy Resolution (1958) rightly states that 'The key to national prosperity, apart from the spirit of the people, lies, in the modern age, in the effective combination of three factors-technology, raw materials and capital-s-of which the first is perhaps the most important, since the creation and adoption of new scientific techniques can, in fact, make up for a deficiency in natural resources and reduce the demands on capital.'

The science and technology education and research in India have made significant contributions to the overall development of the country. From a merely agriculture-based society in the early 40's, India is today rated among the biggest industrialized nations having a sound base of industries alongside with a highly developed agriculture sector. As we march towards the 21st century and with our policies of economic liberalization, it is imperative that our developmental efforts are supported by the relevant science and technology inputs on one

hand and relevant human resources on the other. Technical education and research have thus, to playa very significant role in the changed economic scenario. For this, they need proper reorientation.

DEVELOPMENT OF TECHNICAL EDUCATION IN INDIA

Growth of technical education depends on the socio-economic r.~ld.- industrial conditions of a country and its development is controlled by ,- the needs and requirements of the economy. After Independence, the country was faced with the greater challenge of rapidly industrializing the predominantly agricultural economy and in this process major efforts had been made to create a wide-based infrastructure of higher and technical education institutions, research laboratories and industry, covering a broad spectrum of disciplines and capabilities. There are now over 185 universities and academic institutions of national importance and 7958 colleges with a total enrollment of about 4.8 million students for graduate, post-graduate and research degrees and diplomas, with over 270 000 teachers. The higher education institutes include those offering programmes in arts, science, commerce, engineering, technology, management, finance, humanities, social sciences, etc.

With regard to technical education institutions, there were only 38 institutions at the degree level with an intake of 2940 students and 53 institutions at the diploma level with an intake of 3670 students in the year 1947. Today, there are 372 technical institutions at the degree level and 958 technical institutions at the diploma level with an annual intake of 88 930 and 152 554 students, respectively. These include regular engineering colleges, polytechnics, Indian Institutes of Technology, Regional Engineering Colleges and other institutions. For training craftsmen, there are over 2650 Industrial Training Institutes/centres admitting over 380 000 students per year. About 2000 institutions conduct vocational courses at the higher secondary school level (10+2 level), admitting about one lakh students per year. There are 306 centres, including institutions conducting part-time and correspondence courses and Indian Institutes of Management, imparting management education to over 27 440 students. There are about 100 centres offering post-graduate progranunes in engineering and technology with an annual intake of over 9000 students. The Government has set up about 450 major S & T research laboratories under its various departments and ministries. There are also about 1360 recognised in-house R & D laboratories in public and private sector undertakings. More than 200 consultancy firms are engaged in engineering design, analysis and research. The growth and enrollment pattern of technical education in India is shown in Appendix 1. Plan-wise total outlay for education including technical education is given in Appendix 2.

STRUCTURE OF TECHNICAL EDUCATION

Keeping in view the requirements of the country, we needed four levels of technical education: (i) Programmes/courses offered by ITIs whose products will be working as skilled workers, (ii) Diploma level programrnes offered by Polytechnics whose products will be working as Supervisors, (iii) Degree level programmes offered by IITs, Engineering Colleges and Universities, whose products will function as engineers and technologists, and (iv) Post-graduate programmes like MBA and other PG Diplomas, M Tech and PhD offered by IITs, IIMs, Universities, etc whose products will become Management Personnel, teachers, scientists and researchers. The structure of technical education in India is shown in Fig l.

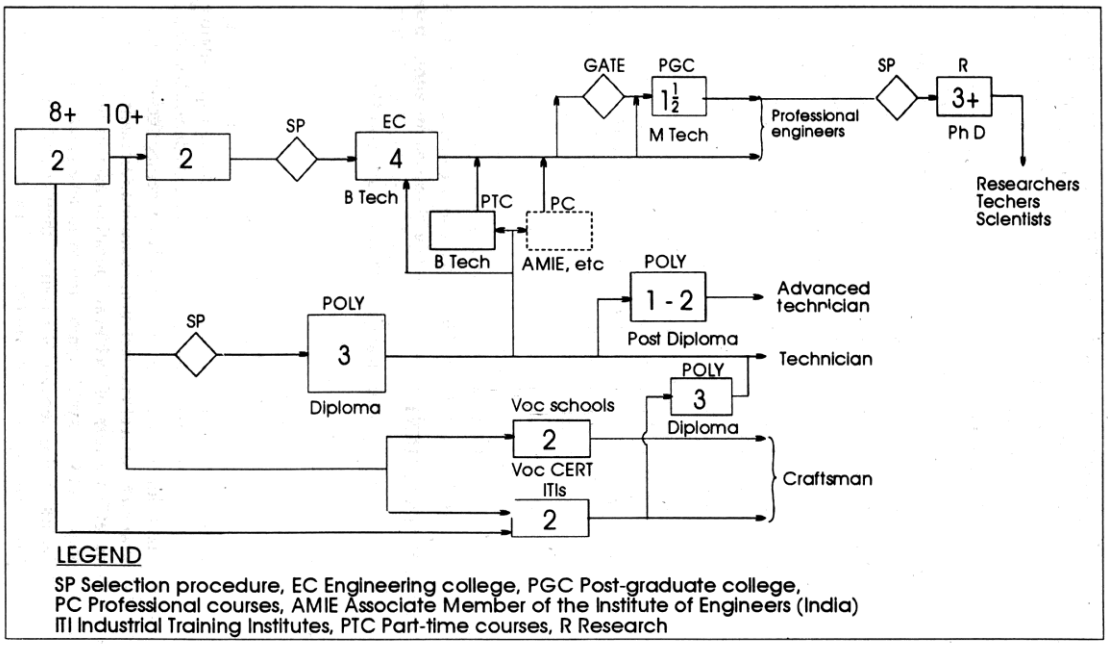


Fig 1 Stucture of Technical Education in India

The Indian Institutes of Technology are established as institutions of national importance to initiate and nurture indigenous effort for technological development. The Regional Engineering Colleges are established with the objective of bringing a major quality change in educational programmes and to train personnel to handle and manage engineering activities in the country.

The four Indian Institutes of Management represent a potent force for professionalizing management in India. Collectively they have graduated nearly 8000 MBAs whose annual earning capacity of around Rs 1000 million indicates the kind of contributions they are making to Indian industry. The IIMs have also shown a considerable capacity for adding to the teaching, training and research capability of the nation in the field of management.

Four Technical Teachers' Training Institutes were established during 60's to function as resource centres for the development of polytechnics in the respective regions. Their duties include curriculum development, teachers' training, development of learning resource material, educational research and other activities related to diploma level education.

DEFICIENCIES AND DISTORTIONS IN THE SYSTEM

The technical education system suffers from certain weaknesses and deficiencies. No doubt, there has been considerable quantitative expansion in technical education but quality suffered and there is lack of relevance. The following are the major imbalances and distortions which need focussed attention:

(i) The quantitative expansion has resulted in the lowering of standards and there exists a structural imbalance of skill requirement of the industry and business sectors and the traditional curriculum transacted by the educational institutions. These factors give rise to problems of unemployment and underemployment.

(ii) Wastage in the system is enormous. An analysis of the intake and out-turn figures of recognized institutions shows that wastage is of30% at degree level, 35% at diploma level and 45% at post-graduate level.

(iii) The infrastructural facilities available in the vast majority of technical educational institutions are extremely inadequate.

(iv) There is an acute shortage of faculty with about 25%-40% of faculty positions remaining unfilled.

(v) In most of the institutions there is hardly any R & D activity.

(vi) The technical educational institutions are functioning in isolation. Linkage and interaction between technical educational institutions and user agencies such as industries, R & D and design organisations and development sectors are not sufficiently strong.

(vii) There has been an enormous increase in public expenditure on education but little attention has been paid to the strategies for raising non-budgetary resources and maximizing people's participation.

POLICY STATEMENTS

(a) National Policy on Education, 1986 (as modified in 1992)

The National Policy on Education, inter alia, underlined the need for reorganizing the technical and management education system to effectively deal with the changes in the economy, social environment, production and management processes and rapid expansion of knowledge and advances in science and technology. It laid specific guidelines for the qualitative and quantitative development of the technical and management education sectors; establishment of linkages amongst the concerned agencies; manpower assessment and technical education forecasting; increasing effectiveness of technical education management system; proper delivery systems, measures to achieve greater cost effectiveness and generation of resources through suitable means. It further states that technician education has to play an important role in developing highly skilled middle level technical manpower for the organized as well as the unorganized sectors and necessary steps will be taken to make technician education tlexible, modular and credit-based with provisions for multi-point entry to achieve this goal. Programme of Action (poA) 1992· spells out the steps for implementation of the National Policy on Education.

(b) Eighth Five-Year Plan

The perspectives for development of technical education during the Eighth Plan have the following thrust areas:

(i) Modernization and upgradation of infrastructural facilities,

(ii) Quality improvement in technical and management education,

(iii) Responding to New Industrial Policy and Institution-Industry-R & D Laboratories interactions, and

(iv) Resources mobilization.

The strategies envisaged to achieve the objectives related to these thrust areas are explained here.

Modernization

Modernization relates to both technical equipment and teaching methods. We have to adopt futuristic approaches for achieving modernization and self-reliance in a sustained manner. Coordinated and concerted efforts are needed to upgrade and consolidate the infrastructural facilities in the existing institutions. The process of removal of obsolescence would include enhancement of computer facilities and establishment and interlinking of large computer systems with educational and research institutions through appropriate telecommunication facilities. Steps should be taken to strengthen and create facilities in crucial areas of technology where weaknesses exist, in areas of emerging technologies and in the new specialized fields.

Quality Improvement

A holistic and need-based approach will have to be adopted to reorient the technical and management education. A more broad-based tlexible system with provision for multi-point entry, is required to enable us to offer a better response to the unspecified demands of the future. At the micro level, the curriculum should be developed to encourage creativity and innovation in experimental work by introducing problem or process-oriented laboratory exercises. New technology-oriented entrepreneurship and management courses are to be introduced in selected institutions having adequate infrastructural facilities. There should be greater emphasis on production engineering and towards design and product development. It would be desirable to couple the technology forecasting with the system of manpower forecasting and planning. Universities and the IITs should play an important role in technology forecast and assessment with the fruitful involvement of Technology Information, Forecasting and Assessment Council (TIFAC), Institute of Applied Manpower Research (IAMR), and Indian Trade and Industries Associations. This would enable to develop the right type of indigenous technologies, to assess related manpower requirements and to produce related trained manpower. Existing facilities for continuing education and retraining are inadequate. There is a need to formalize the training programmes for engineering and technology personnel engaged in all sectors and to make them mandatory. Programme learning packages need to be created and distance learning methodologies employed to enable self-development and training of scientific and technical personnel.

Responding to New Industrial Policy

Momentous changes have taken place on the international scene which will have a profound impact on international relations and the world economy. Most developing countries have also embarked on bold measures of reform, restructuring their economies and opening up to forces of competition, both domestic and foreign. The Government of India also have taken new initiatives and bold decisions to reoriented and restructure the economy to meet the challenges of the economic crisis in the country through- its policy of liberalization, new Industry and Trade Policies, etc. The impact of these changes on Indian industry is considerable and it is now exposed to global as well as indigenous competition. To meet these challenges, it has to resort to modernization, upgrading technology and competence of the workforce, adopting modern management techniques and increasing efficiency and productivity. In this context, the various constituents of national development like universities, engineering institutions, national R & D laboratories and the professional bodies and academies have greater roles to play. A strategy may have to be evolved for effective interaction between them, To bring about such a meaningful interaction, a Model for University-Industry- National R & D Laboratories-Professional Bodies and Academies Interaction for country's economic development has been formulated by me. The model is shown in Appendix 4. The model identifies the areas of interaction between the various above constituents leading to country's economic development. It is imperative that each of these constituents has a Cansultancy Unit/Cell and there is a national coordination mechanism for promoting effective interaction.

Resources Mobilization

Now the time has come where the government alone cannot bear the burden of financing the technical education and, therefore, additional resources are to be mobilized to share the cost. This is not peculiar to India alone and it is the case with many other countries too. This brings into focus the need for technical education system to generate funds to supplement the funding from the government through suitable means, which will not, in any way, affect their primary task of teaching and research. There are a number of measures which could be taken up to tackle the inadequate resources situation and lessen its impact. The following measures could be adopted:

1. Avoidance of duplication of investment in technical education institutions located close to each other and proper maintenance of available facilities and instruments.

2. Developing institution-wise specialization in respect of courses and technical manpower so that the institutions can have the most sophisticated and modem library and laboratory facilities in their chosen fields.

3. Weeding out of outdated and stereotyped courses and introduction of relevant courses in emerging areas.

4. Multiple use of infrastructural facilities through part-time courses, continuing education progratmnes, consultancy and testing services.

5. Marginal increase in intake capacities in areas of scarce manpower and decrease in intake of low demand areas.

6. Introduction of multiple or at least double shifts in technical education institutions.

7. Maximum use of non-monetary inputs, like better planning, advanced technologies and practices, better system of supervision and administration, monitoring and review, etc.

8. Commercialization of the research output of the institutions.

9. Raising of fees in government-run, government-aided and unaided institutions on a graduated scale. The measure of raising fees, however, should be coupled with scholarships for SCsjSTs and for students below poverty line and a loan scheme to other students.

10. Creation of a corpus fund with contributions from industry, alumni, charitable trusts, etc as well as from government.

11. Implementing the Institutional University-Industry-National R & D Laboratories-Professional Bodies and Academies Interaction with all seriousness which will not only help towards national development but also help towards fund generation by the universities and other technical institutions.

The All-India Council for Technical Education had appointed a High Power Committee on Mobilization of Additional Resources for Technical Education under my chairmanship and the report of the Committee was submitted in May 1994. Some of the important recommendations of the High Power Committee are: (i) The Central Government should examine the feasibility of levying an educational cess on industries for funding technical education and R & D activities in technical institutions; (ii) The Government of India may set up an Educational Development Bank of India (EDBI) for financing soft loans for establishment of institutions and also to assist students to meet their fees and living requirements; (iii) A National Loan Scholarship Scheme (NLSS) may be set up under EDBI to provide soft loans to needy students; (iv) Wherever necessary, the State Governments may also set up a State Education Fund, supplementing the NLSS, to give assistance to needy students in the form of loan scholarships at nominal interest rates and easy repayment terms; (v) The plan allocation for technical education sector, both central and state, should be based and- related to the plan outlays in the industrial and service sectors and as a matter of policy, these sectors should have an appropriate share earmarked for technical manpower development and this share be made available to Ministry of Human Resources Development to be used exclusively for the development of technical manpower; (vi) The tuition fees in all government-funded and -aided institutions in all the states should be revised to a rational level of at least 20% of the annual recurring cost per student. (vii) A corpus fund is to be established in every institution.

BRAIN STORMING SESSIONS

Taking a lead from the Prime Minister's two important observations made during one of the Planning Commission meetings regarding the need for modernizing the teaching and research activities in engineering institutions like the Indian Institutes of Technology, who are considered as centres of excellence, and the need for adopting futuristic approaches to meet the emerging challenges of science and technology, a series of Brain Storming Sessions were organized in the Planning Commission to formulate perspectives for achieving excellence and relevance in technical education in the country. As a result of the brain storming sessions, documents relating to an Approach Paper for IITs and their Technology Development Missions, development of Indian Institutes of Management, perspectives for excellence in Regional Engineering Colleges, Polytechnics and Technical Teachers' Training Institutes, were prepared. These documents contain valuable recommendations and suggestions for reorientation of technical education and research.

POLYTECHNIC EDUCATION

Polytechnic education catering to the middle level technician education is equally suffering from lack of quality and relevance. In the past, the complaint was that the polytechnic courses were mostly theoretical with a very little practical bias and they were a poor imitation of the degree courses and, therefore, they did not really serve the middle level technical personnel requirements. Further, the complaint was that no attempt had been made towards specialization, that is no attempts were made to produce specialized technicians. Perhaps the situation has not changed much even now due to the proliferation of substandard institutions. The Central Government had launched a massive project with the assistance of the World Bank to enable the state governments to upgrade their polytechnics in capacity, quality and efficiency, which is quite laudable. The Brain Storming Session held in the Planning Commission on Polytechnic Education discussed in depth as how to reoriented polytechnic education and the discussions resulted in bringing out a document titled 'Towards Excellence in Polytechnic Education - Perspectives for the Year 2000 and Beyond.' This document, among other things, discusses a new concept of polytechnic education, which envisages new goals and missions for the polytechnic education system and its operation.

REGIONAL ENGINEERING COLLEGES (RECs)

The Regional Engineering Colleges are national institutions established as joint and cooperative ventures of the Government of India and the concerned state governments. They have a national character. They are expected to provide academic leadership to the other technical institutions in the respective regions. As such it is imperative that proper conditions are created which will be conducive for free academic growth and to become real Centres of Excellence. It is more so in the present changed Indian economic scenario wherein the industries have to meet the new challenges of global competition. As a result of the Brain Storming Sessions on Regional Engineering Colleges held in the Planning Commission, a document on 'Perspective for Excellence in Regional Engineering Colleges' has been brought out. The report identifies several priority activities for RECs. during the Eighth Plan and beyond. There are some deficiencies in the present system. The most important of these are lack of academic freedom, dual funding and multiple controls. Removal of these deficiencies would require some structural changes in the Regional Engineering Colleges set up. The question of granting 'deemed to be universities' status for some of the well-developed RECs and for the rest granting 'autonomous status' initially, by University Grants Commission, could be seriously considered. With these measures, it should be possible for the RECs to blossom into centres of excellence and play a leading role in helping the Indian industries and revitalizing technical education in the country.

INDIAN INSTITUTES OF TECHNOLOGY (IITs) AND TECHNOLOGY DEVELOPMENT MISSIONS

The IITs are the institutes of national importance and considered as centres of excellence in engineering and technology. A series of Brain Storming Sessions were organized in the Planning Commission on IITs in the context of the changed economic scenario and in the context of the Prime Minister's observations relating to the need for modernizing teaching research and other facilities in the engineering institutions like TITs. The discussions in the brain storming sessions first resulted in the development of an approach paper dealing with new thrust areas, international consultancy, creation of corpus fund and industrial foundation. As a result of further discussions, the five IITs and the Indian Institute of Science, Bangalore, have identified eight generic areas for taking up focussed technology development missions, as indicated in Appendix 3. The missions involve not only major research component but also a commitment to technology development through innovation and its subsequent transfer to public/private sector industry. Developing, testing and delivery of technology are very much part of the package. The missions include areas of strategic significance and export potential. It is envisaged that the funding of these projects should be through multiple agencies like Planning Commission/Ministry of HRD, other concerned ministries and industries. A National Steering Committee under my chairmanship has been constituted to monitor the progress of the technology development missions. These missions will set an example for the development of the required indigenous R & D efforts through putting together some of best brains in the academic institutions in a cooperative mode and with the involvement of the user agencies.

MANAGEMENT EDUCATION, TRAINING AND RESEARCH

The role of management in the development process is widely recognized. Similarly, management education is perceived as being important for building managerial competence. The rapid growth of industrial and commercial enterprises in the 50's produced a demand for more and better trained managers in India. During this decade, management development took place largely through short management programmes for senior administrators and managers. Four Indian Institutes' of Management were subsequently established; two during 60's at Ahmedabad and Calcutta, one during 70's at Bangalore and one during 80's at Lucknow and these four represent a potent force, professionalizing management in India. Two Review Committees were appointed on the Indian Institutes of Management. The first one, the Nanda Committee, was appointed in 1979 and the other Review Committee, the Kurien Committee, was appointed in 1991. The Nanda Committee recommended that the objectives should include training and education of (i) Managers for public utilities and services, and (ii) Management teachers. The Kurien Committee reaffirmed the Mission of the IIMs to strengthen management in business, industry and commerce. It further recommended that the mission statement needs to be expanded to emphasize lIM's conunitment to public service and public management.

The University Grants Commission is providing assistance to about 40 universities/institutes for conducting programmes in Management Studies. The IITs also decided to develop management education programmes which started during the late 70's. The thrust of the programmes is on the management of technology. A number of other private institutes of management like XLRI, Jamshedpur, are also doing good work in the field of management education and research.

During the 90's, the country is heading towards becoming progressively more integrated into the global economy. As indicated earlier, with the advent of new Industrial Policy and liberalization, the Indian industry is exposed to more domestic and global competition. Competition and pace of technological change are likely to intensify in most sectors of economy. 'Professional Management' becomes a vital component in industry. It

equally applies to other sectors of economy especially, in the context of the financial resources crunch and the need for better and effective management of available resources.

With the above situation, management education, training and research assumes greater significance and the Indian Institutes of Management, Schools or Departments of Management in Universities and other Institutes have to playa greater role in helping to formulate management strategies for the changing scenario. Unless management of public and private sector enterprises respond to greater competition in an effective manner, there will be large-scale sickness especially among smaller enterprises. The management institutes should disseminate to competing enterprises through teaching, training, publishing and consultancy, the expertise to cope effectively with competition.

In the context of changing domestic and global economic scenario, the Planning Commission has taken the initiative to convene meetings of the IIM Directors and other experts to discuss and formulate new approaches in the management education, training and research. The discussions resulted in identifying some vital issues and areas which would contribute towards strengthening management education, research and training in the country. A document titled 'IIMs and the Eighth Plan' was brought out, which identified certain priorities for the IIMs during the Eighth Plan and beyond.

Focus on innovations in management education and training and quality in research is needed. Issues and problems relating to organizational culture and commitment, productivity and quality, processes of internal change, new initiatives in the social responsibility of management, globalization of industry and trade and relevant strategies for India are to be addressed and solutions sought. In this context, the IIMs, universities, other institutions of management, professional bodies like the Association of Indian Management schools have a responsible role to play.

TECHNICAL TEACHERS' TRAINING AND ORIENTATION

Technical teachers' competence and updating of knowledge are crucial for the improvement of the quality and excellence in technical education, Teacher is the pivotal in the teaching and learning process, As such, it is important that suitable facilities are' provided for teachers' training and orientation.

The Technical Teachers' Training Institutes (TTTIs) have been doing pioneering work in the areas of technical teachers' training, curriculum development, institutional model development, research and development, consultancy and extension services related to technician education. The objectives of TITIs have become all the more relevant in the context of the National Education Policy, the recent World Bank assisted project for strengthening technician education in India and also in the context of the changed economic scenario. As observed by the Review Committee on TITIs (1990), in spite of high internal efficiency exhibited by these institutes in undertaking various programmes and activities, their external efficiency in tenus of improving the quality of technical education system is less significant. A major reason for this is the constraints and limitations imposed on these institutes because of their present status and because of the lack of authority required to introduce, modify and close down programmes depending upon the changing context of technician education in the country. To overcome the above constraints and to ensure that TITIs are able to play the role of bringing about excellence in technician education, the recommendation of the Review Committee that these institutes are accorded some kinds of exalted status and dignity, is quite relevant.

A major consequence of the brain storming sessions organized in the Planning Commission on TITIs is the preparation of a document 'Perspectives for Excellence in Technical Teachers' Training Institutes.' The document indicates a set of clear directions for TITIs to be pursued in the future during the turn of the century. This new design should benefit' technician education and many other related constituencies.

At higher technical education level there does not seem to be any concerted effort for teachers' orientation and training. The Academic Staff Colleges established by the University Grants Commission at some of the universities lire mainly catering to the general disciplines of higher education. Therefore, there is every need to establish mechanisms for teachers' training and orientation at higher technical education level. In this context, it would be desirable to pursue the project proposal formulated by the Jawaharlal Nehru Technological University, Hyderabad, with which I was associated as it') Vice-Chancellor in the past, for establishment of a National Academy of Pedagogy in the engineering, technology and management, which was already approved in principle by the AICTE, is worth pursuing. In addition, the Academic Staff Colleges of the UGC should also be strengthened for covering the needs of the technical teachers' training and orientation. Distance education mode could also be utilized for technical teachers' orientation.

DISTANCE EDUCATION MODE IN ENGINEERING AND TECHNOLOGY

Education imparted through the Open University System is not a rival but a complimenting approach to formal system. Distance learning system facilitates democratization of adult education process. Many countries in Asia and elsewhere have provided opportunities for adult education by adopting the open education system and set-

up, for this purpose, higher educational institutions of distance learning. There has been significant developments in the field of communication technology like use of satellites for telecast of educational programmes and computers for learning. Adopting such new technologies in distance education can help to cut costs and improve quality, equity and participation. Even though distance teaching may tend to prove to be the most flexible and the most easily adapted alternative approach, it demands a lot of efforts to maintain quality and standard in the e~ntent of a degree programme or an enrichment programme meant for competence upgradation or a vocational programme for that matter. Distance teaching also needs an innovative approach for its success. India having its own multipurpose satellite is well set for using electronic media for distance learning.

Distance education progranulles offered are mostly in non-engineering, non-technological or non-vocational areas in India. Attempts to provide distance education programmes, in engineering, technology and vocational courses are very few except by some of the professional bodies like the Institution of Engineers (India). Courses which are suitably designed and developed could be offered through distance education mode in engineering, technology and vocational areas with success and acceptability.

The working engineers in the country, especially those who are in the far-flung areas, need opportunities to upgrade their expertise and qualifications. Distance education mode can provide the needed opportunity. The Jawaharlal Nehru Technological University, Hyderabad, is the first university in the country to provide distance education opportunities in engineering and technology for working engineers and scientists to remove obsolescence and provide opportunities for updating, upgrading, broadening and diversifying their knowledge and skills. The university is offering Distance Education Programmes in B Tech and M Tech. The university has already opened its doors for external registration for MS and PhD programmes for working engineers in the country. Such an 'open' concept in engineering and technological education should be encouraged.

MANAGEMENT OF TECHNICAL EDUCATION

The technical education system should be dynamic and capable of responding to the changes in the socio-economic conditions of the country, national aspirations, objectives and goals. For this, the system should be efficient and the concerried people should have freedom for operation and innovation.

In the Indian technical education system, there are two levels of organizations - at the Central and State levels - with a complex interface between them, for the management of technical education, in addition to institutional management. The All-India Council for Technical Education (AICTE) is responsible for planned and coordinated development of technical education, promotion of qualitative improvement and regulation and maintenance of norms and standards. The University Grant Commission (VGC) has also a role to play in the development of technical education, as it finances about 32 university departments dealing with higher education and engineering. It has also the authority to recommend 'deemed university' status to institutions to the Central Government.

Most of the state governments have established Directorates of Technical Education for effective administration of technical education. However, the academic control of state level engineering colleges vest" in the universities to which they are affiliated. Each state has set up a State, Board of Technical Education for giving proper direction to the development of technical education in the state. At the diploma level the academic control is also exercised by the State Board of Technical Education. In case of government engineering colleges and polytechnics full administrative control and financing of institutions is exercised by the government. Aided private institutions are managed by a Board of Governors with representation from the government.

It is essential that the management system should be effective and functional with sufficient decentralization. Even more important, the system itself should be responsive to changes as indicated earlier. It is imperative on the part of the AICTE to evolve suitable management structure for different types of institutions.

Autonomy to selected engineering institutions will help towards freedom and innovation in academic activities. 'Corpus fund' concept will facilitate reaching towards 'financial freedom' as well. These approaches and ideas deserve all the support when we are aiming at excellence in technical education.

CONCLUSION

The impact of the change in global and national economic scenarios is the emergence of an era of global consciousness. The industries require, among other things, a workforce having a scientific bent of mind a possess the much desired temper and skills to maintain high quality and productivity at par with the world standards. Our R & D efforts should also be-geared up commensurately. The science and technology education and research have, therefore, to respond to these emerging challenges to train men and women of calibre and competence of world standards and provide the needed R & D capability. In addition, the explosion of knowledge in science and technology sectors requires highly talented men and women whose fast grasp of knowledge could enable them to respond tv the desired innovations in advancing the frontiers of knowledge and

know-how. However, the success in this regard will depend upon our abilities to cope up with the emerging pressures of resources crunch on the one hand and the need for upgradation of the quality of science and technology education and research on the other, through proper reorientation.

APPENDIX 1
Growth/Enrollment of Technical Education

Year	Post-graduate Level		Degree Level		Polytechnics	
	Institution	Enrollment	Institution	Enrollment	Institution	Enrollment
1947-48	8	136	38	2940	53	3670
1990-91	140 *	12 500	372	88 930	958	152 554

* Among the 140 institutions at Post-graduate level, 50 institutions including four IIMs having an enrollment of 4000 students are imparting management education.

The remaining 100 institutions offer post-graduate programmes in engineering and technology and have an annual intake of 9000 students.

In 1990-91 there are also 130 institutions at degree level with an intake of 84 393 students imparting medical education.

APPENDIX 2
Plan-wise Total Outlay of Education Outlay/Expenditure on Higher and Technical Education from First to Eighth Five-Year Plans

Five-Year Plans	Total Plan Outlay	Total Education Outlay	Percentage of Education Outlay to Plan Outlay	Higher Education Outlay	Expenditure on Higher Education	Technical Education Outlay	Expenditure on Technical Education
First Plan (1951-56)	1960	169	8.62	15	14	23	20
Second Plan (1956-61)	4762	277	5.82	47	48	51	49
Third Plan (1961-66)	8577	560	6.53	82	87	142	125
Fourth Plan (1969-74)	15779	822	5.21	183	195	106	106
Fifth Plan (1974-79)	40097	1285	3.21	292	205	156	107
Sixth Plan (1980-85)	97500	2524	2.59	486	537	278	318
Seventh Plan (1985-90)	180000	6383	3.55	*420	1190	683	1085
Eighth Plan (1992-97)	434100	21 217	4.89	1515.55	—	2786.38	—

* Only Central sector outlay

Source: Planning Commission, Government of India., New Delhi

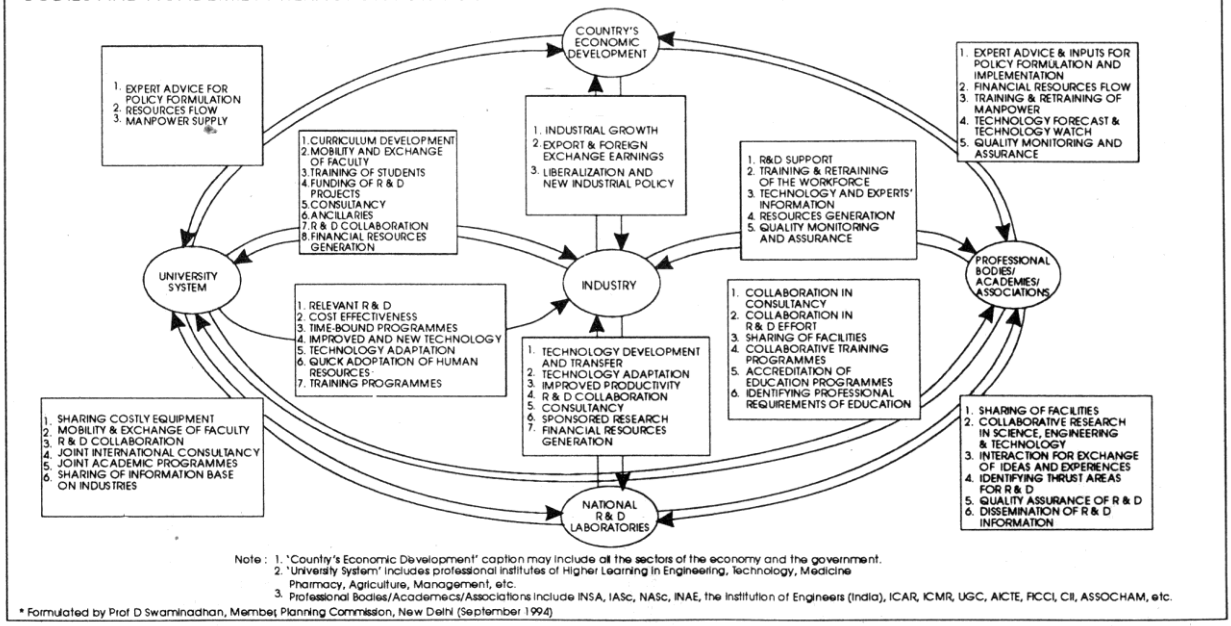
APPENDIX 3

Technology Development Missions

Generic Area	Coordinating IITs and IISc
Food Process Engineering	Kharagpur, Bombay
Integrated Design and Competitive Manufacturing (Engineering and Industrial Design, FMS)	Kanpur, Bombay
Photonic Devices and Technology	Delhi, Kharagpur
Energy Efficient Technology and Devices (Fuel Efficient Engines and Coal)	Madras, Delhi
Natural Hazards Mitigation (Use of Remote Sensing Applications)	Bombay, Madras
Communication, Networking and Intelligent Automation	Kanpur, Kharagpur
New Materials (Composites and Electronic Materials)	Madras, Delhi, Kanpur, IISc
Biotechnology and Genetic Engineering	Delhi, Kharagpur, IISc

APPENDIX 4

*A MODEL FOR UNIVERSITY-INDUSTRY-NATIONAL R & D LABORATORIES-PROFESSIONAL BODIES AND ACADEMIES INTERACTION FOR COUNTRY'S ECONOMIC DEVELOPMENT



Note : 1. 'Country's Economic Development' caption may include all the sectors of the economy and the government.
2. 'University System' includes professional institutes of Higher Learning in Engineering, Technology, Medicine Pharmacy, Agriculture, Management, etc.
3. Professional Bodies/Academecs/Associations include INSA, IASc, NASc, INAE, the Institution of Engineers (India), ICAR, ICMR, UGC, AICTE, FICCI, CII, ASSOCHAM, etc.

* Formulated by Prof D Swaminadhan, Member, Planning Commission, New Delhi (September 1994)

The Ninth Dr Ajudhia Nath Khosla Memorial Lecture was delivered during the Eleventh Indian Engineering Congress, Bangalore. December 20-24, 1996

Strategies to Meet the Challenges in the Power Sector

Rajendra Singh

Chairman & Managing Director, NTPC, New Delhi

The continuance and durability of an institution, especially through periods of cataclysmic changes, is a fair indication of its vision, its relevance, its resilience and its utility. The Institution of Engineers (India) has completed seventy-five years of its institution and is meeting for its 76th AGM having completed. sixty years of its incorporation in 1995. I congratulate Shri P M Chacko, President of the Institution, and Maj Gen S P Misra, its Secretary & Director General, on the completion of the 'Platinum Jubilee' of the institution and the 'Golden Jubilee' of the incorporation of the IEI and I also thank them for providing me with this opportunity to share my thoughts with all of you in this august forum of engineers and technologists.

It is pertinent to underscore the total change that the world has undergone since 1920. In the year 1920, when IEI was established, the League of Nations, formed in 1919 at Paris, held its first session at its headquarters in Geneva to oversee the issue of world peace after the First World War and this year, 1995 witnessed the 50th session of its successor. The United Nations, trying to come to grips with a post-cold war new world order. Also, in 1919 the world was flush with its strident pro and anti Socialist- Communist stance in the wake of the Russian Revolution and today in 1995, we inhabit a world where that socialist order is getting wiped off the face of the 'global polity'. In India, the year 1920 was marked by vehement opposition of the Montague- Chelmsford Reforms by the Indian National Congress. Indian industry was at its extremely nascent stage with a few units in the area of steel, cotton and jute textiles, chemicals, etc. The year 1935, the year of lEI's incorporation, saw the enactment of the Government of India Act and a flurry of political activity in its wake. The industry was yet to have a substantial size and variety which it later started acquiring when it had to contribute to the war efforts of Britain. Today, we are in the fifth year of our economic reforms and liberalization efforts and are on the threshold of the 21st century. In fact, for many students of history, the 'extended 19th century' lasted till 1919. So, lEI has travelled through the entire 20th century as it were.

I feel happy that we are assembled in this unique city – Jaipur for the 10th Indian Engineering Congress and for the series of Memorial Lectures. As a civil engineer, I feel particularly proud of the rich tradition of engineering, town planning and architecture exemplified by this city built as early as 1728. The broad avenues, the symmetry and harmony of construction, the grid system and fortification arrangements, the rich synthesis of Hindu, Jain and Mughal influences and above all the impeccable planning make this 'Pink-City' an engineer's as well as a tourist's delight as opposed to an aesthete's lament about a city growing in a disorganized way, in the words of Kipling:-

'... Chance directed ... chance erected
..... grew a city... more's the pity.'

What holds true of a city, holds equally true of all our endeavours - whether in our economy, in our industries or in our specific sectors - we have to good planning and proper implementation. Dr A N Khosla was a meticulous planner, rigorous investigator and researcher who verified all the findings before thinking of implementing them. He had the sagacity of integrating diverse objectives while formulating a scheme. One can use epithet after laudatory epithet to describe Dr Khosla without the slightest risk of exaggeration. Known as the father of river-valley projects in India, Dr Khosla, in my opinion, is among the foremost builders of the 'temples of modern India'. Hirakud, Bhakhra Nangal and Ram-Ganga are abiding testimony of his genius and his concerns. He made invaluable and innovative contributions to civil engineering through his theories and inventions, his investigations, researches, and development and management of water resources from the mid-twenties to the mid-sixties. Design of weirs on permeable foundation and propounding the concept of the basin as a unit of development are some of his pioneering efforts. In a broadcast to the nation in 1945, he had said that while planning the projects 'account should be taken of the social benefits as well as economic, general benefits as well as special and potential benefits'. It is people like Dr Khosla who built the foundations upon which we are in a position to take off in the market driven competitive environs of today.

Today, India is poised for a great economic transformation and notwithstanding the daunting challenges in a populous, democratic, capital-scarce, pluralist and federal polity, we have covered substantial ground since 1991 and along with China, India is perceived as the major arena for economic-industrial activity. However, to make the transformation happen, India needs a world class infrastructure which is a necessary precondition for the

kind of growth we require. It is very appropriate that the theme of this Congress is: 'Infrastructure - Its Importance in the Development of the Economy'.

Infrastructure requires high investment and relatively long gestation. Further, with declining investment and support by the government which was the prime investor in this sector till now, a shift towards private participation and commercialization is an imperative. Most areas of infrastructure have sector specific issues to grapple with. And for successful commercialization of the sectors under infrastructure, viz, energy, transport, water supply, communication, housing, financing, etc, we need strong institutional structure and a conductive legal framework. .The states, too, have to work in tandem with the centre to obviate apprehensions among the investors. We have to insulate development of infrastructure from the vagaries of political vicissitudes through suitable legal administrative- financial mechanisms in the changing global national economic scenario. Or else, we may just miss the bus. The West is watching the 'economic miracle' sweeping across many countries of Asia in a transfixed state. If India has to join the action, we must change our mind-set and our approach, especially in the infrastructure sector. As a Japanese saying aptly puts it 'you cannot do today's job with yesterday's tools and be still in business tomorrow.'

We, in the infrastructure sector, have to attune ourselves with the changing needs and circumstances. Within infrastructure, energy, being the prime mover and also being the most capital intensive sector, is attracting tremendously popular, populist and media attention. It is attracting the investors too. Between July 1991 to July 1995, Rs 1000 billion worth of foreign direct investment has been approved. Keeping in view the tremendous demand-supply gap, India is and will remain for some time to come, a 'power scarce' economy.

To meet the 'power challenge' effectively under our unique political- economic circumstances, we need to maximize our power supplies at minimum possible investments. I feel that optimum utilization of our existing capacity provides a very cost effective and prompt way of creating substantial supply of power. Augmenting our existing capacity through renovation and modernization of existing plants, curbing transmission and distribution losses and improving the performance and reliability of the plants, we shall be able to supply substantially additional amount of power from the existing capacity at much less costs compared to those required for adding new projects. But we have to add greenfield projects too. All this has to be done along with restructuring or realigning of the major players in the power sector like the State Electricity Boards, the RLOCs, the IPPs, CEA, etc. I shall try to give a structured description of the major issues concerning the power scenario in India and of the strategies to realize the objectives of providing reliable power, clean power and green power to the country.

HISTORY OF POWER SECTOR

In 1897, India had its first power plant, a hydro electric machine of 130 kW near Darjeeling. At the time of independence, power availability was in pockets totalling to an installed capacity of 1363 MW. Since then the power industry had grown phenomenally. As on March 1995, the installed capacity of India is 81 164 MW.

The transmission which started with a voltage of only 78 kV has now matured into a 400 kV grid and 500 kV HVOC systems for bulk power transfer. Recently, the Central Power Research Institute (CPRI) has test charged a 1500 kV HVOC line. The distribution system which started with a few circuit kilometres, today has a length of 2,82 billion circuit kilometres.

HYDRO-THERMAL MIX

For meeting energy and peak demands at optimal cost, traditionally a 40: 60 hydro-thermal mix was favoured. But due to problems like

- high capital requirement;
- very long gestation periods; and
- associated environmental problems, etc;

the hydel sector's share in total installed capacity has reduced from 44% in 1970-71 to about 26% in 1994-95. Without losing sight on short-term problems, the country need to improve the share of hydro sector.

CURRENT SCENARIO OF POWER SECTOR

As of March 1995, India has an installed capacity of 81 164 MW of which 20 829 MW in hydel, 58 110 MW in thermal and 2 225 MW in nuclear. In the Eighth Plan period, the government initially estimated the additional demand to be 48 000 MW. But considering the resource crunch, the target was fixed at 30 538 MW, of which the likely addition will not be more than 18 500 MW. This is likely to result in a peak demand shortage of 28%-29% and energy shortage of 14%-15%. If the grid conditions have to be healthy then load shedding will be inevitable and rough1y one-third of the country will have to go without power in the peak hours. It is alarming; but then we may be heading towards that only.

The new capacity requirement for the Ninth Plan period is estimated to be 56 783 MW. The country will watch with concern the extent of the realization of this target.

POWER SECTOR — AN OUTLOOK

The power sector of our country is on the cross roads today. It is riddled with multifarious problems — right from demand-supply management to deciding on an appropriate regulatory framework. We may broadly structure the discussions on the following lines:

- Supply and demand management;
- Adding new capacities;
- Restructuring of SEBs;
- Dispatching and Electricity pricing; and
- Sustainability of growth.

Supply and Demand Management

The prime purpose of the power sector is to meet the demand with fairly good reliability and at least cost. With the economy growing fast, we need to predict the growth in demand to plan for new capacities. As the new capacities take considerable time to yield benefits, advance planning becomes essential to meet the demands of future. The Central Electricity Authority (CEA) conducts annual electric power surveys to assess the growth in demand which forms the basis for planning new capacities.

In general, the demand-supply management aims at augmenting the power supply at least cost on the one-hand and pursuing to improve the efficiency of usage of electricity at the user's end. Also, it attempts to even out the consumption by various segments of consumers over the day through a variety of incentives and disincentives. Demand-supply management can be done in a better way, though already being attempted partly, by better utilization of existing capacity; reducing transmission and distribution (T & D) losses; energy conservation; peak demand management; and new capacity addition;

Utilization of Existing Capacity

The country's generation capacities have been grossly underutilized. For 1994-95, our thermal plant load factor (PLF) was 60% as against 79% for South Korea which also is a developing country. The reasons for under-utilization may be many; like lack of resources for renovation and modernization, non-availability of required skill base with SEBs, etc. But the fact remains that the country did not get the full benefit of the investments made.

It is a matter of concern that only 31 857 MW is available to the consumers with an installed capacity of 81 164 MW with a transmission and distribution loss of 21.5%. A 10% improvement in thermal PLF in existing capacity will be equivalent to 8300 MW of new installed capacity. This is the potential available on this account for a relatively smaller investment.

The main avenues to improve the capacity utilization will be

- Availability improvement by using beneficiated coal
- Addressing systems' problems
- Renovation and modernization (R & M)
- Cycle efficiency improvement

The use of beneficiated coal is one of the surest and eco-friendly ways of improving availability. With reduced erosion and equipment breakages, the coal with reduced ash content and free of foreign materials will reduce forced outages. The beneficiation of coal through washeries will have additional benefits.

- Reduced burden on transport system. Power stations consume 180 Mt (approx) of coal and this has an average of 35% ash.

- Shale removed at source, ie, mines, will be useful to stow the mines. This will help avoid degradation of the land near the power stations. At Ramagundam STPS of NTPC, experiments of stowing the mines with bottom ash proved successful. This has good potential all over India.

Addressing systems' problems are the cheapest ways to improve availability substantially. The performance of Unchahar TPS (2 × 210 MW), which NTPC acquired from the Uttar Pradesh Government was improved dramatically by using debottlenecking techniques successfully. Details of the performance improvement are given below:

Performance parameter	Prior to take-over	Six months after take-over	12 months after take-over
PLF, %	18.02	35.52	73.69
Availability factor, %	27.22	49.51	78.96
Specific oil consumption, Ml/kWh	21.83	6.32	3.33

The efforts for renovation and modernization and cycle efficiency improvement too need substantial resources, though not as much as for setting new capacities, and also technical expertise. Many of the SEBs may not have these. Therefore, organizations having both expertise and capability to raise resources could be allowed to make investments in this field. But then remains the question of working out a mechanism for inviting investment for this purpose and sharing the benefits of the performance improvement.

T& D Losses

The T & D losses are as important as generation. But, unfortunately, the T & D systems have not got the attention they deserve. While the investment on generation capacity grew phenomenally, that on T & D systems dropped substantially. The investment on T & D systems in the First Plan was 54% of the power sector outlay while today it stands at 28% in the Eighth Plan. The actual expenditure on T & D systems in 1993-94 was only 25% of the power sector's annual plan.

The T & D losses are technical and commercial in nature. While the losses in developed countries is 7%-8%, in India the losses (both technical and commercial) accounts for 21.5%. The main areas that we need to concentrate on:

• Administrative means to ensure that electricity supplied is billed and what is billed is paid for.

• Technological upgradation of our transmission system. The country's main transmission network is still 220 kV. Upgrading transmission voltage, deployment of EHVDC links for bulk power transmission are of utmost importance.

• Building enough redundancies in the system. Apart from reducing losses by reducing congestion in dispatching, it also helps building a competitive market by allowing free trade of electricity.

• Upgradation and modernization of the distribution network.

• Improving the systems with the state-of-the-art technologies.

Reducing T & D losses to 10% and with a PLF of 70%, the power available for consumption at the user's end can be augmented by 9200 MW. A subject of this importance deserves serious attention.

Power Development Fund is an innovative concept I have presented before the Sub-Committee of National Development Council. It envisages a nominal levy of 10 p/kWh on electricity sales. It is estimated that Rs 3500 crores can be mobilized annually from such a levy.

The proposal is to retain 25% of the fund as reserves and make available 75% as loans to the utilities/agencies who contribute at a nominal interest of 2%-3%. This fund will be utilized on approved schemes for renovation and modernization of power stations, improvement of transmission and distribution systems and for meeting part of capacity addition requirements. To give due attention to all the areas, it is proposed to fix caps on exposure limits for various schemes.

With the yearly accumulations, and additions from fund operations, it is estimated that this proposal will yield about Rs 22 000 crores in the Ninth Plan and Rs 48 000 crores in the Tenth Plan. This will be a boon to the fund starved R & M programmes and T & D improvement schemes as also to facilitate some new capacity addition.

The fund could be managed by a body of experts. Thus, the nominal levy from the ultimate customer will be used to provide hefty benefits to him by improving capacity utilization and reducing losses.

Energy Conservation

Another front to be confronted is energy conservation on the demand side management.

The most inefficient use of electricity takes place in agriculture sector, the agriculture sector consumes about 30% of the country's power generation. The water pumping system that can operate at much higher efficiency level, operates today at 25% - 30% efficiency. The agriculture sector has consumed 27 billion units in 1993-94 and imagine what a 100% improvement in efficiency levels in water pumping systems will do to the country?

Industrial sector cannot only save up to 30%-40% of power consumption by deploying right technology, process, right machine and skill but can save manifold by improving the quality of their products, especially electrical appliances.

One notes with satisfaction that the efficiency of refrigerators and air-conditioners have improved by 102% and 42% respectively by 1989 from 1972 levels. In the USA the efficiency of cars has improved by 92% from 1973 to 1985.

Lastly, the lighting, both domestic and public, has a potential to save up to 20% by simple measures like house keeping and usage of energy efficient devices.

An area of this high potential like energy conservation has not been given adequate attention. Priority in lending money through banks at concessional interest could be made available to manufacturers who commit to make products conforming to 81S. This will help the economy in a big way.

Peak Demand Management

The demand for power is not uniform all through the day. In the mornings and evenings the demand is at its peak. Meeting peak demand is one of the most important as it involves the common public as the predominant consumers. Loss of load in the peak time will put the public at large into inconvenience. With the current rate of new capacity addition, it is estimated that the country will face a peak power shortage of 29% by the end of the Eighth Plan.

The management of peak demand can be achieved by addressing the problem on various planes:

• By developing spinning reserves for meeting the peak demand. Hydel is the most suitable for Indian conditions though in most advanced countries GTs are used for this purpose. These GTs are operated on 'Daily Start and Stop' (0 & S) basis. For Indian conditions, adequate pump storage generation capacities, may be most suitable.

• Another strategy will be to develop adequate inter-regional power transfer facilities (EHVDC links). Peak times may slightly differ from region to region. This can be made use of to meet the demand of one region with power from other regions. A national grid thus formed with inter-regional links will facilitate establishing inter-regional balancing of power supplies and better utilisation of installed capacity.

• Levying differential tariff for peak and non-peak hours as is being done by some of the Electricity Boards. This will involve 'Time of the Day' (ToD) metering and will help flatten the peak.

Adding New Capacities

New capacity addition: For the industrial activities to pick up adequate and reliable power availability is an essential pre-requisite. Though the full utilization of the existing capacity is of utmost importance, it cannot be a substitute for new capacity addition.

With

• Indian share being a meager 0.43 in world trade

• India's per capita electricity consumption of about 270 kWh, is way behind even our neighbors like Pakistan and China

• The growth of Indian economy starting to pick up, there cannot be a second opinion about increasing our installed capacity.

The new capacity can be of conventional and non-conventional nature. While enough attention is being given for conventional generation capacity, the non-conventional energy field would need further impetus.

Wind energy is one of the important sources of non-conventional energy. Against an estimated potential of 20000 MW, the country till March '95, could tap only 235 MW. Currently about 2000 MW is under process.

Another important source of energy is the sun. The country is blessed with ample sunshine throughout the year and there is vast solar energy potential to be tapped. We have not made much headway in this field of high potential. I strongly recommend a very heavy dose of R & D expenditure in this area.

With

• the limited availability of fossil fuel
• the associated environmental problems of using fossil fuel on a continued basis
• the growing concern for deteriorating environment

I feel this is time for us to focus equally on non-conventional energy as a serious source of energy to be tapped. Apart from providing 'Green Power,' the isolated wind farms and solar powered agricultural farms will reduce transmission congestion and eventually T & D losses.

Appreciating the huge additional capacity requirement, a prerequisite to our economic development, and the quantum of funds required, government has invited private investors to participate in the expansion of the power sector.

Putting up of 56 783 MW in the Ninth Plan will require $ (US) 67 billions. To facilitate and attract private investment the government has announced several policy initiatives.

Some of the salient concessions being offered to new investors are:

1. Return of equity 16% at 68.5% PLF
2. Full fixed cost recovery at 68.5%
3. Up to 0.7% additional ROE on each one per cent incremental PLF beyond 68.5%
4. Debt-Equity ratio up to 80 : 20
5. Capitalization of interest during construction (IDC) at actual cost instead of at 1% over RBI rate
6. Longer license duration of 30 years in the first instance and renewal for 20 years
7. Tax holiday for initial five years
8. Low customs duty for import of capital goods

The result of this is that more than 200 project proposals have been received by the government for a total capacity of over 80000 MW. But still as we all know, the translation of the proposals into reality is very slow. GOI has to initiate actions to speed up the process by removing the impediments. The problems / factors that come in the way of speedy translation of the proposals into reality will have to be studied in detail and resolved. However, it must be underlined that in view of the crucial role being played by the State sector in the area of power and also the realistic future scenario, continued significance of the State sector is a must for an integrated and coordinated development of power generation, transmission and distribution. A number of measures can be taken up to facilitate speeding up of capacity additions both in the public and private sectors. To speed up the project implementation, the government has to simplify the project clearance procedures and finalize a time frame for according approval.

Another area for the government to take initiative is ensuring fuel availability. The government could permit private mining instead of limiting it to the generating companies, for meeting their fuel requirements. Recently, the government has made some announcements regarding liquid fuel-based power plants. While HSD has been excluded for power generation, the policy encourages use of heavy fuel oil (HFO), low sulphur heavy stock (LSHS), heavy petroleum stock (HPS), naphtha, etc for the purpose of power generation. Use of liquid fuel for captive generation by industries, generation linked to the residual fuel of a refinery, and stations dedicated to and located near the load centres, is sought to be encouraged. What is really needed is a National Fuel Policy to facilitate faster investment decisions. Also the government has to develop a long-term perspective on the import of natural gas. Railways should be encouraged to enter into long-term fuel transport contracts with their customers.

The investors both in public and private sectors have to be assured of their legitimate payments by the customer SEBs. Due to the poor financial health of many of the SEBs, the government has come out with a range of alternative counter-guarantees to provide comfort to the investors.

Notwithstanding the counter-guarantees and alternatives to it, nothing can substitute a healthy and reliable customer, namely, the SEB.

Restructuring of SEBs

It is a common knowledge that the SEBs are in a poor state of financial health. Their accumulated losses in 1994-95 stood at Rs 6332 crores and is estimated to climb up to Rs 7130 crores in 1995-96. This is a direct fallout of the 'effective subsidy' being offered to agriculture sector and cross-subsidization of domestic sector at the cost of industrial and commercial sector. The net rate of return (RoR) that the states have earned in 1994-95 was (-) 13.5% against statutory 3%.

The average cost of generation in 1994-95 was 159.9 p/kWh while average revenue stood at 132.9 p/kWh. This poor state of health of SEBs is coming in the way of fructifying massive investments to power project from private sector.

As stated earlier, no amount of guarantees can substitute the health of SEBs. Today at least five states have come forward to reform their SEBs. Of the five states, Orissa, Andhra Pradesh, Rajasthan, Uttar Pradesh and Haryana, the reform studies are in an advanced stage at Orissa. As per the Orissa model, the SEB will be

restructured and three entities will emerge as: (i) Generation Company; (ii) Transmission Company; and (iii) Distribution Company.

But the experiences elsewhere in the world on unbundling SEBs and privatizlnj them show that there can be a combination of horizontal and vertical integration/disintegration.

Apart from above said vertical disintegration, the generation and distribution can be vertically disintegrated such as hydel and thermal and HT and LT consumers. Also there can be horizontal disintegration in generation and distribution on territory basis. The experience of other countries show certain amount of vertical integration of generation with distribution. But then a proper model to suit our systems is yet to be developed.

The following advantages are expected out of the restructuring experiences:

- Reduction in technical and commercial losses
- Improved reliability and customer service
- Independence in commercial operations
- Commercial viability
- Rationalised tariff
- Handling of social and economical costs directly by the states
- Improved efficiency due to competition
- Enhanced confidence in IPPs regarding their payments.

The reformed power sector, I believe, will be more vibrant and will support the economic upsurge of the country.

Dispatching and Electricity Pricing

Dispatching the generation of power stations with minimum loss and at least cost is one of the vital functions of power industry. Dispatching based on merit order rating of the generating stations contributing to the grid will be the ideal way as it ensures the power generation at least cost. However, bulk of the dispatching in India is done on the basis of long-term contracts. But the entire dispatching cannot take place on the basis of merit order rating or longterm contract, mainly because dispatching has other objectives like maintaining grid frequency, matching demand and supply in the short run, minimizing losses in transmission, and overcoming transmission constraints and congestions.

Still it is beneficial to the system and to the ultimate consumer to do dispatching based on merit order rating. to overcome transmission congestion and other constrains, substantial investments to augment and upgrade the transmission and distribution network commensurate with the investments being made in capacity additions is to be done on a priority basis. Above all this will ensure a stable grid.

Sustainability of Growth

Every mega project such as the power project has a social cost and an environmental cost. It is not that we produce power: but produce 'Green Power' at minimal cost to the society.

A thermal power project consumes many natural resources such as coal, water, land, etc belonging to the society and pollutes air, land and water. The thermal sector consumes more than 180 Mt of coal and generates more than 54 Mt of ash.

A hydel project submerges a vast span of land and brings in seismic risks apart from disturbing the ecology of the neighbourhood.

A nuclear plant brings in operational risks-related issues as well as nuclear waste disposal-related problems.

Thus these projects carry substantial social and environmental costs, which the project should address adequately. Unless the project goes with the environment, the development cannot be sustained. In today's context, substantial portion of the project cost is spent to address the social and environmental issues such as

- rehabilitation and resettlement of project affected people
- community development
- pollution abatement
    - particulate in flue gas;
    - SOx and NOx in flue gas;
    - high pH of ash water, etc
- Industrial safety, etc.

But now serious consideration is being given by industries to increase the green cover. It is amply clear that. with the growing awareness and stricter norms of environment pollution, and ecology- related issues and with

numerous NGOs actively participating in the movement, industries need to develop strategies to sustain growth in the most environment-friendly way.

CONCLUSION

Finally, if we look at what has been said earlier, some of the significant points can be summarized as below:

• Utilizing the existing capacity to the fullest possible extent is as important as creating new capacity.

• The mechanism to clear new capacity addition should be simple, rational and time-bound.

• Technological advancement should go hand in hand with political will and managerial innovation for the power sector to emerge as a viable sector.

• Sectoral reorganization is a must to infuse health, confidence and competitiveness.

• While it is important to increase the productive efficiency of generation and transmission agencies, it is imperative to improve allocative efficiency to optimal levels.

• Creating enough transmission and distribution facilities to evacuate the power effectively.

• Dispatching to be based on merit order rating of the generating stations.

• Sustainability of growth and development is the most important of all.

• Commercializing every aspect of power management under the cardinal principle:

• What is installed must generate;

• What is generated must be transmitted;

• What is transmitted must be distributed;

• What is distributed must be billed; and

• What is billed must be paid for.

Commercialization and reorientation of the power sector will go a long way towards strengthening our infrastructure. The state sector and the private sector, both have to work in unison and with urgency towards the growth and modernization of power sector. The efforts at growth and modernization are to be carried under the overarching socio-economic imperatives which determine our national objectives and policies. Our economy, our infrastructure sector and within it, the power sector, all are going through a phase of transition. Like many other developed countries have done before us, we too are going through the path of a learning curve and I am quite confident that the Indian power sector will quickly acquire the desired impetus and will provide the thrust and dynamism to the other sectors of Indian economy even as power sector itself evolves into a mature and competitive market allowing for free inter-play of productivity, profitability and excellence in harmony with the sustainable growth of Indian economy.

The Ninth Dr Ajudhia Nath Khosla Memorial Lecture was delivered during the Eleventh Indian Engineering Congress, Bangalore. December 20-24, 1996

Manufacturing - Global Scenario

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ABSTRACT

Manufacturing is as ancient as human civilization. But, it became a technology when steam Engine was invented and manufactured. Later on it grew into Engineering and changed over as Science. It is today a business of Science with Technology as one of the three components and other being Management and Workforce. This paper is devoted to bring out the global scenario and chronological events and development of manufacturing, evoluation of F.M.S., ClM and Agile Manufacturing with examples at home and abroad, for global competitiveness.

INTRODUCTION

Manufacturing activities world over, is witnessing rapid changes hitherto never imagined, keeping in tune with never ending and ever changing demands of customers. Made to customer be it one or one million, will be the slogan of next century. This demands techno-economic newer materials and methods of manufacture for customised products. It is therefore necessary to arrive at the method of flexible manufacture that provides advantages and cost- effectiveness of automated manufacturing.

DEVELOPMENT OF MANUFACTURING NATIONAL AND INTERNATIONAL

Twenti-first Century will be the era of modern manufacture. The development of manufacturing technology has been going on since prehistoric time. Man had learnt to manufacture fire by rubbing of sticks. In the stone age man learnt to sharpen stone so that he could hunt with them. Later on when he discovered the knowledge of agriculture, he needed the basic knowledge of manufacturing to make his implements. The progress in the field Of manufacturing increased by leaps and bounds during the Industrial Revolution.

Table l and Fig. 1 explain the chronological events in manufacturing in India and global development of manufacturing respectively.

TABLE 1 : Choronogical Events in Manufacturing in India

1930-60

India started in-house R & D towards development of Machine Tools, Organised production of Machine Tools in 50's. Collaboration with firms from west Germany, Switzerland, U.K., U.S.A., France and Italy. Central Machine Tools Institute started in Bangalore.

1960-70

New Breed of Machine Tools like N.C Lathes, N.C Tool Room Milling Machines and N.C Machining Centres started. Introduction of CAD/CAM.

1970-83

First Indian CNC Machines introduced, R & D provided by CM. T.I. manufacturing by HMT (Both these centres contributed prodigiously). 1973 - First Indian N.C Machine built, 1979 - First Slant Bed N.C Lathe/Vertical Machine Centre built in India. Other machines like CNC Gear Cutter/CNC Wire-cut EDM and CNC Turret punch presses were under stages of development.

1983-85

Development of various software.

1985-90

Introduction of Robots

FMS Cells-Groups working on Robotic Development - R & D of CMTI, HMT, IIT, Madras. IISc., Hyderabad Science Society - First indigenously developed Robot produced - BEL - 3 Axis pick and place Robot.

1990's

Advances in Research on Sensors

Advances in Research on Sensors, Advanced sensors inculated in Bulb Industry

In addition to these, the Hyderabad Science Society has developed the country's first Robot. A lot of research has been conducted by this team on Sensors.

The ultrasonic sensor developed by the Society team has been attached to Walrobo-two, a robot- developed by the Society earlier.

The robotics laboratory of the school of automation at IISc. has developed a microprocessor based robotic arm actuated by the stepper motor. This is controlled manually from a front panel or automatically through a video terminal and a keyboard.

The department of Mechanical Engineering of University Visveswareya College of Engineering, Bangalore started Robotics Laboratory in 1985 and built stepper Motor - Driven 5 Axes Cartesian co-ordinated Robot and published in the 1E(1) Journal, Vol. 67, part PE2, November 1986.

The reports of perspective planning indicate that the future of robots must be pursued with vigour. It also indicates that a helathy and self-supporting machine tool industry will make the metal working industry and other user industries like Machine- building, electrical, other industries more dynamic. This in turn could lead to national industrial resurgence as it had happened in USA, West Germany and Japan.

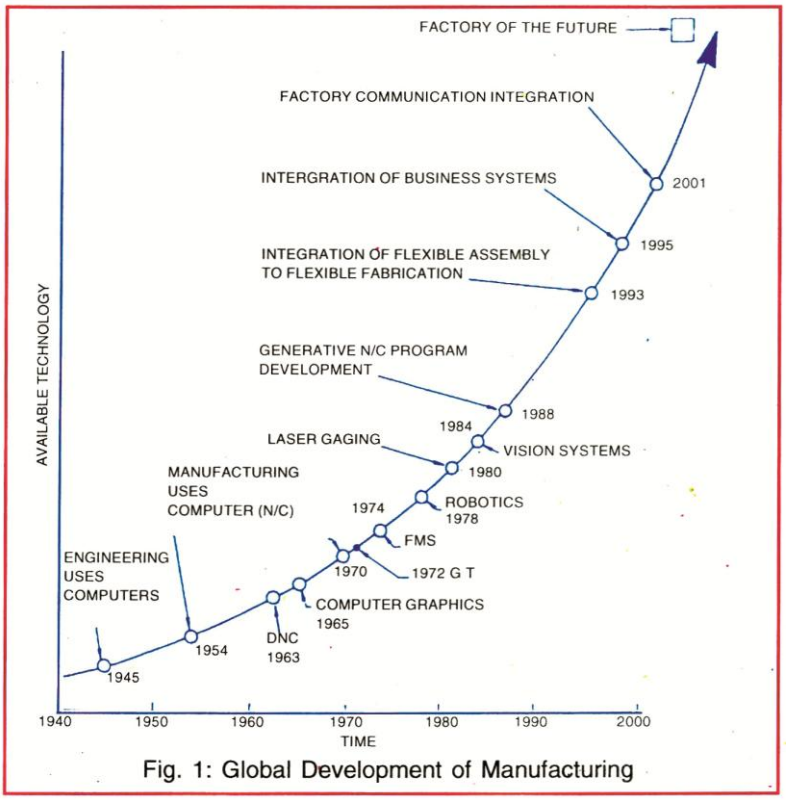

Fig. 1: Global Development of Manufacturing

GLOBAL SEQUENTIAL SCENARIO OF MANUFACTURING

This sequential scenario of manufacturing in the world in Fig. 2 presents the history of manufacturing from the past to the present status.

Defination of CIM (1)

Computer Integrated Manufacturing (CIM) is an interdisciplinary science applied to manufacturing. It involves the amalgamation of Information Science with Automated Manufacturing. Figure 3 illustrates this concept. The USA used rigid automation whereas Japan used flexible automation which made them superior in manufacturing.

Direct Application is where the computer or a network of computers monitor and control the hardware in a manufacturing plant, such as machine tools, inspection machines, robots and automated guided vehicles which physically transform or transport or assemble components.

In Indirect-Application, the following are included: CAD; PPC; Inventory control, Marketing/Sales, Factory Management.

Additionally, it may further include ·the following:

* Business Software such as material requirement planning (MRP - I)

* Manufacturing Resources planning (MRP - II)

* Just in Time Techniques (JIT)

* Optimised Production Technology (OPT)

Computer Integrated Manufacturing includes the utilisation of both the direct and the indirect applications.

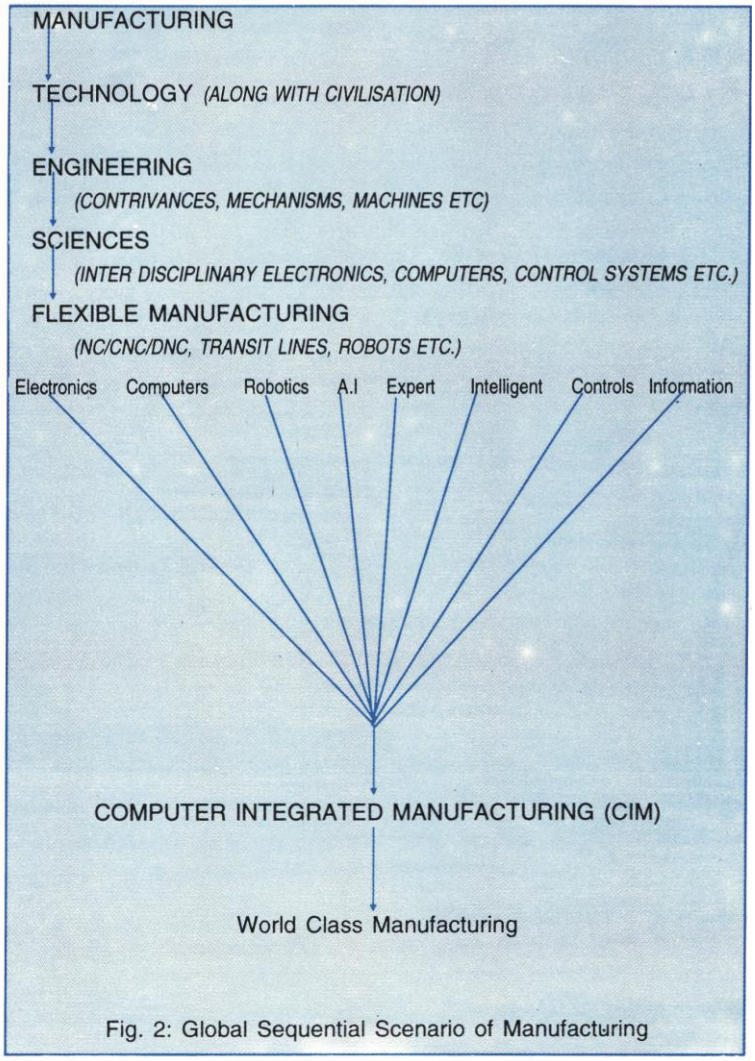

Fig. 2: Global Sequential Scenario of Manufacturing

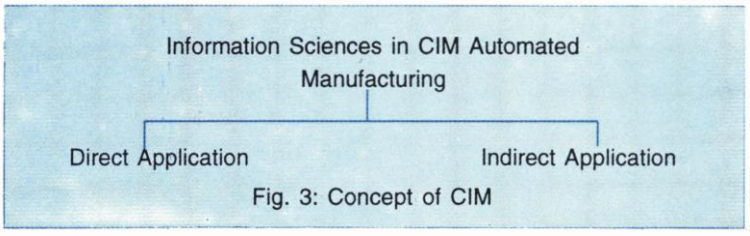

Fig. 3: Concept of CIM

Global Scenario of CIM with Examples

The growth of CIM in developed countries has been phenomenal. Recent studies indicate the growth of CIM in the form of FMS has been steady around the world. A typical CIM set up involves the versatile FMS cells comprising of NC Machines with material integration provided by an automated material handling system and by information integration provided by Local Area Networks (LAN).

Table-2 gives the Robot population in the world. Robot is the basic automation machine for a wide variety of CIM Models and their number is an accurate indication of the developement of CIM setup.

The Robot plays an important role in the CIM Model. In most of the developed countries including Czechoslovakia tasks such as welding, spray painting, machine loading, material handling and assesmbly are carried out by robots on the factory floor. Recent advances in machine vision and expert systems have made robots versatile and an integral part of factory automation. Robots are synonymous with high productivity. They are also used in hazardous environments like toxic chemical industries, assembly of explosives, deep sea, underground and nuclear reactors, removal of mines, etc.,

Table - 2
Number of Robots World Wide

	1987	1992
1. Japan	67,435	3,50,000
2. USA	14,000	50,000
3. Switzerland	8,050	NA
4. West Germany	6,600	47,000
5. France	3,400	NA
6. USSR	3,000	NA
7. Italy	2,700	NA
8. UK	2,600	NA
9. Sweden	2,400	NA
10. China	400	1,000
11. Canada	700	NA
12. India	NA	100

The major incorporators in CIM are. USA & Japan. The partial list of machining FMS in use in USA, are given in Table No.3.

An example of reported savings in operating cost through use of CIM Models - General Electric Eric, is given in Table No.4.

Table - 3
Partial List of Machining FMS in USA

USER	VENDOR	YEAR Installed	Volume & Number of parts	TYPES OF PARTS
Sunstrand Aviation	White Sunstrand(WS)	1967	NA	A1. Pump Parts
Ingersoll Rand	White Sunstrand(WS)	1970	20,000/14	Hoist/ Motor cases
Rockwell	Kearney & Tracker (K & T)	1972	25,000/45	Axle carriers
Allis Chambers	Kearney & Tracker (K & T)	1970-73	23,000/8	Agriculture Equipment
Cater Pillar	White Sunstrand(WS)	1973	66,000/6	Crank Case Housing
Avco-Will Amsport	K & T	1975	24,000/9	Aircraft Engine
Avgo-Lydo-Ming	K & T	1979	15,000/10	Turbine Engine
John Deere	K & T	1981	5,000/8	Farm Equipment
General Electric	W.S.	1981	5,600/7	Motor Housing

Table - 4
Hardware Investment and Reported Savings in operating costs for Machining FMS at General Electric, Eire

Comparison	Old Machining System	New Machining System
Number of Machines	29	9
Total Production Worker Requirements for two shifts (operators, supervisors & Maintenance	86	16
Typical number of machines Loadings required to complete one part	10-11	4-5
Max. annual output for family of seven parts	41,000	5,600
Average in-process time for a part	16 days	16 hours
Productivity change (total factor)	base	+240%

Table No.5 gives the Hardware Investment and Reported savings in Operating costs for selected CIM sites. The number of factories selected from USA are five in number as examples out which four are switched over from FMS into CIM due to the adoanioges indicated in the table

Thus, we see that the experience of all the companies mentioned is the case of considerable savings in different aspects.

In most of the countries in the developed world, both the Government and Industry have invested Billions in Research and Development in manufacturing service. The areas of investment are:

* Development of new materials
* New cutting process
* CAD/CAM Integration
* Material Handling Equipment
* Computer and Communications Standards
* Computer Control System

* Expert Systems for Process Planning
* Scheduling and Real Time Control
* New Organisational and managerial structures for running factories

Table-5
Hardware Investment and Reported Savings on Operating- Costs for Selected CIM Sites

User	Cost in Million $	Product Volume Part Varieties	Reported comparisons with old system
Rockwell (Truck Axles)	5.6	24,000/45	1/4 Floor space setup costs eliminated
Avco-Williams Port (Aircrafts engines)	8.4	24,000/9	1/3 Floor Space 1/4 Labour 1/2 No. of holding devices
John - Deere (Tractor components)	18	50,000/8-12	Cost estimate of FMS $8 million dedicated transfer line: $28 million
Master Truck (Truck components)	5	65,000/5	Cost estimate FMS about same as estimate for dedicated transfer line with comparable cycle time less flexibility
Caterpillar (Construction equipments) [like our BEML]	5	8,000/8	Total transit time through system Old system: 85 hours New system: 6.3 hours

In the area of education, almost every university in the west has started a centre or department on CIM with sponsorship from the Industry and the Government.

Indian Scenario of CIM with Examples

The diffusion of Automated Manufacturing Technology (AMT) in India is less hectic than in the west. Table 6 below indicates the actual numbers of AMT Elements in India.

Table - 6
AMT Elements in India

NC Machine Tools	CAD SYSTEMS	FMS
1178	700	1

The only FMS in our country is installed in the Heavy Alloy Penetraior Project (HAPP) at Trichy. This system has intelligent CNC work Centre, integrated with a tool management system and loading/unloading gantry. Material integration has been achieved by automated guided vehicles (AVG) and information integration by a superoisory computer. Inspection through electronic gauges is integrated with manufacturing process.

Robots and other hardware for CIM are being developed at Bhabha Atomic Research Centre for nuclear applications. The remote handling systems developed here haue freed Indian from foreign dependence.

However, the current manufacturing technology and practice in India is plagued by low levels of quality, productivity and reliability with high input costs. This is because of lack of technology. Most of this is imported. This has not been imporoed and adopted properly. Hence, the gap in technology between India and other developing countries is increasing.

Even in manufacturing, the absorption of CNC Machines, conveyor systems, assebly robots, industrial robots, A VG, Local Area Networks are minimal. The reason for upgradaiion of technology can be summarised as follows:

* to meet needs in defence and nuclear areas
* to enhance export
* to meet domestic demands without making it protectionist
* to produce high quality consumer goods at low cost.

Example of CIM for prismatic Components:

This is a proposal for machining of prismatic parts like transmission cases, gear boxes, crank cases, cylinder blocks and cylinder heads of light automotives. The manufacturing details are given in the following sections:

Machines

- Use of small multiple drilling heads which could be accomodated in the tool magazine.
- Standard horizontal and vertical machining centre with pallet size 600 mm × 600 mm.

Material Handling

- Choice of use was between wire guided cars and Automated guided Vehicles (AGV)
- For their superiority AGV'S are proposed to be used.

Tool Management

- Automated tool management system
- Consists of a tool presetting device, a tool-rack and tool transfer system.
- Robot for transfer from tool rack to the different tool magazines on machines
- Tool transfer system may be rail gudided or the gantry type inspection Values are measured regarding size and position and compared with expected values.
- Corrections are fed back to the machine to ensure zero defect.

Load and Unload Station

- Fixters are prepared and stacked in a pallet pool
- Components are loaded on to the Fixtures with the help of a gantry loader or a jib crane.

Work Station

- Average machining time for a component - 15 minutes
- Number of shifts - 2
- Utilisation - 80%
- Number of hours available - 4000/year
- Number of parts machined per year machine - 16,000
- Combination - 6 Horizontal and 2 Vertical machining Centres.
- Economic Volume - 1,20,000 prismatic components per year in 2 shifts
  'OR
- 1,80,000 primatic components per year in 3 shifts

The cost analysis of CIM for prismatic components is shown in Table 7.

Table - 7
Cost Analysis of CIM for Prismatic Components

Cost of the Project	Rs. in Cr.
CNC machining centres (8 Nos.) including tools and spares	8.00
Mini Computer Plus peripherals	0.50
AGV/Robot Car/ Central chip disposal/ coolant unit	0.50
Tool presetting/sharpening machines	0.40
Inspection station/washing station load/unload with PLC controls tools/Tool racks/pallet pool	0.50
Building and factory equipment	0.50
Software development cost	2.00
Salaries/Overhead for threee years Materials for trails/ for providing outputs miscellaneous	0.50
Total (Rs. in Crores)	15.00

Strategies for Excellence in Manufacturing (3)

Excellence in manufacturing is an integrated result of appropriate technology, committed and visionary management and highly wilful and productive workforce as shown in Fig. 4.

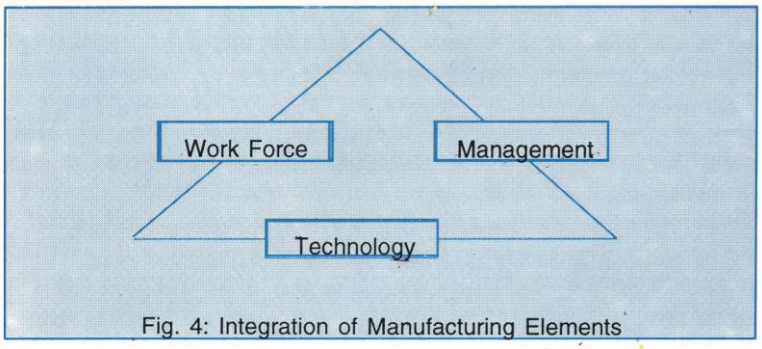

Fig. 4: Integration of Manufacturing Elements

Technology

Technology should be construed as a broad-based activity ranging from product design through production, product' use and maintenance. Technology can be mastered through integrative exercises and on advanced apprenticeship experience covering basic knowledge and applications. An in-depth understanding of technology and its integration into an overall system is a must. Technology can be developed with a proper understanding of product design, production technologies, process management and control, production planning, materials selection and management, human factors, logistics, marketing, vendor support, economics, CAD, manufacturing system, automation and control, information technologies and Total Quality Management. Technology development can become meaningful if the coupling or linking goes far beyond traditional academic and industrial boundaries. Further, manufacturing related research with the help of industry and R&D personnel, will prove or disprove existing principles that the currently believed to govern manufacturing practice and suggests new thinking for achieving World Class Manufacturing.

Management

Management in a manufacturing programme should always aim at newer' ideas and newer methodologies so as to enable them to remain as leaders. There should be a methodology for creating values and methods for lifelong learning and collaboration. The career paths in manufacturing management should be financially competitive and intellectually challenging that will prove opportunities to lead and effect a meaningful change.

There should be a continuous and rewarding effort to disseminate and implement the programme's knowledge base. Development of a process and network through which managers can conceive and effect positive changes in the manufacturing protocol, rapidly exchange concepts, ideas and results on turn key basis.

Workforce

The workforce should be committed to careers in manufacturing. Workforce should have aptitude to learn but also have strong talents for working in teams. There should be an active encouragement for the workforce to cut across traditional disciplinary boundaries to address major manufacturing issues. They should have ample opportunities to learn concepts and best practices in other disciplines and adapt these to their own field of specialty. Monitoring the workforce for their qualities and activities help in continuous improvement of the workforce. This will aid in understanding the sensitivity of the workforce to manufacturing issues that will pave the way for improvement in manufacturing productivity and competitiveness.

Some of the following policies for Workforce development will certainly help to achieve excellence in Manufacturing.

* Develop an integrated and market-driven system of lifelong learning
* Develop a System that makes existing institutions accountable to serve workforce needs
* Encourage work-based adult training
* Improve transition from High School to High Skill career
* Build the demand for higher skills
* Focus on job evaluation and rotation
* Workforce participation

AGILE MANUFACTURING APPROACH (5)

The Goal of AMA is to discover and codify guiding principles for the manufacturing, educate future leaders for manufacturing workplace and otherwise infuse important principles and technologies into manufacturing practice.

Manufacturing has to be viewed as broad-based activity ranging from product design through production, product use, maintenance etc. But the AMA recognies as an interdisciplinary activity that requires the seamless

integration of Technology, Management, Information system, Workforce etc. It approaches holistically, rather than take rifle - shots at individual issues, to achieve quick fixes by bridging the traditional technology, management, workforce, etc., with a broad understanding of manufacturing that integrates key functions and disciplines involved in creating, designing, making, selling/ servicing products etc. It encompasses not only the critical operations within a corporation, such as technology, product process engineering, administration and marketing/sales/services, but also vendors/suppliers, customers, community and Government as shown in Fig. 5.

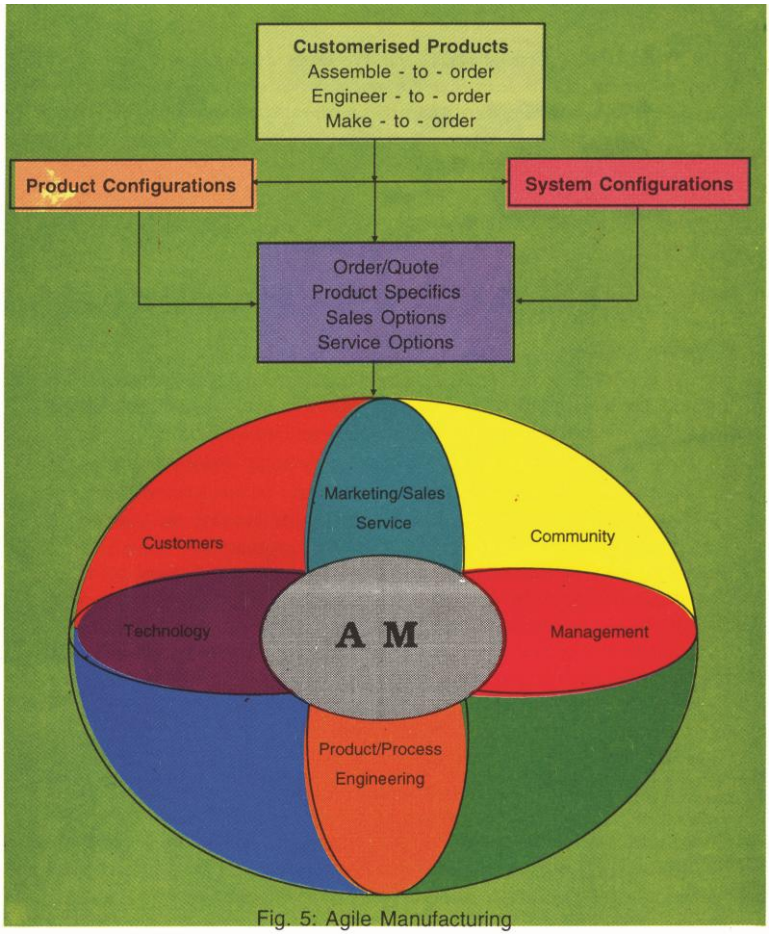

Fig. 5: Agile Manufacturing

Agile manufacturing is the science of a business system that integrates management, technology and workforce making the system flexible enough for a manufacturer to switch over from one product that is being produced to another product desired to be produced in a cost effective manner within the frame work of the' system. Agile manufacturing includes the entire business process commencing from planning, finance and proecess, design, tooling, machines and machinery layout, materials and inventory, cost specifications, price constraints, marketing and sales, service and support, quoting and delivery dates etc.

Examples do exist where the entire system gets re-oriented depending upon the magnitudes and qualities of the orders placed 011 the industries. Practice of Agile Manufacturing has become, of late, an absolute necessity in view of the demands of customer oriented products. 'The entire system needs to be made flexible to meet the challenges on the Indian Industry Houses, especially in the present context of liberalised economy and stiff global competition posed to the industries by the multinational companies and units started by the Non-Residents Indians. Products manufactured by an Indian Manufacturer will have to meet the International standard in respect of quality and price. Agile manufacturing precisely provides and desidered flexibility to the manufacturing houses,

Some of the functions in Agile manufacturing can be made available as special modules. Industrialists can choose the right modules they desire to have and can later add other modules as they provide the desired interface. Finally each industry can emerge as a unit that has adopted Agile Manufacturing in its entiety.

INTEGRATION OF SYSTEM PARAMETERS IN AM (ISP in AM)

ISP in AM of Management with Technology and Workforce:

Traditional management accounting must be changed to provide flexibility which is vital for Agile Manufacturing. Activity based accounting provides this desired flexibility. Since the technology that is adopted

by the system is to be user oriented, it is essential that the user must have control over the technologies that will be adopted by the management. This can be brought about effectively by organising the interactions between the user and the workforce in an industry. Keeping in view the welfare of the workforce which has been a vital component of the business system, a system for the long term education and training of the workforce is an essential component, whereas the middle level and top level workforce can be deputed to institutions for higher learning as a part of quality improvement programme, labour class will have to be provided with in-house education and training programme. Organisational pattern must: be flexible enough to provide perfect co-operation between the three components of Agile Manufacturing - Management, Technology and Workforce.

ISP in AM of Technology with Management' and Workforce:

To achieve a balanced Integration of Management, Technology and Workforce, an interdisciplinary design methodology. must be adopted to bring the concept of total enterprise design. Emphasis must be laid on strategies to enhance skill and knowledge of workforce and not on replacing old technology by new technology. Technology deployment is as important as Technology Development. Technology Deployment must be viewed as a criterion for Technology Development. Research into technology must involve all the three components to arrive at an appropriate technology most suitable to the system. This appropriate Technology could be either arrived at by human resources within the system or borrowed from an outside agency. Energy conservation and wastage minimization management are the two parameters which must occupy top priority especially in view of energy crisis and threat to environment and resources. ISP of AM of Workforce with Management and Technology:

The ultimate aim of the entire business system is to satisfy customer. It is essential that the workforce be built up to produce products that would satisfy the customers. In the words of Universal Man of all times Mahatma Gandhi.

* A customer is the Most Important Visitor on our premises
* He is not dependant on us; We are dependent on him
* He is not an interruption on our work; He is the purpose of it
* He is not an outsider on our business; He is a part of it
* We are nto doing him a favour by serving him; he is doing us a favour by giving us an opportunity to do so

Innovative skills can come out of any class of workforce and this must be rightly rewarded. Development of some products needs team work and this concept of objective team work must be encouraged with suitable incentives. The power of communication that is vital for the success of an enterprise, must be given the right boost by suitably recognising such people with excellent power of communication. Development and deployment of appropriate technology also depends upon the psychological environment of the people who will be involved in it.

CONCLUSION:

In the developing countries, a rapid change over to ClM has seen overheads are lessened and profits increased. The case studies reveal the stunning performance of elM units. It is to be specifically noted the support given to this discipline through universities a-nd industries. While discussing the importance of vital ingredients, viz., technology, management and workforce for agile manufacturing, it is imperative athat these three must be properly and effectively integrated. This is possible only by careful and suitably selected R & D Management. Viable Technology, committed and Visionary Management and highly wilful and productive workforce are the essential ingredients for Manufacturing Leadership. The Agile Manufacturing Approach (AMA) as shown in Fig. 4 is the only solution for Leadership in Manufacturing for Global competitiveness.

REFERENCES:

1. Dr. MP Chowdiah 'Automation in Manufacturing - Global and Indian Scenario', Memorial Lecture delivered at 9th National Convention of production engineers on 'Integrated Manufacturing' held in Trichirapally on 30th Sept. and 1st Oct. 1994.
2. Dr. MP Chowdiah 'R & D Management for Leadership in Manufacturing', presented and published in the proceedings of First National Convention of National Design & Research Forum of IE(I) on 'R&D Management' held in Bangalore on March 25-26, 1994 Tata McGraw-Hill Publishing Co. Ltd.
3. Dr. MP Chowdiah, "Technology policies for Economic Grow1h by Development of Indian Workforce' proceedings of 7th Indian Engineering Congress held in Bangalore Feb. 12-15, 1993, Tata McGraw-Hill Publishing Co. Ltd.
4. MIT, USA, Brochure on Leader for Manufacturing.
5. Dr. MP Chowdiah, Agile Manufacturing for Global competitiveness, published in the souvenir of International Conference on Agile Manufactring held in Bangalore during Feb. 22-24, 1996.

The Tenth Dr Ajudhia Nath Khosla Memorial Lecture was delivered during the Twelfth Indian Engineering Congress, Nagpur, January 9-13, 1998

Water Resources Development in Maharashtra Krishna River Basin

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Preamble

The river Krishna is the second largest river in Peninsular India. It rises in Mahadev Ranges of Western Ghat near Mahabaleshwar, in Maharashtra, at an altitude of 1336 m (4385 feet). After flowing through the States of Maharashtra, Karnataka and Andhra Pradesh and collecting waters from its innumerable rivers, streams and tributaries, along the course it finally meets the Bay of Bengal. This whole area lies between lat. 13°7' to 19°20' N and long. 73°22' to 81 °10' E.

The total catchment of the river Krishna is 258984 km^2 (99980 square miles) distributed over the three states as 69425 km^2 (26805 square miles) in Maharashtra, 113271 km^2 (43734 square miles) in Karnataka and 76252 km^2 (29441 square miles) in Andhra Pradesh. The Krishna basin is subdivided into 12 sub-basins. The details of sub-basins are given in Table 1.

Table 1 Showing the catchment area of various sub-basins in main Krishna basin

Sub-basin	Area, km^2			Total	Percentage of Krishna Basin
	Maharashtra	Karnataka	Andhra Pradesh		
K-1 Upper Krishna	17127.62	844.34		17972.01	6.97
K-2 Middle Krishna	1388.24	16169.37		17557.61	6.81
K-3 Ghatprabha	2009.84	6819.47		8829.31	3.43
K-4 Malaprabha		11548.81		11548.81	4.48
K-5 Upper Bhima	45335.36	730.38		46065.74	17.85
K-6 Lower Bhima	3563.84	18466.7	2517.48	24548.02	9.54
K-7 Lower Krishna		1683.5	34441.82	36185.32	13.53
K-8 Tungabhadra		38790.43	9036.51	47826.94	18.57
K-9 Vedavathi		18218.06	5371.66	23589.72	9.16
K-10 Musi			11212.11	11212.11	4.35
K-11 Palleru			3263.4	3263.4	1.27
K-12 Muneru			10409.21	10409.21	4.04
	69424.95	**113271.1**	**76252.19**	**258948.2**	**100**

Hydrology of Krishna Basin

As explained the Krishna river gathers water from its 29 main tributaries which are inter-State rivers. Table 2 shows the details of the main tributaries. The length of the main Krishna river is 1400 km. The total 75% yield as decided by the KWDT in 1973 from the total catchment of Krishna basin from Mahabaleshwar to Vijayawada is 2060 thousand million cubic feet (TMC). The State-wise distribution is estimated by us to be approximately as follows :

State	Yield in TMC	Percentage
Maharashtra	963	46.72
Karnataka	761	36.94
Andhra Pradesh	336	16.34
Total	**2060**	**100.00**

The total geographical area of Maharashtra is divided into five main basins namely:

- Krishna
- Godavari
- Tapi
- Narmada
- West-flowing rivers

Table 3 shows the area-wise details of all these basins.

Table 2 The inter-State rivers of the Krishna river system and their successive & common lengths in the States of Maharashtra, Karnataka & Andhra Pradesh

Name of River	Lengths in kilometre				
	Maharashtra	Karnataka	Andhra Pradesh	Common Length	Total Length
Krishna	299.46	483	576.38	41.86	1400.7
Ghataprabha	59.57	215.74		8.05	283.36
Bhima	487.83	289.8		83.72	861.35
Tungabhadra		381.57	91.77	57.96	531.3
Vedavathi (Hagari)		293.02	72.45	25.76	391.23
Vedganga	66.01	19.32		3.22	88.55
Dudhaganga	69.23	19.32		12.88	101.43
Panchaganga	70.84			3.22	74.06
Agrani	54.74	41.86			96.6
Don	12.88	196.42			209.3
Hirehalls (Krishna)	3.22	35.42			38.64
Markandeya (Ghataprabha)	8.05	66.01			74.06
Tamraparni (Ghataprabha)	25.76	25.76			51.52
Hiranyakeshi (Ghataprabha)	62.79	19.32		6.44	88.55
Doddanalla (Bhima)	48.3	9.66			57.96
Bor Nala (Bhima)	38.64	28.98			67.62
Bori Nadi (Bhima)	99.82	22.54			122.36
Amarja (Bhima)	9.66	62.79			72.45
Kagna (Bhima)		70.84	69.23		140.07
Bennithora (Kagna)	48.3	88.55		9.66	146.51
Suvarnamukhi		74.06	9.66	3.22	86.94
Chinna Hagari		128.8	28.98		157.78
Peddavanka (Vedavathi)		24.15	22.54		46.69
Peddavanka (Tungabhadra)		8.05	19.32		27.37
Garchi Vanka (Tungabhadra)		24.15	32.2		56.35
Gonde Halla (Chiana Hagari)		33.81	4.83		38.64
Doria Halla (Bor Nala)	19.32	9.66			28.98
Katra (Bhima)	8.05	11.27			19.32
Sar Nala (Kagna)		37.03	8.05		45.08

Table 3 Details of Krishna basin

Particular	Total Cu. Ar., km^2	%
Total Maharashtra	307713	
Krishna Basin	69425	22.56
Godavari Basin	152199	49.46
Tapi Basin	51504	16.74
Narmada Basin	1538	0.05
West-flowing Rivers	33047	10.74

The total catchment area of Krishna basin 69425 km^2 (26805 square miles) is further divided into main five sub-basins namely :

1. Upper Krishna (K-1) Sub-Basin: 17128 km^2 (6613 square miles) :

This includes main rivers as (i) Koyna, (ii) Wama, (iii) Panchagana, (iv) Dudhaganga, (v) Vedganga, having confluence with Krishna river from right side and (vi)Yerala from leftside. The basin isspread over in Satara, Sangli and Kolhapur districts.

2. Middle Krishna (K-2) Sub-Basin: 1388 km^2 (536 square miles) :

This is the originating part of Agrani river in Sangli district and small nallas joining to Agrani river. This basin is the smallest in Krishna basin in Maharashtra.

3. Ghataprabha (K-3) Sub-Basin: 2010 km^2 (776 square miles) :

This basin, entirely within Kolhapur district, is formed by Ghataprabha, Tamrapami and Hiranyakeshi rivers with Markandeya nalla.

4. Upper Bhima (K-5) Sub-Basin: 45335 km^2 (17504 square miles) :

This is the biggest sub-basin in Maharashtra and is spread over in Pune, Solapur, Ahmednagar and Beed districts with part in Satara and Sangli districts. The main tributaries are: (i) Ghod, (ii) Sina joining from left side to (iii)Bhima, and (iv) Mula-Mutha, (v) Nira and (vi)Man joining from right side.

5. Lower Bhima (K-6) Sub-Basin: 3564 km^2 (1376 square miles)

This sub-basin is lower part of Bhima from its confluence with Sina up to Krishna. In Maharashtra only a small area of this sub-basin is located mainly in Usmanabad district with Bori and Hami as main tributaries.

Five entire administrative districts, namely, (i) Pune, (ii)Satara (iii)Sangli, (iv) Kolhapur, (v) Solapur are fully located in Krishna basin, whereas (i) Ahmednagar (36.20%), (ii)Beed (14.20%) and (iii)Usmanabad (31. 80%) are partly located. Table 4 shows district-wise distribution of areas and percentage of total area of districts.

Table 4 also shows the normal weighted rainfall over the district.

Table 4 Krishna basin district-wise distribution of sub-basin areas in Maharashtra

District	Region	Within Krishna Basin km^2	% of Total Area of District	Sub-basin	Normal Weighted Annual Rainfall of District in cm
Pune	Western Maharashtra	15483.0355	99.1	K-5	130.048
Solapur	Western Maharashtra	14931.3649	99.2	K-5 K-6	59.944
Satara	Western Maharashtra	10466.2005	100	K-1 K-5	124.968
Sangli (South Satara)	Western Maharashtra	8539.23854	100	K-1 K-2 K-5	74.930
Kolhapur	Western Maharashtra	7586.11759	91.4	K-1 K-3	199.898
Ahmednagar	Western Maharashtra	6179.74618	36.2	K-5	65.024
Ratnagiri	Western Maharashtra	116.550117	0.9	K-3	299.974
Osmanabad	Marathwada	4555.81456	31.8	K-5 K-6	85.09
Beed	Marathwada	1566.95157	14.2	K-5	70.104

Development of Water Resources in Maharashtra before Independence

• There was hardly any development of Water Resources up to end of 19th century. The construction of some medium tanks was started from the year 1890 onwards. These are: (i) Budhihal tank, (ii) Visapur tank, (iii) Nher tank, (iv) Mhasawad tank, (v) Ekrukh tank.

• In the year 1886, the then King of Bhor State started the construction of old Bhatghar dam. The Khadakwasla dam was originally constructed in 1880. The Mutha canal system ex-Khadakwasla and Nira Left and Right Canal (1892 & 1928 respectively) and ex-Veer dam are the prominent examples of irrigation development. In Kolhapur district a new technique was invented. The small height 2.5 m (8 feet) masonry piers were constructed by leaving a gap of about 2.5 m in-between. Timber sleepers are then inserted between the masonry piers, in the slots provided therein. Water is stored behind this structure from the post-monsoon flow, which is lifted and utilized for irrigation. These structures were conceived and constructed first in Kolhapur area and therefore are known as Kolhapur Type Weirs (K-T Weirs). A large number of such types of weirs were constructed for irrigation.

• The Tatas had harnessed the waters from Mula river and Andhra river and some local nallas from Mawal Taluka of Pune district for Power Generation using the large hydraulic head available in the Sahyadri Ranges - inter-continental divide, that is, between the Deccan plateau and the coastal strip, which meant divertingthe waters to Westward side. This was done during the period 1918 to 1930.

• Prior to the development of storage for irrigation, well irrigation was being practised on a large scale. The concept and practice of storage of water, flow irrigation by means of canals and distribution system was not widely followed and people were using wells extensively for irrigation purpose.

Development of Water Resoruces in Maharashtra after Independence

• After the Independence more and more data regarding rainfall and stream flow were collected. A typical feature of Krishna valley indicated that all the tributaries and the main Krishna river had large volumes of water flowing during monsoon period which went unutilized and as a waste into the Bay of Bengal. However, in contrast, during fair weather period the flows in rivers dwindled and were too meager to plan for irrigation through rivers.

• The pattern of availability of inflows being such, construction of storage to even out the wide seasonal fluctuations and to facilitate irrigation in the post-monsoon period became the key technique for development of water resources.

It also became evident that the geology and topography of Krishna basin in Maharashtra did not permit a large-scale development of well irrigation, as the underground water was not in sufficient quantity and whatever available was at great depths. The groundwater was best left for planning of drinking water use.

• As a result of the two findings it was decided to harness the surface flows of Krishna waters. Accordingly some projects were undertaken till 1969-70. Tables 5(a) and 5(b) show the listof projects, the waters being utilizedfor irrigation as well as power generation. About 295920 ha of land was brought under 'Well Irrigation' in Maharashtra.

Table 5(a) Statement showing details of completed/on-going projects up to 1969-70 in Maharashtra

Name of Project	Year of Operation	Sub-basin
Above 3 TMC		
Nira System	1962	K-5
Bhima Project	Under con	K-5
Kukadi Project	Under con	K-5
Khadakwa Project	1970	K-5
Krishna Project	Under con	K-1
Warna Project	Under con	K-1
Radhanagar Project	1952	K-1
Between 1 to 3 TMC		
Krishna canal ex-Khadakwasla		K-1
Tulshi Project		K-1
Mhaswad Project		K-5
Mangi Project		K-5
Ekruk Project		K-5
Khasapur Project		K-5

Table 5(b) Apart from irrigation development following hydro-electric projects based on westward diversion of water were completed up to 1969-70 and are in operation

Name of Project	Installed Capacity (MW)	Sub-basin
Koyna H	540	K-1
Tata hydro-electric project		
(i) Khopoli	72	K-5
(ii) Bhivapu	72	K-5
(iii) Bhira Project	148	K-5
Under Construction PH		
Koyan H	320	K-1
Bhira T R	80	K-5
Radhanagar	48	K-1

Appointment of KWDT

• The Maharashtra State was busy in developing water resources in Krishna basin. The other riparian States namely Karnataka and Andhra Pradesh were also exerting hard on developing utilization of Krishna waters by constructing more and more storage in their areas. This gave to disagreement between the States regarding the share of water to be used by each of the riparian States. As a result a dispute arose regarding correct distribution of available waters in Krishna Basin amongst all the three riparian states. In terms of the Inter-State Water Dispute Act 1956, the Government of India was required to refer the matter to a tribunal. The State of Kamataka asked for referring the matter to a tribunal in January 1962. The State of Maharashtra also demanded for a tribunal in June 1963.

• As a result the Krishna Water Dispute Tribunal (KWDT)was constituted by the Government of India on 10th April 1969.

• The KWD Tribunal headed by Shri R S Bachawat, Judge in Supreme Court till July 31,1969 along with Shri Shamsher Bahadur, Judge at Punjab and Haryana High Court till November 14, 1969 and Shri D M Bhandari, Chief Justice of Rajasthan High Court till December 15, 1969, as members, studied all the different aspects of hydro-meteorological aspects of Krishna basin, the present and futuristic demands of waters from allthe three riparian States, the total available surface waters, the present and the future population in the States, etc and gave the final decision regarding allocation of Krishna water. The KWDT popularly known as Bachawat Award, assessed the 75% dependable surface water flows of Krishna valley as 2060 TMC, and allocated the same in Table 6.

Table 6 Distribution of total yield in Krishna basin & total State-wise allocation of Krishna water

Name of State	Yield in TM	% of Yield	Allocation in TMC	% of Allocation
Maharashtra	962.5	46.72	560	27.18
Karnataka	760.9	36.94	700	33.98
Andhra Pradesh	336.6	16.34	800	38.84
Total	**2060**	**100**	**2060**	**100**

It is seen that the State of Maharashtra contributes 46.72% of total yeild but the water allocated for use by KWDT is only 27.18% of the total yeild.

The award also stipulated that there is a freedom to all the States to use the allocated waters fully during every water year. Further, the decision may be reviewed in May 2000, if felt necessary by anyone or all of the riparian States.

At the time of presenting the data of actual utilization of water for the year 1967-68, before the KWDT, Maharashtra had quoted total water use as 69 TMC. The total area irrigated as 553700 ha. The main crops were as given :

(i) Jowar	32.8 %
(ii) Sugarcane	16.8 %
(iii) Wheat	10.6 %
(iv) Bajra	5.2 %
(v) Paddy	4.8 %
(vi) Other crops	29.8 % (balance)

The other crops were maize, ragi, cotton, barley, grams, pulses, condiments, spices, groundnuts, tobacco, fodder crops etc.

Development of Water Resources in Krishna Basin after the KWDT Award

After the decision of the KWDT the overall development of projects had to be readjusted due to the fact that:

(i) There was a restriction on use of water in K-3 sub-basin and from the main stream Bhima :

(a) In K-3 sub-basin the total water use shall not be more than 7 TMC in any water year.

(b) The total water use, on main-stream Bhima, shall not exceed 95 TMC in any water year.

(ii). The westward diversi~n shall not be more than

(a) 67.5 TMC from Koyna dam (K-1 sub-basin)

(b) 42.6 TMC from Tatas lakes (K-5 sub-basin)

Economic Aspect of Water Resources Development

In 1968-69, when the irrigation system was not' fully developed the cropping pattern was such that the percentage of food-grains crops was more. These crops were of seasonal nature and the water requirement of these crops was less.

As the farmers kenw that requisite water is made available to them, the tendency towards taking cash crops like sugarcane, vegetables, cotton, etc started increasing. More and more number of sugar factories came up in Krishna basin, which changed the standard of living of rural Maharashtra.

The habits of using more vegetables and fruits in daily food increased.

The assured availability of water had changed the industrial scenario. Based on the sugar factories, engineering industries, cotton mills, etc and a number of small-scale industries grew in vivid industrial areas located in the urban as well as rural areas in Krishna Basin.

The Maharashtra Government had also decided to use the dams developed by major and medium projects to generate Hydro Electric power. Accordingly, the survey and construction of mini, medium and major hydro electric project was undertaken simultaneously.

Formation of Maharashtra Krishna Valley Development Corporation

• With all the sincere efforts put in for so many years, it was not possible for the Maharashtra State to use allthe allocated waters. This was mainly because of scarcity of funds. However, the need for a total and comprehensive development of water resources for supplying the water for irrigation and non-irrigation purposes such as drinking and industrial use, especially to the chronic draught-prone areas, was always the goal of the State.

• Therefore, a bold and innovative decision was taken by the Government of Maharashtra in January 1996, to form a statutory corporation which could push up the activities of construction and completion of irrigation projects in Krishna basin and fully establish the use of allocated water to the State, in Krishna basin. This corporation could then have the freedom to mop up the fiscal resources from capital market and finance the projects till completion, in a given time frame. Accordingly, "Maharashtra Krishna Valley Development Corporation" (MKVDC) was formed. The formation of MKVDC has geared up all the machinery in Krishna Basin and has embarked on a programme of construction of all the projects those will establish the utilization of the water allocated to the State of Maharashtra.

Present Position of Water Resources Development

Irrigation-Flow Systems

The MKVDC has undertaken survey of project sites on a large-scale for major, medium and minor projects, and Lift Irrigation Schemes. Most of these schemes involve construction of a storage and a canal system for flow irrigation.

Till recent days the generalized pattern for use of water for irrigation was by gravity flows, through canals and distribution system. The overall efficiency of such projects is in the range of 45 % to 50%. The main drawback of this system is that the large areas laying on upstream side of canal alignment can never be irrigated. The lands on the higher levels, ie, upstream of canal alignments were, for centuries together, remained unirrigated and the irrigation by lift irrigation for such large areas was becoming very much expensive and difficult.

Lift Irrigation Schemes

However in keeping with the will of the Government to provide irrigation water and water for drinking purposes to these areas in the draught-prone districts, it was considered necessary to provide these facilitjes through lift irrigation schemes. Such drought-prone areas in Krishna basin were identified and it was decided to give irrigation benefits to all such population. These lift irrigation schemes will also obviate the necessity of providing water tankers for drinking water supply, which was required to be done even in monsoon period due to chronic water shortage.

Valley-wise Water Balance and Water Planning

An in-depth water balance study for each valley was carried out.

The Krishna basin in Maharashtra is formed of 16 main tributaries of Krishna and Bhima rivers. The total water planning is based on these sub valleys.

For this, sub-valleywise yield studies based on actual measurements of river flows are done. The project-wise water use is deducted and thus the balance water is found out. This is the water which can still be used.

Inter-basin Transfer of Water

This is the most ambitious projects undertaken by MKVDC for full utilization of the Krishna waters. As explained earlier, the balance water in each of the sub-basins has been decided. It is found that many of the sub-basins are short of water and only a few sub-basins are excess in water.

It has been planned to transfer the excess water from water-excess basins to water-short basins. Gigantic-lift irrigation schemes are planned for transferring excess waters to water-short basins. The main aspect of such huge works is to provide for irrigation facilities and water for drinking purpose in the perpetual drought-prone areas.

CASE STUDY

An example of water short valley - Man valley, is considered. The total catchment area of Man valley is 1834 square miles.

The total surface water available at 75% dependability is 11.26 TMC. Considering the total water requirement of the valley and taking into account the (i) drinking water requirement of population plus the livestock and (ii)Rabi equivalent water requirement - it works out as TMC.

It is seen that the 75% dependable water available in Man valley is very much inadequate than the requirement. Hence, it is necessary to import water from the adjoining water surplus valley.

The MKVDC has planned for transfer of waters from the main Krishna river which is a water surplus river to Man basin where the water is pumped by lift schemes like (a) Tembhu LIS, (b) Jihe Kathapur LIS, (c) Krishna Koyna LIS Stage I to V, etc.

Efforts are made to plan the use of this transported water by non-conventional ways of irrigation like (a) Drip system, (b) Sprinklers, (c) Pipe line distribution system - taking water up to the fields with help of underground pipe lines so as to reduce the seepage losses to a considerable extent.

Also the conventional cropping pattern is planned to be replaced with cash crops such as horticulture and vegetables, which require comparatively less water and higher water charges can be levied. This is possible only when cash crops are taken. In low grade soils horticulture is much beneficial.

Land Drainage

• As the irrigation network started developing over a time span, the earlier irrigation systems like Nira Canals (ex-Veer), Khadakwasla system ex-Khadakwasla, started showing effects of water logging. Because of excess watering of fields the areas towards end of slopes of fields and near natural drains became water logged. This is a common phenomenon which needs urgent attention. Accordingly, a few years ago a large-scale survey of such areas was taken up by the Irrigation Research and Development Organisation. The water- logged areas in each of major irrigation systems were identified and land drainage works were planned. These works are mainly to drain excess waters in sub-soil and make the total land free of water logging.

Table 7 shows the ICA of various irrigation systems which are under monitoring since 1991-92 to 1995-96. It also shows year-wise damaged area.

Table 8 shows in brief the schemes undertaken, their numbers, protected area, the length of drainage system. The area improved mainly due to these works, and the percentage of area improved to area protected.

Table 7 Present Status of Drainage schemes in Krishna Basin established canal systems are considered canal commands

Name of Project	Project-wise ICA in Hect.	Total Damage Area									
		1991-92		1992-93		1993-94		1994-95		1995-96	
NRBC	77308	1676	2.17	1394	1.80	1685	2.18	1692	2.19	1695	2.19
NLBC	60623	2349	3.87	2309	3.81	2217	3.66	2312	3.81	2164	3.57
GHOD LBC	24602	1669	6.78	1455	5.91	1463	5.95	1162	4.72	1285	5.22
GHOD RBC	11019	1082	9.82	1075	9.76	973	8.83	1031	9.36	1042	9.46
NM RBC	39162	2722	6.95	2895	7.39	2498	6.38	2106	5.38	1974	5.04
KRISHNA (KHODSHI)	10728	3087	28.78	3377	31.48	3283	30.60	3127	29.15	3164	29.49
DHOM LBC DHOM RBC	32925	55	0.17	54	0.16	165	0.50	496	1.51	490	1.49
KANHER LBC KANHER RBC	1605 39470	Nil		Nil		Nil		306	19.07	533	33.21
UJJANI LBC	38647	2950	7.63	3074	7.95	3811	9.86	3408	8.82	3628	9.39
KUKADI LBC	20031	137	0.68	171	0.85	198	0.99	192	0.96	198	0.99

Table 8 Status of drainage schemes 1995-96 after land drainage works are executed

Name of Scheme	No. of Drainage Schemes			Protected Area in Hect.			Length of Drainage Schemes, km			Improved Area	
	Comp.	U/C	Future	Comp	U/C	Future	Comp	U/C	Future	Area	%
NRBC	48	7	34	20242	623	18830	276	10	109	4590	22.68
NLBC	65	6	17	24194	394	1584	364	8	18	7219	29.84
GHOD LBC	18	11	18	7482	4712	1346	108	60	28	1400	18.71
GHOD RBC	5	8	8	1070	3535	781	17	46	8	300	28.04
NM RBC	25	43	18	5355	7398	1960	71	123	46	2094	39.10
KRISHNA (KHODSHI)	10	3	7	2601	1332	1121	35	9	17	281	10.80
DHOM LBC DHOM RBC	1	7	19	52	272	882	1	9	23	30	57.69
KANHER LBC KANHER RBC	Nil	3	12	Nil	341	999	Nil	7	16	Nil	
UJJANI LBC	9	5	7	868	438	1078	9	8	19	190	21.89
KUKADI LBC	Nil	5	5	Nil	446	255	Nil	9	5	Nil	

Surface Water Observation Network in Krishna and Bhima Basins

• In order to assess the availability of water in a particular basin/sub- basin at a particular location, it is necessary to gauge the river at that particular point. This is called River Gauging Station (RG Station). The discharge of river at this location is measured with the help of current meter / float as per the site conditions. Automatic water level recorders have been established to know the hourly gauges.

The numbers of RG Stations in operation from 1900 to 1996 are as given in Table 9.

Table 9 R G Stations in operation during 1900-96

Period		No. of RG Stations in operation		
From	To	Bhima	Krishna	Total
1900	1964	33	10	43
1964	1974	33	16	49
1974	1975	16	18	34
1975	1977	19	19	38
1977	1980	21	18	39
1980	1982	23	29	52
1982	1984	39	43	82
1984	1987	40	44	84
1987	1990	41	44	85
1990	1994	30	27	57
1994	1996	31	28	59

In the revised Master Network 73 RG Stations were approved by the Government of Maharashtra. However, some RG stations are closed after the completion of the projects for which these stations were established.

Since. 1995-96 World Bank loan under Hydrology Project has been sanctioned for the standardization, exchange of data and upgradation of the RG Stations for 8 participating States including Maharashtra and other central agencies. The following organizations participate in the Hydrology Project:

1. Central Water Commission (CWC)

2. Central Water and Power Research Station (CWPRS)

3. N.!. Hydrology

4. Ministry of Water Resources (MoWR)

5. Indian Meteorology Department (IMD)

6. States of Andhra Pradesh, Gujarat, Kamataka, Kerala, Maharashtra, Madhya Pradesh, Orissa and Tamilnadu - eight in number.

58 RG Stations in Krishna and Bhima basins have been approved under the Hydrology Project. Out of these, 30 are in Bhima basin and 28 are in Krishna basin.

Hydrology project also includes 574 Rain Gauge Stations and 42 full-scale Climatological Stations in Krishna basin.

Hydro Power Development

It has been decided by the Government of Maharashtra to construct hydro power stations on each of the major and medium projects. Accordingly, a number of schemes are in investigation, under construction and under operation. Table 10 shows the present position. Table 11 shows the energy requirement of different schemes.

Table 10 Showing the hydro-electric projects in operation & under construction in Krishna basin

Name of Scheme	Installed Capacity (MW)	Sub-basin
1. Completed Projects		
Koyana (D)	40.0	K-1
Koyna sta	880.0	K-1
Bhatghar	16.0	K-5
Vir	9.0	K-5
Kanher	4.0	K-1
Dhom	2.0	K-1
Panshet	8.0	K-5
Varasgao	8.0	K-5
Pawana	10.0	K-5
Radhanag	4.8	K-1
Tata	292.0	K-5
Total	**1273.8**	
2. Under Construction Projects		
Dudhagan	24.0	K-1
Warana	16.0	K-1
Kasari	1.5	K-1
Koyana sta	1000.0	K-1
Kanher L	1.2	K-1
Ujjani P B	12	K-5
Dimbhe	5.0	K-5
Manikdoh	6.0	K-5
Total	**1065.7**	
3. Administratively Approved Projects		
Patgaon 1	2.5	K-1
Kadavi 1	2.5	K-2
Malshej 2	300.0	K-5
Chaskama	3.0	K-5
Total	**308.0**	
4. Projects Submitted for Approval		
Kumbhi 1	2.5	K-1
Sonawade	8.0	K-2
Ambai 1 U	3.0	K-3
Radhanag	10.0	K-4
Total	**23.5**	
5. Projects under Preparation		
Chitri 1 U	2.0	K-1
Urmodi 1	3.0	K-1
Bhama 1	2.0	K-5
Temghar	4.0	K-5
Chikotra 1	2.0	K-1
Jambre 1	2.0	K-1
Tarali 2 U	5.0	K-1
Humbarli	400.0	K-1
Nira Deog	7.0	K-5
Kanakvira	1000.0	K-15
Gunjawani	2.0	K-15
Dimbhe L	5.0	K-15
Thugaon f	1.5	K-15
Ujjani L B	4.0	K-15
Dhamani	2.5	K-1
Total	**1442.0**	
Grand Total	***4113.0***	

Table 11 Showing the energy requirement detail of various LI Schemes in Krishna basin

Name of Scheme	Energy Required (MW)	Transfer of Water from Basin to Basin	
Janai Shir	14.56	K-5	K-5
Purandhar	6.95	K-5	K-5
Jihe Katha	69.66	K-1	K-1
K-K LIS	153.55	K-1	K-5,K-2,K-1
Tembhu LIS	174.25	K-1	K-5,K-2,K-1
Ashti LIS	5.01	K-5	K-5
Barshi LIS	10.64	K-5	K-5
Dahigaon	11.05	K-5	K-5
Ekruk LIS	14.36	K-5	K-5
Shirapur LIS	8.94	K-5	K-5
Total	**468.97**		

Summary

Water resource is considered as renewable source of energy. However, the quantity is limited. Nature renews it every year to a degree depending on the occurrence of rainfall which in turn is based on some 16 meteorological parameters. So far it has not been possible to exactly predict the rainfall that will occur in monsoon. The models on National Scale give a general state in terms of a percentage of normal and it is difficultto estimate accurately, rainfall in specific locations.

There are always conflicting demands on any source. Drinking water has the highest priority. Then concurrent importance is given to the industrial and irrigation use. Last comes the hydro-electric purpose. National Water Policy of 1987 defines that the water resource should be planned valleywise and only in case where the need in a valley is satisfied surplus water can be diverted to other valleys.

In Maharashtra there are large areas where there is a chronic water shortage. These are all draught-prone areas where drinking water is required to be supplied through tankers. The MKVDC has embarked upon construction of projects whereby the necessity to ply tankers will be overcome.

The projects are planned in such a way that these are economically viable ie, these are within the economic yardstick. There are some cases where exception may have to be done. Water planning can be done to include cash crops so that the revenue thereof can meet the expenditure on account of maintenance and at least 3% to 4% return on investment (This could be a matter of debate).

However, there are some cases where the cropping pattern has to be diluted to a great extent so that the irrigators from a larger command area can raise at least one crop of wheat / jowar / pulses in Rabbi season and have some water left for 1 or 2 watering in Kharif season. This is particularly so in draught-prone areas. The use of drip / sprinklers can reduce the water requirements but this will eventually increase the cost of project.

Many sociologists have been propagating equity in water distribution. The idea of equity being giving that quantity of water which equals available quantity of water divided by the population in the valley. The idea though appears to be appealing to a common mind its implementation is fraught with many problems. The engineering problems have always a solution. It is the economic aspect which prevents the planners from implementing such an equitable distribution.

In between the above extremes lies a solution which has to be sought by the planners of irrigation projects, and there is no ready-made process to arrive at the solution that is most acceptable to everybody.

Table 12 Well observations in protected area

Name of Scheme	1991-92			1992-93			1993-94			1994-95		
	DZ	AZ	Total	DZ	AZ	Total	DZ	AZ	Total	DZ	AZ	Total
NMRBC	1514	14760	3964	63	14835	2775	1421	14280	6736	988	14199	4953
NLBC	558	7815	4148	429	7958	4395	327	8015	5319	189	8042	4708
GHOD LBC	148	1928	865	54	1979	319	135	1987	825	54	2051	509
GHOD RBC	70	1272	452	42	1323	234	103	1230	477	28	885	378
NMRBC	696	6794	4226	519	7010	4342	568	7028	4315	472	7011	4248
KRISHNA	468	868	293	464	924	352	494	910	318	456	860	314
DHOM LBC												
DHOM RBC	4	1648	176	2	1652	382	6	1190	385	17	1544	434
KANHER RBC												
KANHER LBC				0	1701	907	4	1786	519	10	2106	803
UJJANI LBC	474	5605	1518	499	6676	1174	460	6584	1292	718	6243	1515
KUKDI LBC	35	2462	397	10	2827	577	6	2886	731	0	2889	0

Note : DZ — Danger Zone; AZ — Alarming Zone; Total — Total Number of Wells

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The Construction Technology and its Applications — National and International Scenario

M V S Rao

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Introduction

I am grateful to the Institution of Engineers (India) and its President, Prof M P Chowdiah, for giving me this opportunity to deliver the Eleventh Dr A N Khosla Memorial Lecture. which is a great honour to me. With all my humility I submit my views to the distinguished engineers and the august gathering to share and to forgive my shortcomings.

Dr A N Khosla's contribution to the nation is so great that I stand as a small person. even to deserve to speak on his eminence and statesmanship. Unable to speak about a highly sophisticated subject of engineering, I have chosen this subject of construction technology and its application which is almost a neglected field of engineering and remains at the tail end today With my deep reverence to Dr A N Khosla, I beseech all of you to recognise the importance of construction activity as compared with all other fields of engineering.

There has been considerable aberration in the demand and supply in the construction activity with the building construction as a resource and a product in the economy of the country. There has been a lot of effort to promote the science of construction and maintenance. Innovative technologies and materials expressed in various forms by eminent Architects, Designers, Engineers, Planners, Developers, Builders, Financiers. Administrators and manufacturers including the R&D (Research & Development) group. Government departments such as Housing Boards, Development Authorities, Department of Town and Country Planning. Public Works Department. Ecology and Environment Departments. NGOs (Non-Government Organisations) and consultants have emerged to give a better living to the people of the country and at the same time, boost the economy of the country. Therefore. it is felt that there is a need to discuss. Analyse and understand the basic concepts and the implications of the application of construction technology on the construction activity and the economy of the country.

National Scenario

The construction technology as a knowledge is prevalent with the highly educated, technical people and their knowledge is almost equal or even superior to anybody in the whole world. However, implementation of the knowledge at the grass-root level is minimal. Consequently, efficiency and affordability for general public is minimised. Some of the bigger companies like L&T (ECE), ESSAR and others are making use of the latest technologies in their construction projects but this is limited only to big projects.

As far as residential construction is concerned, only the old methods are prevalent. If an attempt is made to induce technology into this sector, the construction cost can be brought down considerably, at the same time assuring quality of construction. This is possible only if the tradesmen are trained and paid attractively so that they accept and use the modern technology in their work. At present, the gulf between the technical people and the tradesmen is so vast, not only in terms of educational level but also in their cultural understanding, with the result of all going their own way instead of sharing and meeting from both ends. This can, to certain extent, change if the construction industry works like an industry. It is better to allow residential development to take place in big clusters, rather than construction of individual homes, by individual contractors with proper standardisation which would also contribute to efficiency.

In the past, in the engineering services of the defence department, I was involved in a number of construction activities, but most of them were of the conventional type where the engineering department would have made the plans. layout. working drawings and the contractors would execute the project. We only administered the contracts. Except for design features of the building. the construction practices were mostly of the conventional type. After my retirement, I attended a seminar on the construction materials used in USA. Canada, England and other Western countries, which was organised by a Canadian Company manufacturing machinery to manufacture high-strength concrete masonry blocks using North American design. I was highly impressed by this basic material "the hollow concrete masonry blocks" which in my opinion should replace our conventional bricks entirely. These concrete blocks, although they appear to be only a building material, are fully an engineered product. This means that the material has been used in the most economic and efficient manner to provide all important properties required in a brick to be a part of the building which does not exist in a

conventional brick. As an example of an engineered product used as a basic building block practised in western countries I seek your permission to dwell a bit on this product, which throws some light on the application of construction technology in the international scenario.

Background

Masonry construction is one of the oldest forms of construction used by man. Structures of stone. mud brick, and clay brick were built thousands of years ago and bear witness even today to the durability of masonry. Brick is the oldest man-made building material used almost from ten thousand years ago and some of the latest bricks in the world taken from archaeo-logical digs are said to resemble long loaves of bread and some of them with patterns of Neolithic thumb print impressed on their rounded tops. It was only during the 19th century. that too after the development of hydraulic cement. concrete masonry began to evolve in the USA where large heavy slab blocks were made of a moulded mixture of quick lime and moist sand cured by steam. Slowly the solid blocks due to their heavy weight became impracticable to use, inconvenient to the masons and the techniques of moulding hollow blocks began. Almost in the past 100 years, it seems these hollow blocks with high strength were patented in England and the United States of America. A number of machines for making these blocks began to appear in the USA starting from hand tamping to power tamping and today almost fully automatic machines capable of making about 8000 to 10 000 blocks per day are being made by companies like Besser and Colombia Machines of US and many other companies from Europe and lot of changes in the curing methods from water spray curing to mist curing techniques to modern low and high pressure steam curing systems have been evolved.

It is said that these developments in the machinery and concrete technology have aided to have fine control over various properties of the blocks as a building material such as: Strength. Efficiency, Moisture absorption, Shape. Texture. Form (Architectural), Thermal properties, Acoustic properties. Fire resistance. and Colour. etc.

It was stated that these high strength concrete masonry blocks have lot of advantages over the conventional bricks and stone that we are presently using in constructions in our country. The advantages are said to be : They can be simultaneously used both as structural and architectural construction materials, resulting in substantial economy in the cost of construction; Faster construction thus saving in the interest cost of investment; No plastering is required, thus substantial saving in cost; Best acoustic properties - no other material provides so much noise reduction for so little cost; Best thermal qualities - provides natural air conditioning for a poor man and almost 50% cut in the air conditioning load for rich man; Excellent fire resistance characteristics; Provides very good environmental properties; Having through hollow cores - (Does not provide media for water ingress from external surface to internal surface thus nil ingress of water and no leakage or seepage through the blocks; Complete concealment of electrical wiring; and Concealment of plumbing); and The blocks have high strength to weight ratio thus making the work easier and faster for the mason.

These are said to be used for all construction activities with much economy, for example: Residential bungalows with load bearing walls, Multi-storeyed apartments (high rise buildings), Designed partly as framed structure and partly as load bearing, Commercial complexes. Industrial buildings. Compound walls. Water tanks and sumps, Swimming pools. Chimneys, and Retaining walls. The main advantage of using these high strength concrete masonry blocks is said to be the economics, which today has become most important with the real estate business having come down in the whole of the world. In addition to the economy, various superior properties of these blocks add to their advantage, such as noise reduction on buildings, fire resistance. thermal comfort. etc.

The Noise Reduction in Buildings

Today. noise pollution has become a very important environmental requirement and is even becoming a legal requirement. Studies and surveys of occupants' desires show conclusively that people want apartments and town houses which are sound-proof between walls, rooms and living units. Three techniques are commonly used to reduce unwanted sound. The first is the elimination of the cause of the noise (this can only be done by legislature). The second method of reducing noise is to diminish the sound level within a room by employing materials which absorb the sound instead of reflecting it back into the room. The third is to prevent sound waves from being transmitted from one adjoining area to another. The walls built out of these concrete masonry hollow blocks have been tested and proved to be providing maximum noise reduction with very little cost. Very few . people understand the difference between sound absorption and sound transmission. Sound absorption deals with the problem of controlling sound already in a room so that it does not bounce around (like reverberation. echo, etc). Sound transmission is a different concept. It deals with the problem of sound travelling through barriers from one place to another. The usual problem of sound transmission is to check sound in one place from travelling into next place. The problem today is mostly to check the noise from the outside travelling into the place of our residence, schools, hospitals, etc, for which these hollow blocks are of great use. It is needless to say that the proper noise control must not only be initiated by the architect and the owner but the engineers and the tradesmen must also be involved and understand the entire gamut of noise control. The starting point for

constructing the structure with a pleasing environment – quiet nice to live peacefully - seems to be the requirement of emphasis rather than having the knowledge of construction materials.

The major problems in sound transmissions could be : Transmission of sound from one room to the adjoining one caused by the wall separating two rooms. The problem can be caused by suspended ceiling of sound absorption material, if the wall which is to serve as a sound barrier does not penetrate the suspended ceiling and terminate at the absolute ceiling; Transmission of sound through floors; Street and outside noise which penetrates into the structure through walls and thin-pane glass which not only fail to give resistance to the penetration of sound but also have tendency to start vibrating themselves; Air conditioning in various mechanical and electrical installations such as fans - bearings, compressors, pumps. generators, etc: Doors and windows also offer special problems for noise control requiring weather stripping around doors and windows and even use of two separate heavy glass panes on the windows; Sometimes even plumbing creates lot of noise such as flushing of toilets, dish washers and even the flow of water through pipes. Use of flexible coupling, shock absorbers on dish washers, separation of pipes from floor areas with mastics applied between floors and pipes etc will solve the problem.

Fire Resistance

Concrete masonry fire walls and fire separation walls are commonly specified as fire barriers because these elements are non-combustible, provide durable fire resistance and are economical to construct. Concrete masonry beams, lintels and columns are inherently fire resistant and may be designed to maintain structural integrity for over four rows of fire exposure. Concrete masonry is also used to protect the structural integrity of steel from fire exposure.

Fire safety in multi-family housing requires awareness and understanding of the hazards involved, so that both the potential for fire occurrence and the threat to life during a fire are minimised. The purpose of safety is to eliminate the threat to life during a fire. Death and injury from fire are caused by asphyxiation from toxic smoke and fumes; burns from direct exposure to fire; heart attacks caused by stress and exertion: and due to structural collapse, explosion and falls. Life safety in multi-family housing is influenced by the design of the building, its fire protection features, through the quality of construction, materials, building contents, etc and maintenance. Design relies on three complementary life safety systems to reduce the risk of death due to fire: The detection system to warn occupants of the fire; A containment system to eliminate the extent of fire; and An automatic system to control the fire until it can be extinguished. Each of these essential systems contributes to lowering the risk of death and injury from fire in multi-family housing. The three balanced design components complement each other by providing fire protection features that are not provided by the other components. In addition to these design components, a strong education programme for people, from the tradesmen constructing the building to the people who live in the completed product. is an essential element of fire protection.

Thermal Comfort in Housing with Concrete Masonry

The function of exterior walls is to provide an effective barrier, between outdoor and indoor environments. Satisfactory resistance to heat transmission is important in single family detachment dwellings because these buildings generally have proportionally greater wall to wall areas than multi-family structures. Although important for the resistance of the opaque portion of a wall, the heat flow is not nearly as significant as other elements of a building. For instance, in a typical dwelling, heat gain through infiltration and through windows is considerably greater than opaque portions.

Concrete masonry walls are very good in maintaining thermal comfort in extreme climatic areas. Because of the relative mass of masonry walls, heat is absorbed and its migration either in or out is delayed. This reduces peak heat flow and has the effect of lowering the outdoor to indoor temperature differential. In massive masonry buildings, one can recognise that they are generally cool in summer and warmer in winter and in addition to this. hollow concrete units enhance this thermal effect with the incorporation of air space enclosed in the hollow portion. Air space may be described as the active ingredient in all insulated materials which are employed to resist transfer of heat by conduction.

Architectural Concrete Masonry Units

The increasingly evident advantages of architectural concrete masonry units in building construction have opened a new door to the world of creative design. This is an exiting media with exhilarating potential for attaining the most lofty design aspirations with lesser cost. In the tradition of stone without its expense but with more flexibility, it looks like what it is: a sturdy, honest, viable material. Nothing the price in term of spectrum of architectural units, the concrete blocks are manufactured in an almost limitless number of sizes, shapes, colours and textures and provide the designers with virtually unlimited choices in patterns which can be arranged in many different combinations of layout, shapes, textures, sculptured effects, colours and sizes such as in the form of towering monoliths.

Although, this discourse made it evident that this is technically a superior product- as many other engineered products used abroad - it was a surprise to learn that the masons were reluctant to use this material. Inspite of

wide approval and appreciation by the architects. engineers and designers A problem of psychological fear and resistance to change.

Present Status of Housing in India

As I had mentioned earlier about the real estate business having gone down. it is worthwhile to dwell on the effects of this situation on construction technology. its application and the status of construction activity along with those indulged in this activity. For this, it is required to analyse the factors which contributed to reach this situation.

In the construction field let us take the example of housing. In spite of the fall in market for the housing sector, there is shortage of housing in our country. Let us first see how the demand for housing started in the past 20 years (and suddenly fell in the past 4 years). Earlier days, say before 20 years, mostly the people used to wait to inherit the ancestral property. Slowly the people who could not inherit ancestral property started going for new construction and mostly this was done by the retired people. From the benefits they got - build a house, marry their children and balance of money if at all saved is put into the Bank to get some interest to augment the pension. Slowly the joint family system started breaking and the nuclear family system started. Therefore, even those who had ancestral property wanted to have a house of their own at their place of convenience. For the new construction financial institutions like HDFC. Banks like CANFIN etc started giving loans (including Government) thus encouraging the people in service to make their own houses much before their retirement. Slowly, with the availability of housing loans the youngsters also started thinking of making their own houses at the very young age to have a psychological satisfaction of their own home, their own car, TV etc of a modern living. Thus, young people, that too with both husband and wife working as earning members, started plunging into making or buying of their own house at young age. Added to this, the attraction of getting jobs - white-collared jobs in the cities offering good standard of living –lured people of rural areas to move to cities and have their own houses. Thus the demand for housing in cities went up leaps and bounds. Mostly this demand as a quantum jump was from middle income group followed by higher income group also. This demand was exploited by the builders and landowners and they became greedy to fully exploit the situation and the prices shot up which was totally an artificial rise. Added to this, with Hongkong completing its lease period and joining back China, it was expected that most of the business people would come away to India where living is simpler, comfortable. Further with liberalisation policy of India, the MNCs started pouring into the cities of India.

While all these contributed to the price hike, to make the things worse and to take advantage of the situation, lot of investors from Hongkong and other countries abroad started investing heavy amount in the real estate with high expectations of 100% to 200% return. They did create speculative market increasing the rates sky high, which was all created by speculators and real estate brokers. The investors after making sufficient profits started withdrawing, when their profits started coming down. Suddenly investors withdrew money, speculators went behind curtains and the people who really required the houses for themselves had a psychological shock that they have paid much higher prices than what it is really worth. Thus even those with genuine requirement for houses stopped buying with a wait and see approach till the prices come down. The question mark in the minds of the genuine buyers was what would be the genuine price? Never was this genuine price fixed either by the Government or by the society and it was allowed to go haywire with no government control or with government control only to make their own buck. As the Government has failed everywhere like public sector industries. infrastructure, airlines etc they failed miserably even in housing. All Government housing development authorities became a mess. At best the government should cater for economically weaker sections of the society and leave all housing to the private sector where the market finds its own level for the rates with proper competition. Government can even control the speculative trends and artificial jumps as they would do for essential commodities as housing is also one of the essential requirements of every human being ie, Food, Shelter and Clothing (Roti, Kapada aur Makan). Let me give an example of what happened in Bangalore where I have watched the entire gambit of rise and fall of real estate. Suddenly it was said that the people from Singapore and Hongkong could be coming into Bangalore. do business and some settle down, lot of MNCs would be starting business in Bangalore for the beautiful weather and people from Bombay and Calcutta also started investing in Bangalore and some even moved to Bangalore. All this initiated rise in price of not only commercial buildings but also housing. Then the speculators and media started proclaiming that Bangalore would become another Bombay. the commercial capital of India, which was nothing but a propaganda and they over did it also. A decent housing complex in a decent area costing about Rs 1000/- per sq ft jumped to Rs 3000/- per sq ft in just an year's time. Now it has come back to about Rs 1200/- per sq ft which looks to be a reasonable price and a good sign for the buyers, although there is lot of scope for reduction by using proper materials (as already brought out in the example of North American standard concrete blocks, its usage and efficacy) with proper training of tradesmen and proper utilisation of finance ie. man. material and money (though machines also play perhaps a lesser role in the construction field).

There is a lot for the government to play their part in reducing cost without directly involving in construction and distribution where only red tape is the result. For eg, in Bangalore. a builder who has to get a sanction for

construction after investing heavy amount on purchase of land has to spend almost 35 per cent of the construction cost on various taxes, fees, levies. cess etc and also pay at the completion stage for a completion certificate. Not only this should go but also the building activity should get the industrial status. The Government should restrict themselves to policy making and control on unfair practices and encourage builders to give the best quality at the most competitive prices.

It is good that the present Government at the Centre has announced lot of incentives for housing with a target to build 2 million houses for the middle income and lower income groups in this year 1999 - 2000. It is stated that there is a shortage of more than 20 million houses for living in our country as of now. To start with, a wonderful job has been done by our Minister for Urban Development in repealing Urban Ceiling Act which required a tough stand against the politicians, who were hood-winking the people that this policy was for their benefit, whereas it was only benefiting the politicians and corrupt officials.

The recently announced budget has announced lot of benefits to the buyer and the builder which will definitely improve the housing sector as it was never before.

But this improvement. needless to mention here will occur only in cities and urban areas and for this to the most important requirement is the development of infrastructure in the cities and the whole of the country. As Pandit Jawaharlal Nehru immediately after independence gave impetus to industries, irrigation and science, it should have been followed with infrastructure. Only after 50 years of independence the Governments have started feeling the importance of infrastructure and has done nothing towards it as yet.

To improve the housing sector another important aspect is de-congestion of the main cities and building of satellite towns around cities which again requires political will to develop infrastructure for the satellite cities and make the central portion of the cities very costly so that automatically housing will develop around the infrastructure built for satellite towns as it is called in Singapore CBD (Central Business Districts) where the people are automatically discouraged to live on imposition of high taxes, high levies for entry of cars and various other heavy charges and at the same time to give all incentives for people to live in the satellite towns. For eg, at New York the people who work at New York come every day from New Jersy which is more than 100 kms away and such other satellite towns. Even in Delhi, satellite towns were built long time back but due to lack of infrastructure facilities like transport, electricity, water, proper roads. the people still throng to the central city areas. Again, the present Government announcing of making high ways connecting the North-South and East-West would take a long way in sprouting of satellite towns, if other aspects of infrastructure are also looked into. Even the other important aspects of infrastructure like water and electricity is better to be handed over to private parties as it is an experience that the electric supply is a best in Bombay for a long time as it is supplied by Tatas.

Finance

Finance is also a very important factor which has been considered in the present budget though not as important as the infrastructure development. As in European countries, the mortgage value available for 30 to 32 years period (in almost in all international countries) for negligible EMIs (equated monthly instalments) which can be afforded by low paid employees with very low interest is a very important attraction to buyers. Another aspect is about the fore-closure of mortgage which is not there in our country. For example, if somebody has taken a loan and after paying certain EMIs stops to pay the recovery, invariably, this leads to litigations and the finance companies will have to spend lot of money to get the house into their custody or make the person to pay the balance of money. Such situations are making the finance companies to keep the prospective buyers of the houses as well as the builders at bay.

Conclusion

Therefore, the construction industry and particularly housing which is the major portion of construction activity, the requirement is proper planning of infrastructure, proper financial control, proper application of construction technology. In the case of application of construction technology, the role of tradesmen is very important. Unfortunately, in construction industry they are mostly illiterate or semi-literate without any formal training. The need of the day is proper training of tradesmen in properly constituted institutions similar to ITI for the manufacturing industry. This will give them the dignity of labour, which was prevalent in our old culture which perhaps was lost under the British Rule. The attitudinal and cultural change to the dignity of labour will not only attract the educated at the middle level to enter into this field but also make them proud to participate in the activity, assimilate the innovative technology and give a feedback on the R & D aspects to the experts like architects, designers and manufacturers of materia.ls in the application field. The construction industry has a considerable share in the economic activity of the country hence the construction activity cannot be left to unorganised and unplanned working entity.

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Human Capital Development in Engineering for Global Competitiveness: Changing Occupation and Skill Patterns

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Reducing unemployment of university graduates depends on two factors in particular (among several others): (a) the general economic growth and the consequent creation of new employment opportunities: and (b) the relevance of the skill profiles of the graduates to the requirement of the emerging occupations. These two aspects are delineated in this paper.

CHANGING PARADIGM OF DEVELOPMENT

The economic growth of advanced industrialized societies can be attributed largely to their capability to generate technologies and apply them to industrial production. Enhancing the technological capability is crucial to development. The technological capability of a country in choosing, acquiring, generating and applying technologies, which contribute to meeting its development objectives, resides first of all in human skills - in individuals with the requisite inclination, training and experience. The second component of technological capability is the institutions which bring together skills and know-how that individuals possess and permits its application. The third component is a common purpose without which individual and organizations would not serve the purpose of development. Each of the components of technological capability has some implications for the skills needed by the economy. The generation of technological capability is, therefore, largely a task of skill generation over the whole range from skills in technologies to skills in their productive applications.

The industrial paradigm is changing. Mass production of standardised products is giving way to customer-oriented small batch production. Pattern of use of labour is changing, leading to enrichment and broadening of job content, reduction of hierarchical levels and greater responsibility at the level of the individual. Production strategies seem to be changing which make large inventions unnecessary, as production can be organised just-in-time to meet the need as it emerges. There is an increasing trend towards dematerialisation - diminishing material consumption per unit of economic activity – and reduced energy-intensity of products. New products are less material and energy-intensive, but more knowledge - and information intensive. The key change in industry is increased flexibility in all its dimensions, and an all-round higher skill intensity. The trend is towards a new management system, which permits continuous absorption of innovations, leading to higher levels of efficiency and competitiveness. The characteristics of the new industrial paradigm are: systemic integration, flexibility and incremental innovation.

Impact of new technologies on employment is a mixed one. On the one hand, employment losses can be anticipated as traditional production areas decline and as industries adopt new technologies which require fewer hands in view of higher labour productivity. On the other, new technologies would open up new areas of production and employment, create more incomes and reduce prices, thereby stimulating new demand for products and services, and in turn more jobs. Employment implications of new technologies are largely skill related. Employment in unskilled and semi-skilled activities decline with the introduction of new technologies and' new employment opportunities arise which require considerably higher skills. Accordingly, a strategy to keep redundancies and loss of employment low on the introduction of new technologies is linked with the retraining of existing workers. Furthermore, the loss of future employment opportunities can be avoided if the education and training programmes are reoriented to meet the demand for new skills required by new technologies. In the final analysis, the impact of new technologies on employment would be determined by the capability of the country in the area of skill generation and skill upgradation.

CHANGING OCCUPATIONAL AND SKILL PATTERNS

Changes in Occupational Pattern

As new technologies are adopted in different parts of the world and organisations undergo structural and technological changes, some fundamental shifts are taking place in the occupational structure of the labour

force. It is possible to visualise these changes in terms of five major trends which characterize the occupational transformation.

The first major trend is the continuous shifting of work activity from agriculture to manufacturing, and from primary manufacturing to the service sector. Decline in agricultural employment has been most perceptible in the relatively more advanced economies. Even in developing countries, there is a general trend away from agricultural employment to increased employment in the manufacturing sector.

While employment in manufacturing is growing rapidly, in many of the developing countries like India, there is a simultaneous discernible trend of employment shifting from agriculture and primary manufacturing to the service sector. As the economies grow and income levels rise, demand for a variety of services is posed by the population leading to expansion of activities and employment in the service sector.

The second trend is the emergence of occupations with less manual, but more supervisory skills. There is a general shift away from blue collar jobs and occupations in manufacturing and services, to white collar jobs particularly in the service sector. In manufacturing, employment tends to shift from directly production oriented activities to non-production support activities such as preparatory, supervisory and monitoring tasks. The manual skills are correspondingly being replaced by cognitive skills.

The third change relates to the changing mix among categories of jobs. The proportion of unskilled workers, operatives and craftsmen, which tends to be relatively high in traditional technologies, tends to drop in the new technology job environment, which calls for relatively higher level of cognitive and judgmental skills. Employment tends to increase in those white collar occupations particularly which require higher educational and training qualifications. The proportion of scientists, managers and technicians grows at the expense of unskilled, semi-skilled and craftsmen. Some studies show that, in general, higher the occupational grade, greater is the likelihood that employment has increased in that grade. The opposite is also true: number of jobs in the lower grade generally decline. As a consequence of adoption of new technologies many firms have increased their employment in the management, professional and technical grades with corresponding losses in other grades.

These trends are a direct result of the nature of new technologies which, in general, require higher skills. In the service sector, requirement for higher skills is stimulated by a rising demand for improved quality of service; these improvements are based on the introduction of new technologies. Apart from the higher level of knowledge, workers also require greater attitudinal skills and the ability to undertake higher responsibility in the production process.

The fourth trend in occupational transformation is the shift away from occupational groupings to groupings based on skill and competence. This shift is blurring the current distinction between different occupations. For example, the traditional boundary between technicians and professional engineers is becoming less clear with the wider adoption of the concept of staircasing or bridging. The rigid demarcation between different occupational sub-groups is giving way to a more flexible grouping of skills which involve cutting across several levels of occupational sub-groups.

The fifth trend generated by the new technologies is the dispersal of centralized production and consequent decentralization of work force concentration. Decentralization of production and distribution is increasing the scope of regional and neighbourhood employment. At the same time this requires workers to undertake broader responsibilities over several functions in comparison to the earlier centralized system of production. The centralization is both stimulated and supported by information and communication technologies. Work patterns undergo significant changes.

New job and new job titles are on the increase. Job rotation, job, enrichment, job enlargement, job sharing, flexible working hours and mix of full time, part time, temporary, contracting and leasing of workers, are some of the other trends in the occupational transformation brought about by technological changes.

As work organisation changes, the workers assume responsibilities, at least partially and indirectly, in not just one aspect of production, but in the entire production system. In the initial stages of adoption of new technologies work organisation may not change immediately as, in most cases, the traditional jobs and organisational structure are retained, and new technologies are deployed mainly with a view to improving the efficiency of existing jobs and activities. Over the longer term, however, the nature of work, and how it is organised, also tend to change in tune with the characteristics of the new technology. New technologies tend to increase the flexibility of production and the capacity of production system to respond to rapid change. This, in turn, generates a requirement of flexibility in the occupational pattern within the organisation. Workers are needed who can easily adapt themselves to the requirement of flexibility and rapid changes.

Summarising, the overall effect of adoption of new technologies on occupational pattern is seen to move in the direction of

- increasing the demand for engineers, technologists, information specialists, mechanics, repairers and installers;

- raising the demand for upper-level managers, technical sales and service personnel;
- lowering the demand for draughtsmen, craft workers (excluding mechanics), operatives and labourers;
- reducing the demand for office, clerical and administrative staff;
- increasing the demand for personnel in service industries, particularly in finance, accounting, consultancy, distribution, transportation and advertisement;
- decreasing the demand in production, manufacturing, agriculture, textile, mining and construction industries;
- increasing the demand for greater share of technicians with a corresponding decrease in the proportion of craft workers and operatives, accompanied by greater blurring in the work force at technician and craftsmen level; and
- overall, shifting away from blue-collar jobs in agriculture and manufacturing industries to white collar jobs in high technology and service industries.

Shift in the Nature of Skills

That new and emerging technologies will present a requirement for new skills is not a very profound observation. Rather, a whole range of technology-specific skills will be required for understanding and implementing the new information technologies, bio-technologies and materials technologies, as the spectrum of skill requirements of these technologies is indeed very large and complex. The question is not whether or not more new skills will be required, but perhaps a more fundamental one: whether the nature of new technologies and the impact they have on the work organisation alter the very nature of skills required? In other words, whether the skill requirement of new technologies is merely additive, or does it involve a basic shift in the nature of skills workers should possess? '

New technologies are known to be more complex and have close association with cognitive abilities on the part of the workers. It is no longer sufficient for the workers to be trained merely in techniques and to follow a set of pre-determined routine. The tricks of the trade learnt from older workers on-the-job will not last long as work processes are constantly reorganized and the work content changes. Concerns for higher productivity and quality as well as the complexity of the products themselves (which require that a large number of elements and sub-assemblies work in perfect coordination to each other), as also requirements of maintaining complex systems, demand that the workers possess a good understanding of the nature of material they use, the possibilities and limitations of the technical processes involved, the highly detailed specifications of the designs and drawings and the stringent requirements of close tolerances during finishing operations.

With the adoption of automation and information technologies there will be reduction of manual content in work and the workers would be needed to be involved more in planning of production, supervising production processes and taking responsibility over a number of functions simultaneously. Workers, in this kind of work organisation, will need to interact, communicate and coordinate with other workers much more than in traditional production where jobs tend to be highly fragmented. Routine, repetitive and. fragmented forms of work, which characterise the traditional industrial activity, are becoming irrelevant in the work environment generated by new technologies. Instead of fragmented work, workers will be involved in building relationships among tiny tasks and the ultimate whole, and demonstrate responsibility, discretion and creativity. The worker will also participate more in decision-making and seeking opportunities for themselves - for demonstrating creativity and innovation. In other words they will have to be more resourceful and independent and no longer mere appendages to plants and machinery.

All this would mean that the new worker would require much higher conceptual and behavioural skills. He, or she, would be able not only to understand the technological and scientific principles but also to possess generic capabilities of reasoning, oral and written communication, inter-personal skills and attitudes supportive of quality, productivity and greater harmony. These skills are clearly in addition to the technology-specific skills needed for the new technology based production system.

It has also been observed that the manual content of skills tends to decrease as direct production work is taken over by the machines. With automated and programmable tools, which achieve high degree of accuracy, precision and consistency, the need for skill depth and dexterity on the part of the worker does go down. Some of the tasks earlier requiring great depths of skills can now be performed with the help of these machines with only limited involvement and skills on the part of the workers. This phenomenon of

- substitution of workers skills by skills embedded in machines of modern technologies,
- user friendliness of modern equipment which reduces the requirements for skills in their operation, and
- the simplification in work organisation, has sometimes been referred to as de-skilling.

It has been argued that such de-skilling is inherent to the nature of new technologies.

A question can be raised whether this means a general lowering of overall requirement (decrease in the average level) of skills on the introduction of new technologies. In this context, it would be interesting to note the results of a survey conducted in some 900 industrial firms in Germany. The survey attempted to quantify the cross

currents of increased skill requirements and de-skilling. It found that, as part of changes brought about in the work place by new technologies, about 90% workers needed higher skills and the remaining, approximately 10%, needed lower skills. On balance, therefore, the need for higher order skills, hinted at in the previous paragraphs, increases far more than de-skilling of some jobs. Another survey also indicated that the skill requirements grew more or less directly with technological upgradation of industrial firms, as they moved from partly mechanised operations to fully mechanised work, and to successively higher levels of semi-automated and automated activities. The de-skilling in the manual concept of the work, it would appear, reappears as a new and large requirement of skills of abstraction, planning and anticipation on the part of the worker.

Furthermore, while the need for skill depth reduces, a greater breadth of skills is required in the new technology environment. Under the new arrangement, work is no longer narrow and easily divisible, and the workers responsibility expands to the entire production process. Accordingly, monovalent skills are no longer sufficient. Workers need skills over a whole range of tasks as the processes become more integrated. Greater mobility among various functions and horizontal application of skills becomes an important requirement of the new work setting. Organisations require multi-skill workers with capability for self-training.

In order to appreciate the changing nature of skill requirements, it would be useful to reproduce the findings of certain surveys conducted in the advanced industrialized economies. A survey on Technological Innovation, Ageing Labour Force and Effective Use of Human Resource' conducted in Japan states that:

- it is wrong to think that adoption of mechatronics will simplify the professional tasks through bipolar disintegration of skills. Their applications will, in fact, tend to, create a complex job, compounding several tasks - programming, maintenance, monitoring, operation of equipment - to be taken care by a single worker. In addition, he or she is required to possess logical mental power, problem-solving ability and adaptability to go through the changes;
- such an all round skilled worker (as against a single or multiskilled worker) is required to be equipped with widely varied skills and technical knowledge, in such a way that he understands every action in the performance of the skills, in relation to the relevant technical knowledge; does a job intermediate between engineering and technical skills, by bridging the gap in such areas as development, maintenance, programming of the equipment, experimental production and quality control.

Another survey conducted in New Zealand on the perception of employers about the most important skills and knowledge in modern work force comes out with the following results:

- ability to communicate information to others. This was seen as the most important; 85% responses supported this view;
- ability in practical and technical skills; this was favoured by 72% respondents;
- skills for supervision; this was rated highly by some 37%, and
- diagnostic skills and design ability; which rated low in earlier years, also grew in importance in employers' perception.

Yet another survey of industries in the USA reported the views of employers on the skills and knowledge needed by American workers in high technology industries. According to this survey, the following skills and knowledge would be required in a modem worker:

- advanced technological awareness, high level of mathematics and statistics, knowledge of systems thinking;
- higher level reasoning and intellectual skills, product quality and control skills, trouble shooting skills;
- communication skills, interpersonal skills, group dynamics, team-work skills;
- computer literacy, key-boarding skills, programming and application skills, ability to access and manipulate information;
- higher level electronic skills, ability to apply company equipment to a wider variety of user and consumer sites; and
- ability to diagnose and prescribe one's own training needs and to update oneself in the latest technological changes.

These perceptions point clearly to the requirement of generating multi-skilled and all round skilled workers, who would be imbued with much higher levels of conceptual and cognitive skills of analysis, abstract thinking, communication, adaptability and inter-personal skills, to mention some. A UNESCO document expands this concept further, and talks of a new type of individual with a broad, but profound, knowledge of science, humanities and society, specializing in one field and possessing the ability to work along with other specialists for a common cause. This worker can be expected to characterise the post-industrial society.

An Australian study by Stevenson and Mckavanagh argues for a more comprehensive view of skills and emphasises the need for the less obvious, but important, transferable skills such as learning how to learn, discovery, analysis, problem solving and experimentation. The worker should be capable of

- categorisation of concepts and the selection of key ideas,
- refining concepts and skills to produce better schemata,
- linking new concepts with existing knowledge, which modifies the understanding of both new and existing knowledge, .
- relating verbal representations, non-verbal representations and concrete objects,
- conditionalising skills,
- analysing and interpreting,
- devising and testing problem-solving strategies, and
- checking and monitoring.

The study feels that additional higher order skills will be required to integrate the disaggregated components. These involve

- analysis of overall systems and processes and their interrelationships,
- diagnosis and fault-finding,
- synthesis and innovation, and
- evaluation of one's own problem-solving and diagnostic strategies.

Apart from the above transferable skills, an important change will be in terms of requiring workers to be more flexible and adaptable. Technologies would be changing frequently and, in response, production processes and job responsibilities will also change several times during their working lives. Indeed skills of flexibility and adaptability are becoming increasingly more important and assuming an important component of the skill development of modem worker. The flexibility and adaptability considerations require that much greater time be spent on their education and training, on learning theory, science and technology concepts and, most of all, on developing the ability to learn on their own. The ability of learning-to learn is now a key objective in future oriented education and training strategies.

Since cognitive abilities seem to be at the centre of the skill profile of the modem worker, it would be useful to look briefly at the cognitive structure underlying skills. Knowledge can be differentiated into two parts: the first part can be called 'declarative' or 'prepositional' knowledge. This is knowledge about things, for example, information, facts, propositions, assertions, theories and principles. The other part of knowledge can be called 'procedural' as it is essentially the knowledge of how to secure a goal and involves skills and techniques. For the acquisition of propositional knowledge the need for cognitive skills is obvious. Prepositional knowledge requires broad formal education in institutions of formal education and training. The procedural knowledge, at a lower level, involved the acquisition of existing techniques of solving known and predictable problems. Higher order procedural skills on the other hand, for example, those needed for transformation of skills, checking for consistency, generating analogies and generalisation and accomplishing tasks for the first time, for which no specific procedures have been laid down; involve higher cognitive abilities which again require broader formal training. 'To be competent in current and future work settings, all members of the work force will need propositional knowledge (information, facts, principles and theories), specific purpose procedures (skills and techniques that enable securement of goals) and higher order procedures (abilities, acquiring new skills and to develop expertise in them; abilities to treat new situations as problems, and teaching solutions that accomplish unfamiliar goals, adaptability)'.

In summary, there has been a profound shift in the nature of skills required by, workers in new technology determined environment. The new workers will need:

- multiple rather than single skill;
- breadth of skills rather than depth of skills;
- supervisory and maintenance skills rather than simple operational kills;
- behavioural skills of cooperation, coordination and group working;
- cognitive skills of learning, abstract reasoning and articulation;
- flexibility and adaptability and positive attitude to change;
- diagnostic and design skills;
- capability to receive and pursue the common cause of the organisation and show initiative and creativity;
- skills of learning, discovery, analysis, problem-solving and experimentation;
- skills of planning and organising work and linking these to the overall processes of the organisations; and
- the ability to take initiative in his own skill upgradation and career growth.

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Hydro Power Development – A National Perspective

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The industrial revolution that took place in the Nineteenth century had brought about metamorphic change in the countries which caught and adopted it well in time. All those countries are now in the category of developed countries. India, which was under the yoke of foreign domination like many other countries, could not avail this opportunity. We can, however, ill afford to miss any other similar oppurtunity. This could be the reason for our being one of the leading software nations of the world.

Energy is the basic requirement for industrialisation. India, being a developing country, has witnessed a rapidly growing energy need owing to speedy industrialisation and increasing s.phere of influence. The electric power industry in India has experienced phenomenal growth since independence. The total installed generating capacity (hyJro, thermal and nuclear) has grown from 1330 MWat the time of independence to the present level of 99271 MW (August 2000). The Ninth Plan had envisaged total addition of 40245 MW but as per mid-term appraisal conducted by the Planning Commission in July 1999, capacity addition of 28097 MW is expected.

Indis has a mixed economy and most of the industries in the core sector like power, steel, railway, civil aviation, coal, petroleum, etc are State-owned. However, as India is the largest democracy in the world, its industrial structure and ownership is debated quite freely and frequently and reviewed from time to time. As such, if neccessary, some of the industries in core sector too are open for private investment.

The electricity supply on a commercial basis had an early beginning in India. The first hydro-electric scheme was commissioned near Darjeeling in 1897 and the first etearn power plant was set up in Calcutta in 1899. These were followed by several hydro-electric and thermal power plants mainly for serving the needs of urban population and industrial demands. The most impressive power development scheme implemented in the period prior to the first world war was the 50 MW Kopoli hydro-electric scheme of the Tatas to provide power supply to the Bombay area. These developments gradually led to electricity estabilishing itself as the most versatile convenient form of energy and to the recoginition that it was an essential pre-requisite for industrial development. Several provincial governments took keen interest in development of water resources and entered the field by undertaking a number of pioneering hydro-electric projects. The period between the two world wars witnessed development of Pykara, the Mettur and the Papana Sanam hydro-electric projects in Madras (now Tamilnadu), llhl river project in Hp, the chain of power stations along the Ganga canal in UP, Pallivasal 'project in Travancore (now Kerala), and expansion of Shivasamudram project in Mysore (now Karnataka). In these States, the grid system began to emerge, as electricity from the hydro-electric projects was carried to remote load centres. Thermal power continuted to develop in all important urban centres as a close preserve of private enterprises. Tatas expanded their hydro stations along the western ghats close to Bombay to form largest power system existing that time in the whole of Asia. The aggregate installed capacity in the country which stood at about 1140 MW at the beginning of second world war increased to only 1330 MW at the time of indepedence, as there was stagnation in power development during the war period.

One of the first steps that was taken in the power sector immediately after independence was to introduce a comprehensive legislation to restructure the power supply industry to promote and r.ationalise power development in the country. This new act viz., the Electricty Supply Act of 1948, provided for' the establishment of a Central Electricity Authority (CEA) and organisations in the States, known as State Electricity Boards (SEBs). The Central Electricity Authority was charged with the function of developing the national power policy and co-ordinating the power development particularly in relation to the control and the utilisation of national power resources. The State Electricity Boards were envisaged as semi-autonomous bodies designed to promote power development in the area under their jurisdiction. The process of development through five-year plans, initiated in 1951,ensured upliftment of the socio-economic conditions of the people. Power sector got a large share of plan funds for many decades. The progress under the five-year ~Ians has been im'pressive both in absolute terms and in terms of growth. The installed generating capacity which stood at 2300 MW at the beginning of the first plan in 1951has be~n steadily increased over to 99271 MW by August 2000.

In 1976, the Electricity (Supply) Act was amended to provide for establishment of generation companies by the Central and State governments. The national companies, namely, the National Thermal PowerCorporation at1d the National Hydro PowerCorporation; one regional company, namely, the North- Eastern Electric Power

Corporation; joint-venture companies like Nathpa Jhakri Power Corporation and Tehri Hydro Development Corporation and many State-owned generation companies were accordingly established.

POWER SCENARIO

The demand for power in the country has been rising at a rapid rate. It has outstripped the availability of power causing wide-spread shortages of power in different parts of the country. To manage the power shortages, the State authorities have imposed restrictions from time to time during the last decade both on demand and energy requirements. The overall power shortage in the country during the past years had been as herein under:

TABLE 1 POWER SHORTAGE FOR 1996-97 AND ONWARDS

Year	Energy Shortage (%)	Peaking Shortage (%)
1996-97	11.5 %	18.0 %
1997-98	8.1 %	11.3 %
1998-99	5.9 %	13.9 %
1999-2000	6.2 %	12.4 %
2000-2001 (upto October 2000)	6.9 %	10.8 %

Further, the Region-wise requirement and availability of power for the period from April, 2000 to October, 2000 are given hereinafter:

TABLE 2 POWER REQUIREMENT & AVAILABILITY (Apr-Oct'2000)

	REGION					
	North	West	South	East	North-East	All India
ENERGY (MU)						
Requirement	86538	97823	75279	28015	2991	290646
Availability	81246	88563	69225	28327	3206	270567
PEAK LOAD (MW)						
Demand	21740	25614	19674	7727	992	73567
Availability	19860	20428	17432	7490	961	65628
SHORTAGE (%)						
Energy	6.1	9.5	8.0	(-) 1.1	(-) 7.2	6.9
Peak Load	8.6	20.2	11.4	3.1	3.1	10.8

The 16th Electric Power Survey Committee, the latest in "the series, was constituted by the Government of India 'to review the electricity demand project one in detail up to 2004-05 and to project the perspective demand load up to 2016-17'. The estimates of energy requirement and peak load on All India basis (Public Utilities), as per draft report of the Committee, up to the end of 12th plan (2016-17) are indicated in Table 3.

TABLE 3 FORECAST OF POWER REQUIREMENT – SIXTEENTH ELECTRIC POWER SURVEY OF INDIA

REGION	ENERGY REQUIREMENT (MKWH) / PEAK LOAD (MW)			
	2001-02	2006-07	2011-12	2016-17
North	155815/25049	217470/35013	302448/48712	419106/67527
West	168364/26498	223239/34969	294641/46158	387105/60649
South	142980/22784	194102/31017	262718/42061	354599/56883
East	53586/9229	69971/12109	91075/15822	118157/20625
N-East	6378/1253	9429/1841	13900/2722	20434/4014
Andamans	148/31	236/49	374/ 77	591/122
Lakshadweep	28/7	44/ 11	70/17	111/26
India	527299/84851	714491/115009	965226/155569	1300103/209846

HYDRO POTENTIAL

The economically exploitable hydro power potential of India has been assessed (in 1987) as 84044 MW at 60% load factor excluding contribution from small schemes. A total of 845 hydro-electric schemes have been identified in the various river basins which will yield 442 billion units of electricity annually. With seasonal energy, the total annual energy potential is assessed to be 600 billion units. The hydro potential when fully

developed would perhaps result in an installed capactiy of over 150,000 MW on the basis of probable average load factor. The State-wise hydro power potential for the country is given in Table 4.

TABLE 4 STATE-WISE HYDRO POWER POTENTIAL IN INDIA (AT 60% LOAD FACTOR) AS ON SEPTEMBER 1, 2000.

Region/ State	Potential Assessed (MW)	Potential developed (MW)	Potential under development (MW)	Balance Potential (MW)	(%)
North					
Jammu & Kashmir	7487.00	501.83	385.50	6599.67	88.15
Himachal Pradesh	11647.00	2007.07	637.17	9002.76	77.30
Punjab	922.00	454.67	375.00	92.33	10.01
Haryana	64.00	51.67	11.67	0.66	1.03
Rajasthan	291.00	192.67	8.00	90.33	31.04
Uttar Pradesh	9744.00	1145.33	1334.00	7264.67	74.55
Sub Total	30155.00	4353.24	2751.34	23050.42	76.44
West					
Madhya Pradesh	2774.00	587.83	1202.72	983.45	35.45
Gujarat	409.00	138.67	110.67	159.66	39.04
Maharashtra	2460.00	1118.83	186.83	1154.34	46.92
Goa	36.00	0.00	0.00	36.00	100.00
Sub Total	5679.00	1845.33	1500.22	2333.43	41.09
South					
Andhra Pradesh	2909.00	1402.25	34.37	1472.38	50.61
Karnataka	4347.00	2204.50	425.23	1717.17	39.50
Kerala	2301.00	1125.50	219.30	956.20	41.56
Tamil Nadu	1206.00	946.50	67.50	192.00	15.92
Sub Total	10763.00	5678.75	746.50	4337.75	40.30
East					
Bihar	538.00	119.95	211.00	207.05	38.49
Orissa	1983.00	1100.50	8.95	873.55	44.05
West Bengal	1786.00	91.33	9.83	1684.84	94.34
Sikkim	1283.00	57.50	109.00	1116.50	87.02
Sub Total	5590.00	1369.28	338.78	3881.94	69.44
North-East					
Meghalaya	1070.00	121.67	0.00	948.33	88.63
Tripura	9.00	8.50	0.00	0.50	5.56
Manipur	1176.00	73.17	47.83	1055.00	89.71
Assam	351.00	111.67	90.83	148.50	42.31
Nagaland	1040.00	56.00	25.88	958.12	92.13
Arunachal Pradesh	26756.00	16.50	108.33	26631.17	99.53
Mizoram	1455.00	1.00	36.83	1417.17	97.40
Sub Total	31857.00	388.51	309.70	31158.79	97.81
All India	84044.00	13635.11	5646.54	64762.32	77.06

Out of 845 identified schemes, 331 sites are those of storage type development with total potential of 48,000 MW at 607. load factor. The Region-wise details of these schemes are given in Table 5.

TABLE 5 POWER POTENTIAL IN STORAGE SCHEMES

Region	Number of Storage Schemes	Potential at 60% LF (MW)
Northern	45	10537
Western	92	4648
Southern	91	6822
Eastern	29	3852
North-Eastern	74	22102
Total	331	47961

As per studies made by the CEA, 56 potential sites have been identified for pumped storage projects with total installation of about 94,000 MW. The Region-wise break-up of these projects is given in Table 6.

A sizeable potential also exists in the country for development of micro, mini and small hydro schemes (up to 10 MW). This power potential has been assessed (June 1996) as 6782 MW through 1512 schemes located on canal falls/ rivers/streams.

TABLE 6 PROBABLE POTENTIAL OF PUMPED STORAGE PROJECTS

Region	Number of Schemes	Probable Installed Capacity (MW)
Northern	7	13065
Western	25	38220
Southern	8	16650
Eastern	6	9085
North-Eastern	10	16900
Total	56	93920

HYDRO DEVELOPMENT THROUGH PLANS

The total installed capacity for hydro units for the country as a whole, before independence, was 508 MW. The State-wise break-up of this installation is given in Table 7.

TABLE 7 HYDRO CAPACITY BEFORE INDEPENDENCE

Name of the State	Installed Capacity (MW)
Himachal Pradesh	0.22
Jammu & Kashmir	4.33
Punjab	49.75
Pepsu	0.24
Uttar Pradesh	22.70
Bombay	245.12
Madras	96.15
Mysore	71.20
Travancore-Cochin	15.10
West Bengal	2.76
Assam	0.55
Manipur	0.15
Total	508.27

The planned development of economy was initiated in 1951 to improve the socio-economic conditions of the people. The development of power was given significant importance in the plan programmes. The main objectives of power development since independence has been to increase power availability rapidly and extend power supply to all the regions of the country.

In 1951, when the first five-year plan was drawn up, the country was facing serious food shortage and emphasis was logically on extension of irrigation facilities and improvement in agricultural practices. The programmes during first decade of planned development (1951-61) included a number of multipurpose river valley projects with hydro-electric power generation as an important component. The most spectacular multi-purpose river valley project undertaken during this period was the Bhakra-Nangal Project, which was planned to irrigate vast areas of land in Punjab, Haryana and Rajasthan and afford electricity generation with a total installed generating capacity of 1194 MW (later uprated to 1405 MW). The programme also included unified development of Damodar Valley for the purpose of providing flood control, irrigation and power supply in the Damodar Valley area. Integrated development of Chambal Valley for irrigation and power benefits in Rajasthan and Madhya Pradesh was also taken up. Besides these multi-purpose projects, a number of single-purpose hydro-electric projects were taken up for implementation. These include the gigantic Sharavati hydro projects in Karnataka, the Koyna project in Maharashtra and the Kundah Project in Tamilnadu.

The third five-year plan (1961-66) and the three annual plans that followed, continued to lay emphasis on infrastructural industrial development. The fourth and the fifth plans laid emphasis on rapid expansion of power supply facilities. The most significant feature in the two plans was the realisation of the need for greater participation by the central government, in the expansion of power generation programme in order to supplement the efforts of the States. The programme in the fourth plan included three hydro-electric projects, viz. Salal (345 MW) and Baira-Siul (180 MW) in the Northern Region and Lok Tak (105 MW) in the North-Eastern Region in the central sector. The fifth five-year plan laid emphasis on speeding up the construction programme and commissioning of power generation project and also maximising generation from the available capacities. Two central organisations, viz. National Hydro-electric Power Corporation and National Thermal Power Corporation were set up in 1976 for estabilishing major hydro-electric projects on regional and national consideration and to promote the development of super thermal power stations located mainly close to pit heads.

The sixth five-year plan laid empahsis on the organisation of power supply facilities with the main objective of achieving a balance between supply and demand as early as possible. One of the foremost tasks of the sixth plan was to improve the functioning of the thermal power stations. The sixth and subsequent plans continued to lay emaphasis on thermal generation, for quick capacity addition, resulting in serious imbalance on hydel-thermal

mix. The ratio of hydel-thermal generation which stood at 39.03% in 1980-81 (first year of sixth plan) dwindled down to 24.63/0 by March, 2000.

The decline of hydro power in the total power generating capacity of India is not due to non-availability of exploitable hydro potential in the country. In fact, about 77% of the total potential of 84044 MW at 60 percent load factor (over 150,000 MW installed capacity based on average load factor) still remains unexploited. The constraints which have slowed down hydro growth are: Technical (difficult investigation, inadequacies in tunnelling methods); Financial (deficiencies in providing long term financing); Tariff related issues; Management weaknesses (poor contract management); Geological surprises (especially in Himalayan region where underground tunnelling is required); Inacceseesibility of the area; Problems due to delay in land acquisition; Resettlment of project affected families; and Law and order problem in militancy prone areas.

It is an admitted fact that deficiency in planning both during project preparation stage and at construction stage have contributed significantly to a slow pace of hydro power development. There is a need for change and from the experience gained from past projects, considerable improvement can be achieved in the aspect of project planning and preparation of bankable DPRs. These DPRs must be complete to such an extent that they contain every minute detail of the Project from concept to commissioning, be it construction equipment or the work specifications or the structural detailing or the operation guidelines. The development of hydro capactiy during various Five Year Plans is indicated in Table 8.

TABLE 8 HYDRO CAPACITY ADDITION THROUGH VARIOUS PLANS

Plan (Period)	Installed Capacity (MW)	Capacity at the end of Plan (MW)
First (1951-56)	431.21	939.48
Second (1956-61)	977.18	1916.66
Third (1961-66)	2207.08	4123.74
Three Annual Plans (1966-69)	1783.17	5906.91
Fourth (1969-74)	1058.39	6965.30
Fifth (1974-79)	3867.77	10833.07
Annual Plan (1979-80)	550.90	11383.97
Sixth (1980-85)	3076.95	14460.02
Seventh (1985-90)	3847.61	18307.63
Two Annual Plans	886.99	19194.62
Eigth (1992-97)	2450.18	21644.80
1997-98	246.28	21891.08
1998-99	551.92	22443.00
1999-2000	1373.00	23816.00

The most outstanding achievement during the half centrury of development after independence has been the development of indigenous expertise in all fields of .hY4ro power engineering-investigation, design and construction. Over the years, many major projects involving large dams, long water conductor systems, surface and underground power houses-some of these World class have been built and are successfully operating. A noteworthy aspect of the experience gained is the successful execution of many projects in the geologically difficult Himalayan region, where bulk of hydropower potential of the country exists. As a result of expertise developed, India is now in a position to assist the neighbouring countries in this field of water resources development.

HYDRO POLICY 1998

The share of hydro power has been continuously declining during the last three decades inspite of the inherent advantages. The hydro share has come down from 43.50% in 1970 to 24.63% in 2000. The ideal hydro thermal mix should be in the ratio of 40:60. Because of an imbalance in hydel- thermal mix, not only power stations are required to back down during off peak hours, but it also contributes towards grid instability. With a view to initiate measures to check the declining trend ih the hydro share in overall energy generation and to exploit the hydro power potential available in the country, the government has accorded approval to the policy on 'Hydropower Development'. Salient features of this policy are as under:

(i) All the ongoing central sector hydro-electric projects would be provided with full budgetary support till completion. Government of India will also provide budgetary support for the new projects to be taken up by the CPSUs during the 9th Plan.

The monitoring of all the ongoing projects will be intensified and a task force would be constituted for this purpose. The progress of important projects in the State and Central sector would be reviewed at the level of Minister Secretary(Power) and all measures will betaken, so that, there is no slippage in the schedule for completion of the ongoing projects.

(ii) A cess would be levied at the rate ono paise per Kwh on electricity consumed in the country. The State/UT Governments would be responsible for the collection of the cess. The amount would thereafter be credited to a 'National Power Development Fund'. Two-thirds of the amount realised from the State/UT Governments will be allocated to the respective government to be utilised for power development. The remaining one-third will be utilised by the Central government for promoting hydel projects in the Central sector and for investment in transmission lines for evacuation of power from mega hydel projects meant to benefit more than one State.

(iii) Detailed studies to firm up the parameters of the projects identified would be taken up on the basis of basin-wise development of hydro potential to maximize benefits.

(iv) Immediate steps would be taken to tie up funding, execution agencies, and conveying of investment decision for the schemes already accorded techno-economic clearance of CEA for capacity addition in the 10th Plan and beyond.

(v) New projects will initially be taken up by CPSUs/SEBs for investigation and updation of DPRs to obtain necessary clearances and pre-construction activities. These projects would then be offered to the private sector for execution, either on 'stand alone' basis or on joint venture basis.

(vi) A consensus would be evolved among the basin states regarding the location, basic parameters of the projects and mechanism through which each project would be constructed and operated.

(vii) Renovation, modernisation and uprating of old hydropower plants would be accorded priority, for tying up technology, funding and executing agencies.

(viii) The State government and Central and State hydro-corporations would be encouraged to take up cluster of small/mini hydel schemes on Build, Operate and Transfer basis, or other suitable arrangements.

(ix) Government would evolve simple procedure for transfer of CEA's technoeconomic clearance and environment and forest clearances would be transferred within a prescribed time limit.

(x) Tariff for power from hydro projects would be rationalised and allowed premium on the sale rate of power during peak period.

(xi) In the case of increase in project cost due to geological risks, developer would be allowed to submit proposals for the enhanced cost for acceptance by the government.

(xii) Greater emphasis would be placed to take up hydropower projects as joint ventures between PSU's/SEB's and the domestic and foreign private enterprises.

(xiii) Limit for selection of developer through MoU route for the hydel projects would be upto 250 MW.

(xiv) Government support would be given for land acquisition, resettlement and rehabilitation and catchment area development.

WHY HYDRO POWER?

Hydropower represents a renewable source of energy which enjoys many intrinsic advantages as compared to thermal power. Besides being inexhaustible, it is pollution free and non-inflationary in character. Hydro power exhibits operational and economic superiority over other modes of power generation particularly in catering the peaking power requirements. Hydro plants play very distinct role in power system operation. Since thermal plants cannot be started at short notice and frequent 'Backing down' leads to wastage of primary energy, they are suited only for base load. On the other hand, hydro stations can be loaded from zero to full load and vice versa in a couple of minutes. With such a flexibility in operation they become ideal for peaking purposes and meeting the fluctuating demands so vital for maximum 'Composite economy' of an integrated power system.

In countries like India where fossil fuel options are also open, the first priority should go for exploiting the renewable hydro energy source whose potential is very high. A higher priority for hydro would help in saving and conserving non-renewable primary energy sources for their utilisation in sectors other than power and also for future consumption even in power sector.

In a mixed system also utilising hydro, thermal and nuclear options for generation, there is a minimum limit of hydro-mix. The operation of the system below this limit would result in operational problems like power shedding, system instability and sub-optimal utilisation of thermal plants.

Generally the cost of generation from a hydro power station is relatively low as compared with other sources of energy generation completed during the same time and emerges to be cheapest in the long run as it does not involve any fuel component. The hydro-electric plants have longer span of life ranging from 35 to 50 years and even more. The hydro projects yield considerable socio-economic benefits to remote areas, where these are generally located, in the form of infrastructural development, improvement in local economy & some

employment generation etc. And above all, in this age of ozone depletion and global warming, we have to look up to hydro power as the energy source of the future, which is clean in the true sense.

STRATEGIES FOR HYDRO POWER DEVELOPMENT

The imbalance in hydro thermal mix needs to be corrected for which considerable capacity addition through new hydro-electric projects is called for. So far, there has been poor response from the private sector in development of hydro power projects, largely due to inherent risks associated with these projects or delays in obtaining statutory clearances. The Public Sector Undertakings (PSU's) and State Electricity Boards (SEB's) shall, therefore, need to play an increased role in the coming decades. The large capacity addition would call for huge investments which may be difficult for the Govt to support through the budget/plan assistance. Therefore, coming years would also witness a greater involvement of Independent Power Producers (IPPs) and joint ventures to realise the targets of hydro power development. Measures like government support for land acquisition, resettlement and rehablitation and catchment area development, simplification of procedures relating to transfer of clearances from State Govt to Centra: PSUs as well as to private sector; providing a different pricing for peakintj power; providing liberal funding suprzert for survey and investigation work with a view to have a shelf of bankable DPRs would go a longway in achieving the objectives of hydropower policy of Govt of India.

The programmed capacity addition from hydel projects during the 9th plan is 9819 MW, of which Central Sector and State sector will contribute 3455 MWand 5814 MW respectively. And the balance 550 MW will be contributed by the private sector. Sanctioned & ongoing schemes under implementation will enable capacity addition of 6538 MW during the 10th plan, of which 990 MW,4498 MW and 1050 MW will be the contribution of Central, State and Private sectors respectively, In addition, 13 projects (7055 MW) have been identified for advance action in the 9th plan for benefits in the 10th plan. The Government of India has decided to take up the following 13 projects in the Central sector: Parbati Stage-II,(800 MW), Himachal Pradesh; Kol Dam (800 MW), Himachal Pradesh; Rampur (535 MW), Himachal Pradesh; Charnera Stage-II (300 MW), Himachal Pradesh; Tlpalrnukh (1500 MW), Manipur; Loktak Down stream (90 MW), Manipur; Tuivai (210 MW), Mizoram; Kameng (600 MW), Arunanchal Pradesh; Ranganadi Stage-II (160 MW), Arunachal Pradesh; Tehri Stage- II (1000 MW), Uttar Pradesh; Koteehwar (400 MW), Uttar Pradesh; Teeeta Stage V (510 MW), Sikkim and Lower Kopili (150 MW), Assam.

The capacity addition during 9th & 10th plan, indicated above, totals upto 23412 MW, which is just sufficient to maintain the hydro share at 25 percent. If the share were to be enhanced to 30 percent, it would require a further addition of 10,000 MW of hydro capacity. Thus we have to live with the situation for some years but greater private participation and much greater Govt involvement is essential in the coming decades for improving the hydro mix to 40 percent.

There are certain misplaced notions about hydro projects which have given a back seat to hydro during the last three decades. Some of these are that these projects require high initial investment, have longer gestation periods, involve huge submergence and that these are not enviornment friendly. With proper projection and active participation from people, a balanced approach for sustainable development shall only bring hydro to the place it deserves.

Tremendous experience has been gained in the past during construction of hydro-electric projects, most of which were located in easily accessible areas. More than 80% of the remaining potential lies in Northern & North- Eastern regions in relatively difficult areas. There is a need to accelerate the development of hydel potential in these areas by adopting appropriate technology. Of special importance are the factors like stabilization of hill slopes, environmental protection and care that needs to be taken for elimination of silt in the case of run-of-river schemes with a view to avoid damage to turbine runner.

Privatization, restructuring and major shift in the way projects are financed have recently presented the hydro community with numerous challenges. Coming years would witness a greater involvement of independent power producers (IPPs) and joint ventures for which the requisite atmosphere, incentive and reliefs need to be provided to stimulate the growth of the hydropower. The role of PSUs/SEBs also needs to be strengthened as mega hydro projects in North and North Eastern regions shall have to be executed by central PSUs in case the State or the private sector is not in a position to implement these projects.

Investment Aspects

Hydro power represents a renewable source of energy which enjoys many intrinsic advantages as compared to thermal power. Although the apparent cost of construction of hydel station is more or less the same as that of a coal based station (the real cost is nearly half of thermal equivalent) in terms of investment per MW, it scores over the latter in a big way because it involves no capital or recurring expenditure on the production and

transportation of a fossil resource which is finite in nature and, therefore, needs to be conserved in the long-term interest of the country.

It has been estimated that every 1000 MW of hydel capacity created to operate at 40% plant load factor, results in annual saving of around Rs. 140 crore on the production and transportation of coal. The development of country's full hydel poptential can thus save the country something like Rs 20,000 crore and also avoid a tremendous strain on our coal and 'transport sector. The estimated completion Capital Cost of some of the recent hydel and thermal projects are given below in Table 9.

TABLE 9 ESTIMATED COST PER MW OF POWER

THERMAL			HYDEL		
Project (Cap. MW)	Estimated Cost (Crore Rs.)	Cost/MW (Crore Rs.)	Project (Cap. MW)	Estimated Cost (Crore Rs.)	Cost/MW (Crore Rs.)
Vizag (1040 MW)	4628	4.45	Teesta V (510MW)	2568	5.1
Torranglu (260 MW)	1093	4.21	Chamera-I (540MW)	2114	3.91
Jojo Bera (240 MW)	1025	4.27	Vishnu Prayag (400MW)	1641	4.1
Talchar II (2000 MW)	7679	3.83	Kopili (250 MW)	373	1.492
Surat Garh (500 MW)	2057	4.11	Lower Periyar (180MW)	326	1.81

As can be seen from the above, the estimated completion cost per MW of hydel is more or less equal to thermal. If we add environmental impact cost on generation in thermal project as 7% of the project cost, as compared to 1.38% to 4.5% in the case of hydel, the cost of generation of thermal power further goes up. Moreover while comparing cost benefit ratio, only investment costs and benefits from sale of energy are compared, ignoring other benefits, which accrue out of hydel projects. Some of these benefits are: Irrigation; Flood Control; Water Supply; Navigation; Development of Fisheries, and Tourism.

Thus it can be said that the notion that hydel projects require higher investments is misconceived and based on wrong assumptions. As a matter offact, thermal projects require additional investments in development of coal mines, railways lines etc. which hydel stations do not require.

Gestation Period

The gestation period of a hydel project (considering infrastrure development etc as well) may appear to be longer that the thermal project but one must not forget that the life of hydel project is more than double of the thermal project. The longer gestation period of hydel project may arise out of the following reasons: (i) Longer period for assessment of the scheme-Investigations relating to hydrology, topography, geology etc; (ii) Involvement of large number of agencies; (iii) Longer period in determining and ascertaining ecological and environmental impact; (iv) Formulation of rehabilitation and resettlement plan and its implementation; (v) Acquisition of land; (vi) General apathy of lenders towards project financing because of misplaced notions; (vii) Remoteness of area of operations; (viii) Relatively large percentage of works related to civil engineering, which is time consuming; (ix) Uncertainty due to unforseen features met with during construction in the civil works; and (x) Lack of potential resourceful contractors. However the longer gestation period can be reduced to a great extent by proper planning and implementation. With the aid of satellite and other modern equipment of survey and geological exploration, the investigation time can be greatly reduced.

As a matter offact, the real construction period for a major hydro project is not more that 5 to 8 years. However, in the absence of any well defined 'Zero Date' if one counts the time from the date of project clearance, the period may seem to be large. One should accept the fact that the activities like infrastructure development, land acquisition, resettlement and rehabilitation which consume considerable time can not be counted towards construction period. Since 'Zero Date' for a thermal project starts from placement of order for the generating units, likewise 'Zero Date' for hydro should be counted from the date of award of civil works.

It shall also not be out of place to mention here that we must not rush through the award of civil works for a hydro without resorting to extensive and detailed designs and preparation of thorough specifications and tender drawings. The history of projects completed on schedule has demonstrated consistently the importance of spending time in planning and design at the 'front end' of the project before implementation. Of equal importance is the monitoring during construction. There are modern management & monitoring tools available to assist in controlling project duration. Computerised monitoring, provided it is implemented seriously, can definitely check delays and reduce the gestation period considerably.

Environment and Other Concerns

The requirement of power cannot be curbed and it has to be provided to the consumers. Efforts should be made to supply un-interrupted power supply round the clock. Whatever be the source of power i.e thermal, hydel, nuclear all make an impact on environment. It would be interesting to see impact of Hydel power project viz-a-viz Thermal power project.

Various environmental impact parameters such as forest, flora & fauna, green house effect, acid rain, air pollution, displacement of people etc. and their rating on a 10-point scale are indicated in Table 10. It also considers parameters of mitigation measures such as compensatory afforestation, catchment area treatment, pollution containing measures, rehabilitation and so on. The algebraic sum of impacts and their mitigative measures places hydro at 3 and thermal at 7 on 10-point scale.

TABLE 10 RELATIVE ENVIRONMENTAL IMPACT OF HYDRO AND THERMAL POWER PROJECTS

Hydro		Thermal	
A. Environmental Impact	Points (on a 10-point scale)	A. Environmental Impact	Points (on a 10-point scale)
1. Forest	7	1. Green House Effect (CO_2)	4
2. Flora and Fauna	3	2. Air Pollution	
		(a) Acid Rain (SO_2)	2
		(b) Dust and Smoke	7
		(c) Others (NO_2)	2
3. Displacement	6	3. Water Pollution	2
4. Water-borne Disease	1	4. Generation of Ash	3
5. Quarry for Construction Material	2	5. Forest	1
		6. Displacement	4
		7. Flora and Fauna	1
		8. Development of Mines	7
Total	19		33
B. Mitigative Measures			
1. Catchment Area Treatment	4	1. Increasing Height of Chimney	2
2. Afforestation	4	2. Electrostatic Precipitator	4
3. Rehabilitation Measures	3	3. Rehabilitation Measures	3
4. Measures for Flora and Fauna	1	4. Environmental Measures in Coal Mines	5
5. Restoration of Land to remove Scars of Construction	1	5. Ash Disposal System	3
		6. Effluent Treatment System	2
Total	13	Total	19
Net Impact (A - B)	6	Net Impact (A - B)	14
Impact Ratio of Hydro : Thermal = 6 : 14 i.e. 3 : 7			

Further, general impression created amongst people is that only large dams are being constructed and they submerge large tracts of land. The fact is that only storage type multi-purpose dams are large in nature and those too are constructed after detailed technological, hydrological, ecological and environmental investigations. Wherever possible small and medium dams are also being constructed in a very big way. It is also propogated that large dams cause submergence of large areas and are inferior to small and medium dams. It is argued by many that small and medium dams would be an ideal substitute for large dams, which is also not true.

THERMAL POWER PROJECTS

Let us now examine a typical case of submergence of area by various types of dams. The total area under submergence, in Gujarat is tabulated below.

As can be seen from above, the area under submergence in hectares per million cub m of storage capacity in large dams is much less than in small dams. This would be even lesser in hilly terrains like UP and Himachal Pradesh. Even submergence of land per MW of power generated also, as tabulated below, will indicate that hydel projects could be very economical source of energy.

TABLE 11 RATIO OF SUBMERGENCE TO STORAGE CAPACITY (GUJARAT) : LARGE AND SMALL

Item	Large Dams	Small Dams	Sardar Sarovar Project
Storage Capacity (in M cubic metres)	15384	1865	9500
Submerged Area (in hectares - Ha)	149847	44834	34867
Submerged Area per Storage Capacity (Ha/M cubic metres)	9.74	24	3.67

.

TABLE 12 SUBMERGENCE PER MW OF INSTALLED CAPACITY FOR HYDEL PROJECTS

Project Name	State	Capacity (MW)	Submerged Area (in Ha)	Ratio (Ha/MW)
Baira Siul	HP	180	15.20	0.08
Chamera-I	HP	540	975.00	1.81
Salal	J & K	690	940.00	1.36
Sawalkot	J & K	600	940.00	1.84
Uri	J & K	480	0.00	0.00
Dulhasti	J & K	390	85.00	0.22
Baghlihar	J & K	450	96.63	0.22
Dhualiganga I	UP	280	28.68	0.10
Rangit	Sikkim	60	19.00	0.32
Teesta III	Sikkim	1200	12.00	0.01
Lok Tak	Manipur	105	0.00	0.00
Total		4975	3111.51	0.62

It is seen from the above that about 5000MW of power is generated with submergence of just 31 sq.km. (0.62 hectares per MW). There are numerous other benefits, discussed earlier, which also need to be kept in mind in selection of a power project.

Unfortunately, our country does not have enough storage sites on account of limitation of topography. Consequently, it has been estimated that the ultimate storage capacity will be about 30 million ha. m, which amounts to about 7.5% of the average annual rainfall and about 16% of the average annual surface flow.

Whereas hydro-electric projects with adequate storage are essential not only for better utilisation of annual flows but also for providing necessary peaking power, at the sametime, they do have larger impact on environment in comparison to run-of-the river projects. On the other hand, run-of-the river schemes, particularly those on Himalayan rivers have to face the fury of silt damages and are thus required to accommodate large structures for desilting of water before feeding the turbines. If adequate arrangments are not made for passage of sediment load of the river during flood season, small diversion dams for run-of-the river schemes get silted up to the crest of eplllwayeln less than a decade. Siltation of reservoir (for diurnal peaking) for such schemes also needs to be checked effectively through regular flushing. Nathpa Jhakri Hydro-electric Project(1500MW) is one such project, under construction in the Northern Region, where efforts have been made to minimise silt damages during project operation. Desilting chambers, four in number, each 525m long, 16.31 m wide & 27.5 m high are the largest underground excavation of its kind in the World. In addition, flushing of reservoir shall be resorted to every year through low level sluices in the dam. Model studies have revealed effective flushing due to narrow width between the banks and steep bed gradient.

There is thus a need to judiciously exploit both the storage sites and run-of the- river schemes for power development as their roleer are supplementary.

In the case of large storage Dam projects like Bhakra, Beas, Sardar Sarovar etc., there has been significant displacement of population which resulted in rehabilitation and resettlement problems. With the passage of time there is much more awareness among the masses than the period soon after independence when projects like Bhakra, Rihand, Hirakud etc., were taken up. Major cause for the R&R issues bringing bad name to the Hydro development is probably the fact that the benefits have not percolated down to the persons affected. The best way to rectify the image is by taking care of each aspect of R&R at the Planning stage itself and by active involvement of the affected persons soon after the project gets a go ahead for construction. For times immemorial, the human civilisation had remained associated with the rivers for their all-round development.

During the last few decades great concern has been expressed over the increasing deforestation due to overall development in the country which was causing serious ecological imbalance. There is a need for ensuring sustainable development by adopting eco-friendly technologies. We must attempt to solve our environmental problems with the active participation of the local people.

Economic development of nations in the next century will depend on their capacity of generating new technology and modernising old technological know how in view of problems relating to changing ecology, depleting natural resources, increasing pollution and green house effect, diminishing productivity of land as well as deforestation.

There is thus also a need to create a strong database on environmental related parameters so as to plan future developmental activities in the country on a most environmental friendly manner. Introduction of a well structured curriculum covering environmental related topics at various levels of formal education system, besides extending support to NGO's shall go a long way towards ensuring a healthy world to live in.

INVOLVEMENT OF IPPs

Private sector involvement and ownership in power represents a major economic, cultural and political shift. It is rather unfamiliar and complex process in the Indian power supply system. Ever since the opening up of the power sector to private investment in 1991, the public has been fed on illusion of plentiful power through private sector participation in power generation. Although the privatisation policy generated considerable enthusiasm amongst both the foreign and Indian investors and over 250 expressions of interest aggregating to over 100,000 MW were received from the private investors none of these proposal~ have in material terms taken off the ground.

The MoU route policy was opposed by many experts and economists who had pleaded the Government to follow, in the interest of the consumers and the nation, a transparent policy for selection of power producers through competetive bidding process. The Government ultimately had to abandon MoU route and competetive bidding was made compulsory after Feb.1995. The private sector so far has been hesitant and cautious to invest in hydro projects. It is proposed that new projects will initially be taken up by CPSUs/SEBs for investigation, updating of DPRs, obtaining the necessary clearances and undertaking pre-construction activities. After these stages, the projects could be offered to private participation by the CPSU/SEB. The expenditure incurred by CPSU/SEB on these activities would be adjusted in the project cost to be recovered from the executing agency to be decided at a later date.

PROJECT FINANCING

Pancity of funds has been the major cause of slow development of hydropower, delays in initial start, delays during construction stage. At times this even resulted in abondoning the project midway as in case of Maneri Bhali, Koel Karo etc. The States (North & North-east) where bulk of hydro potential is located have not the resources to develop major hydro projects of their own.

With the opening up of the power sector to private investment and Govt. Of India's approval to policy on hydropower development, variety of sources are available for hydro financing, both for equity and debt. Many of these have, however, not been fully tapped, due to inadequate knowledge, faulty homework or government policies. For investment to come through in the case of State-owned project, the lender would like to be convinced that. the utility in - financially viable, operationally efficient and capable of executing and commissioning the project in a specified time frame. For a private project, apart from these criteria, a suitable investment security mode has also to be offered.

Following the practice in other countries, private sector projects being developed by IPPs, especially of foreign investors are based on ' project financing' which envisages mobilisation of funds on the basis of performance of a specific project rather on the strength of a company's balance sheet. Such type of financing is sometimes referred to as non-recourse or limited recourse financing since the lenders have no or limited recourse to the project sponsors for repayment of loans. Therefore, it involves careful analysis of project cash flow performance under various scenarios to ensure a high probability for repayment of projects debt to the lenders. The lenders donot want the repayment of the principle as well as interest to be azivereely affected by the risks attributable to others. Similarly the investors want to ensure that their return on equity is not affected by the adverse performance. In view of the fact that the power sector is very critical in the overall economy, there exists a substantial existing and projected demand supply gap and therefore, for project sponsors and the lenders the issue of industry environment risk is not very critical atleaet; at present and at least for first few projects in each state. The matter of policy governing the power sector is an important area of concern for the sponsors.

There are three specialised financial investors in the Indian power sector: Power Finance Corporation (PFC), the Rural Electrification Corporation (REC) and the Indina Renewable Energy Development Agency (IREDA). All the three are located in Delhi & owned by Central government. Of the three, PFC has been the most active in

funding the bigger hydro projects. In 12- year existence it has sanctioned over Rs 22,000 crore worth of loans to over 1000 power projects of various type. Within that total, about one-fifth of the loans have gone to hydro sector. REC, not PFC, now funds all new schemes of less that 25 MW and thereby supplements the effors of IREDA in funding the small hydro sector.

By 1999 end, IREDA has sanctioned loans worth R;; 3413 crore, small hydro accounting for slightly over Rs 800 crore, for 79 projects totalling 260 MW. Since most of the hydropower projects in India, in the past, have been developed by government-owned utilites, they have generally not made use of specific, project related funding from the domestic money markets. Big domestic commercial banks like State Bank of India have been quite active in funding the power sector, directly or indirectly.

Two recent instances of hydro financing by domestic institutions are worth mentioning. The Rs 810 crore (US$180 M) domestic debt portion for the 300 MW Chamera II project has been tied up with a number of domestic banks by its developer NHPC, and it achieved financial closure last June. For the Rs 2250 crore ($450M), 400 MW Maheshwar project, promoted by Bombay based S Kumar Group, leading domestic financial institutions such as the Industrial Development Bank of India, Life Insurance Corp and the General Insurance Corp are considering ajoint equity subscription ofRs 100 crore ($ 22.5 M), taking 15'1.of the stock. Ogden Energy of the US holds the largest portion of its equity-49%-while the balance is held by the S Kumars, and Siemens and Noell of Germany. If this comes through, it would be the first known foray of domestic financial institutions into hydro equity: where previously they gave only debt. Domestic debt at Maheshwar has been provided by PFC, domestic financial institutions and some commercial banks (including the State Bank of India), either through loan or gurantees.

A new finacial institution, Infrastrcture Developement Finance Corporation (IFDC) was set up in India in 1997, specially to finance major projects, by the Central government, multi-laterals and others. The Corporation has already funded few projects, although, none in hydro sector so far.

Multi-lateral financial it1stitutions have also funded hydro sector selectively both directly and indirectly. Of the direct loans, a major one has been by the World Bank $ 437 M (Rs 2000 crore) for the 1500 MW Nathpa Jhakri Project. The bank has also lent $156M (Rs 700 crore) for the Orissa SEB's 600 MW Upper Indravati Project. Indirectly , it has financed 100 MW in small hydro, through $ 70 M (Rs 300 crore) line of credit to IREDA.

One of the reasons why multilateral have not made more impact is a paucity of eligible projects. The Govt. Of India has now asked both its own and State Hydro power utilities to prepare 'shelves' of projects, with appropriate documentation similar to detailed project report (DPRs), to propose to the multilaterals. This will definitely improve lending facilites in the future. Lately, even the private lending area of the World Bank Group, the IFC, has shown a renewed interest in financing Indian power projects through equity and loans. One of the most active institutions in Indian Hydro scence in the past was OECF (nowJBIC) of Japan. Lt gave a ¥ 5.665 B loan to NHPC for the 280 MW Dhauliganga I project due for completion in 2005. It gave even a bigger loan of ¥ 24.65 B for Sardar Sarovar, but the loan has been suspended due to dispute between the developer and the Japanese equipment supplier. Other OECF beneficiaries include Srisailam left Bank (900 MW), Purulia pumped storage (900 MW), Tuirial (60 MW) and Teesta Stage I, II& IV (45 MW). The OECF, however, suspended consideration of new loans in mid-1998, following the economic sanctions imposed by Japan on India for its nuclear tests.

There have been instances of hydro loans and guarantees by certain overseas banks and financial agencies for specific projects. An example is the $900 M(Rs 4100 crore) Uri project (480 MW), developed and commissioned by NHPC in early 1987. The foreign debt portion of about $614M (Rs 2800 crore) for that project was wholly met by loan & credits from ODA and a group of Swedish financial agencies and banks.

Suppliers credit is freely available from the beginning of a project. The equipment tenders often make its availability a condition for bids; at other times, the bidders themselves sweeten their offer by assuring such credits. A recent devlopment, is for the vendors to take up to.l0% of the project equity as at Maheshwar.

Since 1991 the Indian government has allowed for private participation and equity in the sector. A set of incentives and concessions were developed, which include upto 100% ownership of the project (without needing any prior approval), two year exemption from Govt. taxes, concessional duty on import of plant & equipment (fully duty free, if the hydro project is more that 1000 MW), and choice of how to obtain project debt from domestic or overseas sources.

Before commencement of project construction, a number of statutory and non-statutory clearances are required for each project from Central & State Governments. The lead time involved in obtaining various clearances before start of project have been a nightmare of hydro power developers. The shifting of stand of authorities giving clearances have proved to be another cause of worry. Such a situation arises due to absence of clear cut guidelines, ultimately leading to delayed clearances. Major statutory clearances required by an IPP are: Registration of the Company; Approval of the competent Govt. (State/Centre); Techno-Economic Clearance

(TEC) by CEA; Environment & Forest Clearance (State & Centre); Pollution clearance-Water & Air; Notice under Section 29 of Indian Electricity Act; Public Hearing; Rehabilitation & Resettlement of displaced families by land acquisition; and Equipment Procurement and the non-statutory clearances required are Land availabilty and Financing.

CEA has however, evolved a simplified procedure for transfer of TEC in respect of those projects which had been earlier given the clerance but now due to some reason or other are to be implemented by new agencies either under Central Sector, State Sector, Private sector or Joint Venture. As per the simplified procedure, if there is no change in the scheme features and cost, the new agency is only required to furnish a certificate to the effect and the TEC will be transferred after the competent Government has transferred the scheme to the new agency. In case, however, the scheme envisages chage in project features and cost estimates, the TEC will be transferred in the name of the new agency who would furnish within a period of two years the revised scheme for consideration of a fresh TEC by the Authority.

ROLE OF STATE AND CENTRAL GOVERNMENT

For speedy development of hydro projects there is a need to change the attitudes & psyche of all those associated both at the Central & State level. A project executed by the Govt agency in State sector carries the blessings of State govt and co-operation from the District Administration and to a large extent from the public it comes forth quickly. However, attitudes change when a private developer or a Central agency is assigned execution of a project in a State.

There are numerous issues before or during project execution like land acquisition, resettlement & rehabilitation, enforcement of environment guidelines, condition of roads & highways, agitation and strikes by company workers, agitation by the general public etc. where work can not proceed without the active support of the State govt. There is, therefore, a need to evolve uniform policies & guidelines on all these contentious issues and general public should be educated by the State machinery that the development is not only in the interest of State or the nation but their own.

Further, a subsatantial hydel power potential has remained locked up and many mega hydel projects could not be taken up for implementation because of unresolved inter-state issues, even through these projects are well recognised as attractive and viable. The selection and design of project has, however, to be based on integrated basin wise studies, so as to arrive at an optimal decision and care has to be taken that such projects donot in any way prejudice the claims of basin States or affect benefits from the existing projects. A consensus must also be evolved amongst the basin States regarding the location of such projects, basic parameters involved and mechanism through which each project would be constructed and operated. As far as possible, there should be preference to take up run-of-the-river schemes that do not involve any major storage or consumptive uses.

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Water Resources Sector — an Overview and Prospects for the 21st Century

Dr CD Thatte

Secretary General, International Commission of Irrigation and Drainage, New Delhi

PROLOGUE

I want to thank the Institution of Engineers (India), for providlnq me with this opportunity to deliver the 14th lecture in the Dr A. N. Khosla Memorial lecture series, during the 16th Indian Engineering Congress being held at Kharagpur. I am very happy to be amongst the galaxy of eminent engineers of the country, who have gathered here for this four day long Congress and to convey to them my views and concerns in the subject of Water Resources (WR), which was the mission of Dr Khosla's life.

His contributions to the WR Sector of India, indeed have been many splendoured, intense and extremely fruitful for the country. His professional career spanned for almost six decades of the last century. Looking back, one is amazed to see how much did he achieve, when the present-day tools like PCs and internet, were not on the scene. But that is indeed the characteristic of great souls. There may be a few amongst you who knew him well. I was not that fortunate but I must recall here the face to face opportunity of interaction with him that I got in my early career in sixties on the Sardar Sarovar Project. At that time, I was assigned the task to show to him on drawings and charts, the extensive and comprehensive investigations that were carried out by us for the project, under the inspiring leadership of Dr C.C. Patel. He was escorting 'The Khosla Committee' appointed by the Government of India (Gol) on a visit to the project, for considering and recommending a plan for the Narmada Basin Development. I remember how thrilled we youngsters were when he appreciated our work, saying that it's quality and thoroughness was second to none in the world. You are probably aware that the Committee finally endorsed our proposals. Unfortunately, the report did not receive unanimous acceptance from the States and hence the matter went to the 'Tribunal' for a lengthy winding process of adjudication. The Tribunal verdict was almost identical. Still the project languishes due to complications that were raised causing even after a lapse of 40 years, precious waste of water resources that hold a promise to transform lives of crores of our people, like what Bhakra-Nangal did earlier. The price people of our country have been compelled to pay by some shortsighted, selfish and misguided people is indeed enormous.

SECTION I

The Last Decade

During the last few years, the WR sector saw some quick developments. As a follow up to the Brundtland Commission, Dublin conference, and basically due to Rio Earth Summit, (Agenda 21, Chapter 18) in 1992, need for integrated and sustainable development and management of water resources (IWRDM) came to be recognised by all countries. But in the face of continued and galloping increase in population particularly in economically weak countries of the developing world, the mismatch between supply and demand became acute. Several apex organisations like the World Water Council {Will C) a policy think tank, Global Water Partnership (GWP) an action oriented facilitator, and a forum like the World Water Forum (WWF) were set up almost at the same time. The 1.1 WWF was held at Marrakesh in Morocco in 1997 alerting people and politicians alike about the developing crisis in water sector. With the approaching end of the 2nd millennium, the prophecies of doom particularly related to water sector became shriller.

The efforts of these institutions however culminated into the worldwide introspection and reappraisal of WR sector to enable evolution of a 'Long Term World Vision for Water, Life and Environment in 21st century presented at the 2nd WWF in The Hague. The engineering community, professional organisations and Government Departments dealing with water and related infrastructure came under critical scrutiny as never before, by the economists, social scientists, ecologists, ideologists and media. As a result, the sector emerged as a critical thrust area for the future, needing all the care that the world could provide. The sector vision water for food and rural development (WFFRD) in addition to those for 'people' (drinking water/sanitation) and 'nature' (eco-systems) comprised the three main components of the global vision. The GWP proposed a 'framework for action' (FFA) also at the Hague. A ministerial conference was held alongwith, which proclaimed that water security will be the principle concern of the world in future. Hopefully, fresh-water would go up in priority from Chapter 18 in 1992 to a higher slot at Rio+10 World Summit on Sustainable Development (WSSD) in

September 2002 at Johannesburg, preceding the 3rd WWF in March 2003. A preparatory international conference on Freshwater is being held at Bonn in this week.

IWRM and not IWRDM has become the buzz word of the water people, in spite of the importance of 'D' standing for 'development' which unfortunately is at a lowly place on agenda of the developed world. Management replaces 'D' and also brings in socio-economic-financial-trade-ecological- human rights as issues, pushing it to the background. To manage water better, it has to be developed and be available! IWRM defines challenge before the world as maintenance of balance between human and ecosystems meaning between livelihood needs and resource needs. It aims at holistic management, participatory approach, involvement of women and consideration of water as an economic good. At other places Governance, inclusiveness, participation, networking, communication, devolution are the keywords. Science, Technology and Engineering (S&T&E) seem to have become 'dirty' words. Those possessing these instruments or promoting them are considered as 'villains' and as the 'arrogant' ones, who want to conquer the nature, destroy the traditional systems, values and cultures and of course the environment! How stupid we can become, or really how 'smart' to unleash another design to conquest the gullible world. Let us examine through this lecture.

A symptomatic onslaught and systematic attack on the WR sector came towards the end of the decade under the guise of WCD.

Dams around the world constitute some of the most visible and spectacular creations of the engineers around which, the WR sector has grown. One can't think of WR sector without thinking of dams as you heard me making reference to S, S D while mentioning Dr Khosla. Notwithstanding the myriad direct and indirect benefits the society has been able to harness due to the dams, they have attracted adverse attention during the last 3 decades. It seems some sections of societies can't withstand achievements of others and they try to destroy them, like WTC buildings for instance. The World Bank which was funding less than 5% of worldwide dams but exercised lot of clout in other socio-economic sectors with developing countries on one hand and the International Union for Conservation of Nature (IUCN) an avowed critic of dams launched the World Commission on Dams (WCD) in 1998. Ostensibly, WCD was asked to evaluate development effectiveness of dams, to propose options to dams and to lay down criteria and guidelines for future dam building; after reaping the benefits due to dams for centuries, as if the whole development due to dams had taken place in vacuum of ignorance.

Several funding agencies and Governments of developed countries, which had completed their dam building, readily joined the effort. The WCD was a suo-mote venture without support or concurrence of the main stakeholder nations. Developing world mostly remained skeptical and mute to the overtures of WCD, right from the beginning. Predictably, a damaging report was brought out by the WCD in November 2000, which was summarily rejected by the developing countries, which were still building and needing many more dams. The global professional organisations also condemned the report as biased, distorted and impractical. The World Bank itself could not muster enough support to enable acceptance of the report. The venture turned out to be a misadventure. Still the authors of the report are trying to salvage something out of the wreckage, of course with the help of some innocent and gullible people or vested interests. The process of improvement in decision making about dams undoubtedly will continue amongst the dam building engineers, like any other socio-economic activity of the mankind in spite of such antagonistic efforts.

Water and Habitats

Solar energy sets in motion all the bio-geo-chemical cycles on the earth. Hydrological cycle is at the centre-stage because water is life. Since man started walking, he started relying on the natural resources of water, land and biomass around him, initially just to survive the hostile surroundings and later for sustenance. Human habitats spread out on the earth's surface initially wherever food could be gathered and later where it could be produced. Survival and growth of mankind in the face of adverse environment was due to man's ingenuity in meeting with the food requirements. Forests were cut, lands were protected and reclaimed, and cultivation was started. Early civilizations grew along major rivers of the world, with agriculture as the focal point around which, the nomadic mankind gravitated. But towns, cities, metros and mega-cities grew out of needs of people for more organised life through co-ordination, defence, governance, and later with the industrial revolution. The original small habitats remained 'rural'. Rural populations remained agriculturecentric though benefiting from the industrial revolution. The urban ones got differentiated according to the needs of centralisation. The rural areas continued to grow food and feed the urbanites. Collection, process, storage to take care of lean seasons, transport, distribution, trade, market etc. for food gradually got centralised and concentrated in urban areas. But the process triggered infrastructure development in rural areas. Such activities with spread at both locales together, constitute rural development and well being.

Rural-Urban, An Interactive Divide

Right upto the 17th century, the rural folks remained employed on agriculture related activities, the urbanites getting employed more and more in manufacturing and services sectors catering to production of consumer goods of higher value. Agriculture production remained farm and family oriented in many countries, under-organised, lowly valued, contributing a lower proportion to the Gross Domestic Product (GDP) of a nation, as compared to a smaller population remaining engaged in other sectors produelnq a larger share of GDP. The rural populations largely remained relatively poorer as compared to the urban people. Due to increasing pressure on land, landless people grew in numbers. Due to lack of jobs and deficit in availability of water and food for the growing populations, migration towards urban habitats grew, providing labour force but also causing growth of impoverished pockets in urban areas. Poverty, hunger, malnutrition and unemployment both in rural and urban areas got intricately associated. A poor person often remained unemployed, hungry, undernourished and unhappy, even when at times adequate food was available globally, simply for want of buying capacity and accessibility to food. But due to extreme variability in availability of water, people continued to suffer hunger and at times starvation due to famines. With the growth in human population, the process became complex. Today, we depend on water for satisfying our requirements for drinking, food, energy, fibre, municipal, industrial, navigational and recreational needs. Fulfillment of the human needs through balanced development and management, means economic well being, health, sanitation and a good quality of life. Failure can result into poverty, hunger, malnutrition, unemployment, exploitation and deprivation. Success also means a good environment through ecological care and sustenance.

This picture changed significantly during the 20th century due to rapid spread of irrigation, drainage of water logged farmlands and improved flood management in cropped areas. The ill effects of marginal land holdings, continuous fragmentation and resulting landlessness, unemployment, malnutrition and poverty were reversed. They, however continue to stalk many societies even at the beginning of the 21st century, where irrigation and drainage are neither developed nor managed adequately. The development has to be sustained and it has to ensure sustenance of the resources, it harnesses. The IWRDM encompasses integration of different facets, viz. development and management; demands and supplies of· all needs; facilities from mega to micro scale; science-technology· engineering; ecological, socio-economic, administrative, legal, cultural and other issues.

Freshwater Occurrence and Use

Out of the total water available on earth, only about 3% is in the form of fresh water. Further, if we leave out permasrost regions and very deep fossil waters, a very small part of about 0.03% remains accessible for human use. It is available in the form of rain and snowfall (only 10"10in depth considered rain equivalent), runoff of floodwaters generated over a few storms sometimes spanning a few days in a year, enabling its use round the year. running through the drainage systems into the oceans and through the natural hydrological recycling process of evaporation, transpiration and condensation. An appreciable part of it gets lodged in snowcaps and natural lakes and is utilisable subsequently in case of the former, through snowmelt reaching a river system. A sizeable part is retained in surface soils and used up for biomass generation. Another part seeps into the ground feeding natural aquifers. A major part appears in the river system downstream and is drained through streams and rivers into seas, unless captured in man-made storages or withdrawn for use. If runoff time for the surface water is few days, that of ground water appearing in river system and outflow in oceans is in months. Both together constitute the renewable or dynamic water resources of the country. They can't be put to beneficial uses unless they are developed. The downstream process constitutes management. Development and management go hand in hand. Better management assists maximisation of fruition from the developed waters. Both call for intellectual, financial, economic, administrative, sociological, political, legalistic inputs from the society.

Humans are at the centre of the ecology. The word 'eic(k)os', in Greek, means home. Economy deals with management of our home i.e. this planet earth; ecology means science of home. Both are complementary not contradictory. One sustains the other. Besides human needs, those for cattle on which humans are dependent for meat, milk and animal power are also met with. Animal and plant life, both need water for survival, growth and procreation. Of all these uses, water that is used for growing food, supporting plant life and biomass is considered consumptive, because it is converted into water-vapour through evapotranspiration processes; because it is no more useable unless it is condensed in the form of rain again. Water evaporates from snow-caps, glaciers, water bodies, reservoirs, and river systems continuously all through the year, which again is bracketed with 'consumptive' package. 'Consumed' water is that which is put back into the atmosphere, for productive purposes such as transpiration needs of crops for food production, (irrigation globally accounts for more than 70 % of water withdrawals) and ecosystems which provide goods and services for sustenance of life. Evaporation from waste and fallow land is also consumptive use but remains non-productive. That from reservoirs is considered as unavoidable loss but is accounted under productive use.

Most of the human demands are non-consumptive. They comprise major parts of domestic, industrial, power generation, navigation and recreation needs. Water flow and its drop from a height is used to run turbines to generate hydropower. Water is simply used as a dilutant, solvent or facilitator in manufacturing processes or as a carrier of goods like coal slurry, or human waste, or materials and goods as in navigation. A little component of

water gets built in human products and is lost for reuse. Most of it appears as 'water', albeit in degraded quality. The other uses therefore pose a challenge, of a different sort, that of making the used wastewater fit for reuse. We have world wide, either failed miserably or not reacted timely, to the problem. Water is recycled continuously through transpiration through biomass and evaporation from land, river systems and oceans, besides precipitation through condensation, rain and snow. The eco-system depends upon consumptive use of water. A river basin or watershed or catchment area is a naturally closed entity for assessing available waters from precipitation, which are highly variable in space and time and planning beneficial uses for people wherever they need it. Where available precipitation is excessive, land has to be drained to get beneficial uses out of it.

For any use through a scheme in a river basin, water is drawn from a river-surfacewater (SW) system directly or indirectly through a surface reservoir or from groundwater (GW). Such total quantum gets accounted through evapo-transpirational consumptive productive/beneficial use (ET), or a part is returned to the river system, or a part goes back to GW and a part goes to atmosphere through excess deployment. The latter three components have to be minimum to attain maximum efficiency. Ideally therefore, conjunctive use of surface and ground waters is to be ensured to attain this Objective. Renewable water resource of a basin, comprises surface and GW both, because conceptually it is assumed that all the water that infiltrates into ground is either withdrawn, or appears in the surface system as base flow or appears in swamps, besides a small component which flows out to oceans. Undoubtedly, some small quantum seeps deep into static ground water resource. In hard rock areas with high ridges, basin boundaries of both SW&GW match. But in delta regions they overlap. In absence of a better method both are considered as confined within a basin. Surface reservoirs also lose water through evaporation and transpiration by plant life around the reservoir. It is accountable as unavoidable ET against the withdrawals from the reservoirs for serving the multiple purposes.

Often, some parts of a river basin depending on orography and direction of moisture laden winds, are surplus in availability when compared with needs/ demands, while some others face deficit. It may be that a surplus region of a basin may be just adjoining or physically contiguous to a deficit region of an adjoining basin. Transfer of water between such regions, within and outside a river basin across high ground between such regions or on basin boundaries. To remedy such imbalances has been practiced by mankind for a long time. It mostly involves construction of storages for holding/impounding waters and raising their elevation to enable transfer across high ground. Diversion structures involving little or no storage are also constructed for withdrawals through canals and by pumping, where the river flow quantum is adequate and where high ground is not encountered. Incidentally storages wherever constructed invariably absorb and reduce flood peaks downstream in the basin, enabling better flood management.

SECTION II

Water Availability and Agriculture

Fresh-water is a finite, naturally renewable resource received by way of precipitation, but is significantly unevenly distributed in time and space. Hydroclimatic conditions of a region therefore set the limits for its availability. Luckily, the freshwater availability on the earth has been constant although needs of populations it has to support have kept growing. Starting with Malin Falkenmark and Shiklimanov, Peter Gleick and Kulshreshtha and UN agencies, efforts were started to identify norms for yearly water availability and its adequacy to meet human needs per capita. Falkenmark, Lundqvist, Wid strand in 1989 ranked countries according to per capita annual water resources (AWR) in each country. They defined classes of Shortage on the basis of AWR. For AWR 1700 cub m and above, shortage will be local and rare; for 1000 cub m and below, it will hamper health, economic development, well being; and for 500 cub m and below, water availability will be a primary constraint to life. This is considered as a Standard indicator of water scarcity and is most widely used and a referenced indicator. Other researchers have gone by these indicators without much questioning. UNCSD 1997 study by Rask in and others defined scarcity in terms of percentage of annual withdrawals to AWR. This is considered as UN indicator. If the % is greater than 40, the country is considered water scarce.

It is estimated that between 2000 and 2025 AD, the global average annual water availability per capita will fall from 6600 m^3 to 4800 m^3, Due to uneven distribution of water resources, some 3 billion people will live in countries - wholly or partly arid or semi-arid having less than 1700 m^3. Countries or regions are broadly considered water stressed when the annual per capita availability is between 1000 - 2000 m^3. With availability below 1700 m^3, a country is deemed 'water scarce' and with less than 1000 m^3, It becomes 'severe'. In 1990, eighteen countries in the world were 'severely water scarce', a number that could swell to 30 by the year 2025. Most of these are located in Asia and Africa, and are already facing food shortage. Further, there are 12 countries with availability less than 500 m3. This number too is likely to increase to 19 by 2025. More than 1 billion people including one third of the population of China and India live in arid regions facing water scarcity. Similarly, 350 million people mostly in Sub-Saharan Africa face severe scarcity, and ought to embark upon massive water development projects to meet with their water needs. They suffer from lack of recognition of variability of precipitation in space and time in tropical regions, need for its development by means of storages,

and incorrect quantification of AWR by the funding agencies and the Governments alike. These attempts to develop indicators helped in identification of critical areas and assess prognosis for future in past. Things changed dramatically after ~996 with deliberations in WWF.

IWMI Studies

IWMI in 1997 for the first time gave the assessment a new dimension of 'water withdrawn' from the river systems, consideration of the renewable surface and ground water together and consideration of water use efficiency for determining needs of the societies. Countries with weather systems of monsoons like ours had been following such mode of assessment. IWMI work of 1999 went a step further. It worked out the need for additional withdrawal by individual countries to meet with their food needs in the year 2025 AD, after assuming a significant improvement in water use efficiency in irrigation and using the saved water for covering more area under irrigation. Globally speaking, the effort is useful in highlighting stressed areas better than before, but the geographic generalisation of availability and its use in large countries with complex river basins is misleading. The effort obviously needs firming up on basin or regional level. In a subsequent study, IWMI considered 45 selected countries and grouped them into 3 basic categories of projected water scarcity.

Group I: Consists of countries that face physical water scarcity to meet their needs in 2025, even if highest feasible efficiency and productivity of water use is ensured. Indeed, many of these countries can not even meet their present needs. This category includes countries in Middle East, South Africa, and drier regions of western and southern India, and north China, covering 33% of total population. The option is to invest in expensive desalinisation plants, increase irrigation efficiency, recycle waste-water and import more food.

Group II: Represents countries that do have sufficient water resources to meet 2025 needs, but which will have to increase water supplies through additional storage, conveyance and regulation systems, by 25% or more over their 1995 levels to meet their 2025 needs. About 45% of the total population lives in these countries.

Group III: Consists of countries that need to develop less than 25% more water supplies to meet their 2025 needs, which will not be a problem as most of these countries are developed countries and cover 22% of the population.

Agriculture, Food, Economy

Food consumed by mankind comes from crops, or from animals, birds, fish - meat, milk and milk products. Crops are used for providing cattle feed by way of grains or crop residue itself. Cropped foods are relatively economical and are mostly poor peoples' foods. Meat and dairy foods are derived from products of crop foods and hence more expensive. Proportion of consumption of meat and milk, normally grows with economic well being. But growth of both types of food requires proper water management by either water application in the right dose and in right time through irrigation, during the critical growth periods of crops, or by removal of surplus water by drainage, as the basic inputs. Besides other infrastructural needs comprise seeds, fertilizers, pesticides, agricultural implements, mechanised farming, energy for pumping, credit. Irrigation increases productivity, cold-storage, animal power, animal husbandry services, market, transportation, other services for maintenance, which bring prosperity and in turn facilitate installation of infrastructure. But conversely, good infrastructure does help improve the productivity. Not long ago, the first Green Revolution increased the global food production dramatically. Water availability being variable in space and time the human well-being is intimately dependent on its supply, use, disposal and reuse. Like any socio-economic activity in face of finite resources, growth and sustained yield from agriculture per unit of water and land calls for adequate financial and human investments. Survival, development, growth of rural economy and well being thus becomes synonymous with water, food and agriculture. Besides planning another green or evergreen revolution, a blue revolution or as some like to call it, a rainbow (multi-coloured) revolution tied up with optimum development and use of water is coming. Irrigation and drainage indeed promote sustainable rural development, which should permeate through the porous and interactive divide and pervade global economy. A balance of course is to be found between the requirements of the society, acceptable side effects and sustained development.

Land Productivity and Food Sufficiency

Storages or diversion structures are constructed for withdrawal of irrigation water according to the availability. Water quantum used for production of food worldwide is about 70% of total withdrawal. Presently irrigation covers more than 250 Million ha i.e.17% of world's arable land, but is responsible for 40% of crop output and employs 33% of population in rural areas. Basin boundaries often don't match with national or administrative boundaries within a State. Basin plans therefore face competing demands for sharing of available waters, benefits and costs of such plans. Uses themselves are of different complexion; some are consumptive, others non-consumptive. The plans therefore aim at integration of uses, demands, supplies, size of structures required, other available resources and institutional arrangements.

The world population is likely to grow at least for another 50 - 60 years and will then probably stabilise. So will the food demands. The mix of foods consumed - cereals, meat and dairy products - and the level of calorie intake is expected to undergo change with reduction of poverty. Food needs will therefore exceed projections based on growth in population alone. Demands for water will increase causing shortages in regions, which are presently comfortable with availability. The growth in shortage could be avoided if on one hand withdrawals are increased and on the other, water use efficiency is increased reducing the ill effects of low efficiency. Large populous countries would continue to strive for maintaining self-sufficiency in food production, because their shortfalls in case of droughts, will be too large to be covered by world trade. Nevertheless every country would attempt to increase productivity of cropped lands with water that could be made available by improving water use efficiency and increased withdrawals. More people would move away from agriculture sector to manufacturing and services sector in rural areas to enable faster economic growth. Water for food sufficiency and security will lead to rural well being through better livelihood, health, employment, stabilisation of rural populations, education, transportation, communications and human productivity. It will insure societies against natural disasters and provide a more sustainable livelihood. Irrigation, drainage and flood management no longer should be considered as options but as needs of society which also ensure protection of environment.

Sustainability

The IWRDM while meeting with needs of human and natural systems has to sustain the natural cycles. The classical definition of sustainable development encompasses decision-making by present generation, without compromising capacity of future generations to take appropriate decisions according to their perceptions. Agenda 21, Chapter 18 on Fresh-Water laid down as programme areas: IWRDM, assessment, protection, drinking water and sanitation, urban development, food and rural development, impact of climate change. Unfortunately, the IWRDM unlike manufacturing sector, is a long gestating and long drawn complex process, spanning may be a couple of generations. Lessons can be learnt only after lapse of quite some time. Present decisions have to be tailored in light of experiences derived so far and have to address likely problems of future generations. If those decisions are not taken now, not only capacity of the future generation is thwarted, but, their existence itself can be jeopardised.

Some opponents of the presently evolved model of IWRDM claim that it is unsustainable and that it has caused intractable problems, which are irreversible and will compromise interests of future generations. This is a facile argument that has been advanced throughout the history of mankind. Each generation has to make own decisions in light of existing situation. It must ensure sustainability of the product, of the natural resources it uses, and carrying capacity of these resources. IWRDM depends not only on natural resources, but also on man made ones including finance. The sector is sustainable if it uses them judiciously, ploughs back the fruit into the development process and ensures adequate economic returns. Following is my list of sustainability issues. Sustainability of the mankind for whom the IWRDM is carried out, no doubt has to be at the centre of the stage as laid down in the first out of the 27 principles on which the Agenda 21 is based.

- People: present and future stable population, its survival and fulfilment of its basic minimum needs; removal of deprivation, account for limit to capacity of people to suffer it; removal of poverty, hunger, malnutrition, unemployment, lack of hygiene and sanitation; reduction of migration in search of livelihood; proper rehabilitation and resettlement of displaced people.
- Water: loss of storage volume due to siltation; fall of ground water table; recession of glaciers and reduction in snow-melt; effect of global warming on incidence of drought and floods, quality degradation; salinity ingress in coastal areas: treatment, recycling
- Land: water logging and salination, wetlands and marshes, drainage and reclamation, protection for water sheds, prevention of soil, river and coastal erosion, inundation due to floods and sea level rise, advance of deserts, pollution of land due to solid and fluid waste, submergence, incidence of landslides; loss of fertlity and productivity of land.
- Biomass: conversion of wasteland into areas covered with energy plantations, social and irrigated forestry, biosphere conservation zones, use of glass houses; conservation of bio-diversity, gene banks, tissue culture.
- Product: level, quality and safety of food production; balanced composition, level of services and affordability; generation of wealth to sustain growth and development for people.

Indicators

Sustainability has to be measurable in terms of indicators. Carrying capacity of natural resources is one such indicator advocated by some like the Ministry of Environment and Forests (MOEF) in GoI. The concept remains nebulous, excepting perhaps use in some studies carried out for Damodar river basin and the National Capital Region of Delhi. The sustain ability indicators should be able to quantify the level of sustenance of the system and identify the limit to which it can renew itself. The assessment has to be in economic terms. to enable social

benefit cost analysis. UN Committee for Sustainable Development has laid down following indicators for the issues highlighted in Agenda 21.

Driving Force Indicators: Annual withdrawals of SW and GW. Domestic consumption.

State indicators: Ground water reserves. Foecal coliform content. BOD of water bodies.

Response Indicators: Coverage to waste water treatment. Density of hydrological network.

Unfortunately, all these cover only domestic water sector and water quality but practically no ground for irrigation, which globally accounts for 70 % of the total water use. It is necessary that we urgently develop them for assessment. Following forces and indicators are suggested.

Driving Force: Intensification or expansion; going back to nature, demand management etc.

Risks: Limits to potential for development; carrying capacity; with and without development; before and after development.

State: Slow - long term, fast- short term, extrapolation, errors.

Responses: S&T& engineering, socio-economic, ecologic, mid-course corrections, evolutionary.

But it is not enough to lay down such classification. Following are some concrete suggestions.

Status of development: Reduction in availability and supplies.

Fulfillment of minimum needs: Total production, productivity, quality of product Water, land, soil, biomass, fauna: Control, management, reversal, prevention of degeneration.

The discussion leads us to economic sustainability of WR projects. The present method of economic analysis considered for their approval has been often assailed by some, claiming that the advantages are exaggerated, while disadvantages are minimised. In practice, they claim that reversal occurs. Actually, assessment of secondary and tertiary benefits is often difficult. On the other hand, costs increase due to often egalitarian concerns about social and ecological impacts. Basically WR projects are taken up, as there are no options. The BC analysis should only enable their prioritisation. Services provided cost and hence should be priced. Full cost should be recoverable from somebody- may be Governments, may be consumers. Costs can be subsidised. But if they are shared by the beneficiaries in proportion of benefits, there is no subsidy. For instance, when irrigation is subsidised and if farmers don't get benefits because of market competitiveness and their weak bargaining position, it is the consumer who is benefited due to low food prices. It is sharing of costs and serves national goals. Whether water is a social good or not is being debated in spite of the strong views expressed on both sides. Complexities of the issues need to be acknowledged because unlike other public welfare activities, the WR projects remain inescapable. Every society has to make up its mind to pay costs involved in providing requisite services. Standard practices however ought to be evolved to avoid stalemates.

SECTION III

Indian Scenario

Water Resources, Inter-relations, Uses

In India, the annual precipitation is 1170 mm against the world average of about 1110 mm, but it varies from almost zero in the deserts, to 11000 mm in depth in north-east. At a very small number of places it rains for as much as 200 days a year; at others it rains for less than 100 days within 100 hours of a year. One therefore has to make efforts to make the water available where and when it is not naturally available in right quantity and albeit quality. The rain and snow together contribute about 4000 billion cubic meters (BCM) of water. An additional approximately 400 BCM flows in from neighbouring countries. Because of high rates of evaporation, a quantum of about 2200 BCM is lost to atmosphere, about 300 BCM seeps into ground and only about 1900 BCM of water is available for use. But due to topographic limitations, only about 1100 BCM can be developed, withdrawn and put to use. Apart from the inflow from neighbouring countries, a small part flows out to other countries as well. This average availability is considered fairly constant. At present, about 630 BCM of water are withdrawn altogether from run of the rivers, from storages which are filled up during monsoon, and which is pumped from ground water. The balance of 480 BCM can still be developed to make it available for withdrawal. The rest presently flows down unused to oceans contributing to interflow with ground-waters. The quantum that seeps into ground eventually appears in drainage system, apart from a small component, which goes deep underground or directly flows out to oceans.

Fortunately, the National Commission on Integrated Water Resources Development (NCIWRD) set up in 1996 by GoI completed and submitted its report in 1999, which is awaiting acceptance and implementation, starting from the 10th plan, which is on the anvil. Hope our country gathers enough prudence to do so expeditiously. We

saw during the run up to the new millennium, continued shortage of funds for the WR sector. The public investment in the sector dropped from over 22 % of the budget in early plans to about 6 % in recent plans, notwithstanding mounting needs due to population, which is almost three times now. It has resulted into thin spreading of financial resources causing time and cost overruns and disruption of cost economics. We also saw a continued lack of funds for O&M, nor a will to price the water adequately to meet with at least partially the costs involved. Some WR projects got embroiled in controversies and public interest litigations. Meanwhile, the Sardar Sarovar and the Tehri dams, the symbols of anti-dam lobby's frustrating efforts, continue to suffer. Public and not so public figures have taken sides and different voices have become subjects of everyday attention.

It is estimated that presently, out of total water utilised in India, 83% is used for irrigation, about 4.5% for drinking and municipal use, 3% for industry, about 3.5% for energy development besides other activities, which account for 6% use. This is a rather simplistic way of putting it. The process is complex and assessments are difficult because the uses overlap, unconsumed water is reused again and again and is often not correctly accounted. More work on these assessments is required.

River Basins, Water Use Efficiency and Water Balance

Assessment of balance for renewable water is to be carried out basin by basin. But data to achieve the objective are mostly not maintained. All the same, the Central Water Commission (CWC) with the help of some major States and under the leadership of Mr. A. D. Mohile former Chairman of CWC, did outstanding work in this respect and assessed: the quantities available, quantities stored, withdrawn and deployed for different purposes. This is not a one-time job. It needs to be improved substantially. Undoubtedly lot remains to be done on this front. The CWC exercise suggests the water balance for the country as a whole, as it would be without human intervention in a pristine condition. In the second stage, the exercise shows the present status of water balance. The effort then depicts the water balance in future with several assumptions to ascertain whether globally speaking, India's water wealth is adequate to meet with the needs as presently assessed or not. The assumptions are both on the data front and on the side of the processes involved. There are some generalisations as well. Some aspects of the balance can be visualised qualitatively. But the exercise for the first time indicates quantitatively, what is in store for us. For meeting with increase in demands, the exercise indicates the following certainties.

- increase in withdrawals of both SW and GW,
- increase in numbers of storages,
- increase in ET for consumptive use,
- reduction in seepage to GW, reduced return to base-flow,
- reduction in base-flow and flow to oceans.

The WR professionals have set in motion several efforts to increase water use efficiency. It is assumed therefore for instance that, SW use efficiency for irrigation would go up from present level of 40 to 60 'Yo. The GW use efficiency dependent as it is on pumping energy in usually higher and would go up from 70 to 75 'Yo. As a result, the seepage to GW, return to surface flow, return of base flow from GW and consequently outflow to oceans should be less than present. ET from all sources should increase meaning increase in productivity per unit of water deployed for irrigation. We should envisage the needed food production coming from both increase in irrigated areas and because of increase in water use efficiency.

Time Frame, Numbers and Means

Assessment of water resources required for meeting with the needs of the society has to be based on the right time span. India's population is likely to stabilise around the year 2050AD around a minimum of 1350to a maximum of 1580millions. Requirement of water at that point of time for different needs will be as follows.

- for growing food and feed at 420 to 500 million tonnes = 628 to 807 BCM
- drinking water plus domestic and municipal use for rural population at 150 Ipcd and for urban population at 220 Ipcd = 90 to 110 BCM
- hydropower and other energy generation = 63 to 70 BCM
- industrial use = 81 to 103 BCM
- navigational use = 15 BCM
- loss of water by evaporation from reservoirs = 76 BCM
- environment and ecology = 20 BCM

Total water required will be about 973 BCM. As water available is about the same, we would be having a hand to mouth position in the year 2050. The assessment for the year 2025 will of course be relatively comfortable. The assumptions are as follows.

- All intra-basin development will be completed by the year 2025 AD. Inter basin transfers will be implemented after 2025 and well before 2050 AD. Renewable GW alone will be used.
- Surface water use efficiency will go up from 40 to 60 "10, GW use efficiency will go up from 70 to 75"10 in 2050.
- Net area under irrigation will go up from 53 Mha to 80 Mha, with cropping intensity going up from 140 to 150"10 for intra-basin development stage. It will go up further to 90 Mha with cropping intensity of 155"10.
- The productivity of irrigated land would go up from present level of 2.5 to 4.0 Tlha, that for rainfed area from 0.8 to 1.5 Mha.

Land Use and Agriculture

This discussion leads us to another important facet of availability of land. Present land resources in million hectares, their use and distribution in different categories is as follows.

Geographical area = 329, Reporting area = 300, Drought Prone =1/3rd, Flood prone =1/8th, Forest = 68, Net sown area = 142, Gross cropped area =188, (Cropping intensity = 132"10), Net irrigated area = 53, Gross irrigated area = 75, (Irrigated cropping intensity = 141"10),Fallow = 24, Area unavailable for cultivation = 41, Other uncultivated area = 29.

More and more land, will be occupied by urban habitats and the industry, in the future. More land will go under submergence of new reservoirs, some of which will be waste-land and some forest land besides some cropped land. Some land will be allocated to displaced people from different developmental projects, for rehabilitation and resettlement. We need to bring more waste land under crops and more cropped land under irrigation. It will largely come from the stock of rain-fed land in the country.

The continumg emphasis on soil and water conservation implicit in the watershed development concept, will help us convert waste-land into productive agricultural land. More land would be taken out of sub-subsistence grazing while improving productivity of existing grazing lands. This will be in tune with organised feed stock trend for raising the cattle. Similarly rainfed land productivity will be enhanced through watershed development and restored to more productive agriculture. Degraded forests will also be restored through watershed development effort. A very large size of fund is being provided in the 10th plan for such effort through budgets of various departments. Watershed development in catchment and command areas of WR projects, will help augmentation of soil moisture to some extent. It is not an alternative to storages. In rain-fed areas which will be covering 213'd of geographical area of the country, even in ultimate stage of irrigation development, micro watershed development has potential to boost food grain productivity from present 0.75 to say 1.2 T/ha.

SECTION IV

Irrigation, Drainage, Flood Management for Food & Human Sustenance

The rise in population in developing countries is much more rapid as compared to the developed world. In, 1960, out of the world's 3 billion people, 67% were concentrated in the developing world. In 2025, more than 80% are expected to live in developing world. The majority of these people will live in flood prone and or delta areas. This will have critical implication for food requirements, labour supply, and per capita land availability besides fresh water availability. With nearly the same water and land resources base, we shall have to grow enough food to additionally feed 2 billion people. Considering the increased demand resulting from expected increase in the standard of living, there will be need to double the level of food production. In addition, it will call for much strengthened flood protection, better management and drainage measures.

Bulk of the population in the developing world lives in rural areas and is employed on agriculture. The proportion is reducing gradually. A small minority of the rural people in the developing world owns large farms. Majority has small land holdings. Others are land-less and work as labourers in farm related activities. But the rural population is predominantly poor, unlike in the developed world, where the rural areas have developed fast by adoption of advanced technology in agriculture early on due to the industrial revolution and provision of irrigation and/or drainage facilities wherever needed and possible. Many countries equate poverty only with calorie intake through food for adequate nutrition. Rural development and a secured livelihood for rural populations of today, therefore, are synonymous with eradication of poverty through employment generated from agriculture and related activities.

Agriculture needs water, which is provided by rainfall fully at some piaces or in excess in some lands. In these cases, drainage of land is required to enable agriculture. In the latter cases where needs are partially met with by rainfall, supplemental irrigation would have to be provided through wells, canals, ponds, and tanks either by gravity flow or by pumping. Moisture in the soil profile being essential for dry food crop production, its availability has to be maintained at a desired level by replenishment either through local conservation measures or by irrigation, otherwise moisture stress leads to not only reduction in yield but sometime even to complete

loss. Supplemental irrigation however becomes necessary for survival of crops even in humid tropics in winter and summer if rains fail. For the arid and semi arid areas, irrigation is an essential input for farming, even during the rainy season. The provision of irrigation facilities which can make all the difference to a good harvest and watershed development of rainfed areas, together make the agriculture in a river basin sustainable and productive.

Irrigated agriculture yield often is more than 2 to 3 times that of rainfed agriculture. The critical role of irrigation for food security in arid and semi arid areas is evident from the fact that almost one third of the globe area is accounted by arid and semi arid areas and yet the world has been able to largely feed its billions. Even in temperate and humid zones, with timely irrigation during critical periods of growth, when plant is most sensitive to soil moisture deficit, yield of crops may double or even treble. The World Food Summit in 1996, estimated that 60% of extra food required to sustain the world in future must come from irrigated agriculture, which needs more investments and sustained efforts at expansion and improvements. The vision WFFRD also similarly estimated increase in irrigated area even after assuming significant increase in water use efficiency. The challenge of improving the lot of poor rural population hinges on the success of these efforts.

While water is an essential input for agriculture, the potential benefits cannot be attained under excess moisture or salt concentration in the root zone. Thus investment in drainage not only has its direct impact of increasing crop yield but it also maximizes the benefits from other inputs. The irrigation and drainage schemes therefore play a critical role in increasing crop yield, improving rural household income and strengthening rural infrastructure through improved communications and road systems, better healthcare, education facilities for rural communities. Irrigation canals often serve as the only source of potable drinking water for the rural areas of the developing world. Properly functioning drainage channels also improve sanitation and disposal of wastewater in rural areas, wherever possible.

The planning for achieving the objective of food security has to focus on generation of employment opportunities and consequent rural poverty alleviation. Both have contributed to economic growth of such societies. The poor land-less rural people in particular get better employment opportunities in construction and maintenance works of irrigation schemes. Irrigation also plays a major role in protection of rural people from natural disasters like droughts, famines, floods and cyclones. The increased agricultural production from irrigated areas and infrastructural improvement act as powerful magnets to attract investments in rural agri-based industries. The rural development thus becomes synonymous with agricultural development. The linkage becomes apparent every time drought strikes, when the whole rural economy comes to a grinding halt due to set back in agricultural production. The multiplier effect of irrigation arrests this tendency besides reversing the migration of rural people and helps improve the urban environment because of reduction in pressure there. In some water scarce areas, the available potential of water resources has still not been tapped due to several reasons including financial weakness. These causes have to be obviated. The absence of appropriate measures makes such areas more vulnerable to scarcity and growing demands due to population growth.

Among the world's poor, more than 800 million people do not have adequate access to enough food. This number would increase as the world population is set to reach 8 billions by 2025. With most of the increase occurring in developing countries, food needs in these countries would result in great pressure on the agricultural sector to increase overall production and yield. Though advances in bio-technology and genetic engineering may help to increase food production from available land and water resources, the irrigation and drainage expansion and modernisation shall have to play the pivotal role in increasing the food productivity per unit of land and water. It is however necessary to ensure that irrigated agriculture remains a sustainable endeavour.

Increasing Withdrawal to Bridge Mismatch Between Demand and Supply

The potential water resource available in various regions and countries to meet the requirement of 2025 is extremely varied. Many people feel that demand management instead of increase in supply will solve the problems. What has become apparent during the vision study for WFFRD is that supply and demand management has to go hand in hand for removing the mismatch. But particularly in developing countries where supply side belt is already tight, demand side is unmet and there are problems due to large variability.

According to IWMI, as compared to 1995, 31% more gross irrigated area has to be brought under cereal cultivation and water supplies used in agriculture have to be augmented by 15 - 20% over the next 25 years, even under an ambitious assumption of improvement in irrigation efficiency. It is so, because there is severe limitation in the capacity of developing countries to achieve maximum efficiency in irrigation schemes at present level of financial inputs in modernization and improvement of the scheme. The need for doubling the food production therefore calls for more gross area to be brought under cereal cultivation by accelerating the rate of development of storages of water resources wherever potential is yet untapped, in addition to redeploying water saved by increasing the water use efficiency. Availability can also be augmented by recycling the used

and waste-waters after due treatment. The added withdrawals with the help of storages, basin by basin, could remove the mismatch between availability and demand. Links may have to be provided between reservoirs to transfer water to deficit areas. Also, in order to meet with loss in live storage worldwide by about 0.5% every year, additional storages have to be built. Many dams are aging fast and they need raising and or replacement. With impending climate change and increase in variability of precipitation, occurrence of droughts and floods will be more frequent. It will call for more carryover storage to sustain present level of services. Thus on the balance many more storages will have to be built.

Though considerable scope for exploitation of ground water still exists especially in surplus surface water areas, it would need substantial investments on energy and entail repetitive cost. A large component of groundwater is derived from surface water and hence both need to be considered conjunctively. The efficacy of watershed development as an economic option to enable artificial recharge is however severely limited. A discrete mix of mega to micro-scale surface water storages in addition to in-situ conservation measures are called for to augment availability in a cost-effective manner.

Basin Planning for IWRDM

Water flows through river systems covering areas across political boundaries. There are several countries relying on flows arriving from upstream countries. For example Bangladesh, Egypt, Iraq, The Netherlands, Syria, Turkmenistan, and Uzbekistan depend on upstream countries for two thirds or more for their surface waters. Conflict often arises if water sharing between upstream and downstream user countries is not agreed to jointly and if excessive withdrawals are made by one. Similar situations do occur even in shared basins within countries. River basin conflicts in such cases can be tackled by the IWRDM approach through river basin authorities charged with powers implement decisions. For large basins, the approach can be even applied for sub-basins as has been shown successfully in countries like India and China. The plan has to indicate availability of water on a short, medium and long term basis, and the allocations for various uses as per inter-sectoral priority within a political region.

The question of low water use efficiency for individual schemes in a basin often arises. The IWMI study has recently shown that maximisation of basin level water use efficiency is more important, because it can be different than that realised scheme to scheme, because excess or regenerated water is reused downstream. Every scheme allows withdrawal and deploys it with differing efficiency. For an irrigation scheme, more efficient use means less percolation to GW and less return to the river system, which in turn would mean less availability down stream and vice versa. For a given combination of dams I withdrawal facilities, the terminal structure finally affects the basin efficiency. If it allows minimum water flow to the downstream, the basin efficiency is high. One therefore can plan for maximum carryover storage in a terminal dam.

Good financial discipline requires high efficiency for each of the schemes to realise adequate returns. But hydrologically, it may not be always necessary and practicable as WR development takes place over a period obtaining differing efficiency. In a water short basin, a joint strategy has to be agreed upon for using water more efficiently, increasing its productivity, for adding high value crops to the crop pattern, and providing additional water for other non-consumptive sectors. Many in-basin or inter-country differences on sharing of water have caused problems in development of water resources. There are however several developments round the world in recent times, such as in the Danube, Indus, Nile, Mekong, Rhine and Ganges-Brahmaputra- and Meghana basins, which are encouraging. A recent UN convention on international watercourses, which is enshrined on the principles of equity, is under ratification.

While allocating requisite quantities of water, the basin authorities have to ensure that the quality is also of desired level. Where degraded, it is to be made good through identification and treatment of flows emanating from point and non-point pollution sources. Where practicable, beneficiation of low quality waters by means of fresh waters would have to be implemented. Most of the non-consumptive uses are amenable to treatment, recycling and reuse. The twin principles viz. "polluter cleans or pays" and "user pays in one form or the other" if adopted, often pay rich dividends. While talking of payments, another maxim "subsidise the good, tax the bad" also may be kept in mind. Most of the pollutants eventually travel into the estuarine regions and often result into the demand for freshwater releases to flush them and take care of local eco-systems. Such releases often prove more expensive than treatment of pollutants at source. Also if done by depriving established utilities, social tensions develop. The pollutants sometimes degrade the ground water. These issues are best tackled through judicious basin plans.

Cultivated lands and standing crops in several countries round the world suffer damages because of floods arriving from upstream river basin areas, largely due to absence of adequate regulation facilities, by way of storages, lack or failure of flood embankments etc. Deltas and coastal lowlands of many countries face flooding, inundation and or congestion at outfalls into the sea. Some countries also face the fury of cyclones in the coastal areas. They would have to be protected where feasible and politically and environmentally acceptable. In many countries, reclamation of such lowlands has become necessary in view of shortage of arable lands. The schemes

for construction of structural measures like dikes and drainage works, their modernisation, raising and strengthening where required would have to be implemented as an integral part of a comprehensive master plan which also provides for non-structural measures wherever feasible to reduce damage potential. The implementation of such plans would ensure integration of basinwide flood management and drainage to protect the delta zones and coastal area against inundation and congestion of drains.

Basin plans have to ensure that overall, the positive impacts are maximised and negative ones minimised and have to strive for a proper balance between human and environmental/ecological needs. Lastly, where a mismatch between demand and supply can not be removed by basin approach, inter-basin transfers will be required. There were many such efforts made in the past and many more will be in pipeline, as within basin development reaches an optimum. In fact at several places, inter-basin transfers of water have been made for a long time, within sovereign countries and sometimes with co-operation between two countries. Such cooperative efforts will all the more be necessary in future.

Improving Water Productivity in Irrigation

In the developing countries, while significant efforts are directed towards expansion of irrigated area attention is to be paid for improving the on-farm water management to achieve the maximum possible water use efficiency. This will be not only for ensuring maximum productivity per unit of water and unit of land but also to reduce the substantial gap between irrigation potential so far developed and utilised.

Some claim that water scarce countries should aim at only high value crops for export while importing low value food crops, thus importing virtual water. The concept has to be considered in depth in context of poverty incidence in such countries. Also, one has to carefully look at the world food production and trade trends and the size of needs. Increasing water productivity calls for changes in crop varieties. Also steps are necessary to transfer the tested irrigation and drainage technologies from the developed world to the developing countries. An IWMI study of 50 irrigation systems round the world shows a wide variance in productivity. Considerable improvement in productivity is possible in some large systems with well-designed inputs.

Some of the available options for improving the productivity of irrigated lands are listed below:

• establishing water users organisations for involvement of farmers in management and collection of fees, reducing irrigation subsidies and/or introducing conservation oriented pricing, strengthening the training and extension services; in short adoption of a discrete combination of structural and non structural measures;

• improved operation and maintenance of irrigation and drainage systems; using controlledi groundwater table management while improving the quality of drainage effluent;

• employing furrow irrigation; furrow diking to promote infiltration and reduce runoff; employing surge irrigation techniques even in furrows;

• adopting water conservation methods like tillage, to reduce evaporation from land or changing the planting dates to match with periods of low evaporation rates and improving drainage by surface or sub surface methods and recycling of drainage and tail water;

• increasing pressure, sprinkler and micro irrigation systems, instead of open gravity flow taking advantage of low energy, precision application systems to cut evaporation and wind-drift losses; adopting better irrigation scheduling and improved canal operation to ensure supply, when it is crucial to crop yield;

• involving private sector companies in developing cost effective technologies and their promotion particularly in developing countries;

• promoting and adopting results of agronomic researches like: selecting crop varieties with high yield per unit of water; switching from crops consuming more water to those consuming less i.e. better matching crops to climate conditions and to quantity of water available; sequencing crops to maximise output under conditions of soil and water salinity; introducing water efficient crop varieties.

Governance, Legal and Institutional Issues

Traditional small sized societies managed their own resources including water, because per capita resource surpluses were available. Rulers still had a coordinating role and scores of centrally planned, implemented and administered large sized schemes date back to centuries all over the world. After the industrial revolution accompanied by industrialisation and urbanisation of the societies, no doubt, the exigencies of the situations demanded more organised centralisation. Gradually, the planning, development, withdrawal, uses and disposal of waters got transferred to Governments of the individual countries and to local-self Governments. Irrigation of farms by means of water drawn through dams, canals and wells or drainage of lands prone to water-logging grew with active involvement of institutions and legal procedures set up by the Governments. Functlonaries of Governments or institutions charged fees for the water supply and recovered them by way of land revenue or in

kind, by way of levy in form of farm produce. Water disputes were heard by Government or Institution functionaries or courts of law and resolved as per law of the land.

Due to the complexities involved, irrigation, drainage and flood management are likely to continue to be with Governments in the countries of the developing world for quite some time. Legal positions also might not undergo much change, excepting that the concepts of water rights will be debated along-with other rights on natural resources. But the main likely change will relate to basic human rights like right to food, water, employment and livelihood. All required changes in the institutions will flow from these changes. An overall change in complexion of the sector will occur as all shades of rural development activities are woven around WR. While centralisation at apex level will continue, there will be much more decentralisation lower down to facilitate the final use of water for rural development. Even in case of environmental concerns, a holistic view will be possible, only if centralisation at national level exists. But it will call for complete decentralisation, as one goes to local level. On the whole, a much more participatory process involving stakeholders will evolve, for not only the decision making, but also for implementation, operation and maintenance.

Following institutional and legal aspects of WR sector are under debate and need serious consideration.

• Ratification of UN convention on non-navigable water courses. Participation in global processes/conventions related to IPCC, desertification, UNCSD, WTO, WFS, population, poverty, ECOSOC, UNDP, UNEP, UNESCO, FAO, WWC, GWP, international organisations.

• Adoption of a comprehensive water policy covering all types of consumptive and non-consumptive uses and institutional arrangement for its implementation to provide framework for sound decision making. To consider sector-wise legislation like irrigation acts, drainage acts, etc. as a basis for such policy. It should cover and endorse IWRDM and take care of effects of natural disasters and their possible intensification due to climate change and socio-ecological concerns like R&R, deforestation, biodiversity, water quality, land and soil erosion, landslides etc.

• Adoption of legislation, instituting basin approach and authorities for surface, and groundwater rights of stakeholders, establishing appropriate administrative machinery for implementation in catchment and command both.

• For a country like India, a fresh-look at centre-states-concurrent list in constitution. Need to improve Inter State Water Disputes Act for speedy resolution of disputes. A fresh-look at River Boards Act. Institution of independent conflict resolution mechanism

• Putting in place an appropriate mechanism for conflict resolution both for intra basin and inter basin water sharing and transfers. To set at rest controversies about alternative options and evolve a basket of solutions for different scenarios.

• Enabling environment, public awareness, political will and commitment, . creation of inst and giving appropriate roles to them.

• Development of practical WR management instruments.

• Financial evaluation. Investment needs for remaining development; improved O&M; rehabilitation, modernisation and replacement of old facilities. Avoidance of thin spreading of resources. socio-economic analyses and prioritisation.

• Data bank. HRD for development, R&D, construction and its management, mechanisation, indigenous consultancy development, Risk analyses, Opportunity costs.

Stakeholder Involvement, Youth and Women's Participation

Irrigation, drainage and flood management works, were undertaken in most of the countries by the Governments or the rulers of the nations as public welfare activities. In many instances, they were started as famine and drought proofing protective measures and were considered as most important duties of the State. Due to this background and due to the complex nature of the issues involved, most of the water development projects in these countries adopted and continue with a 'top-down' planning process. In recent past, efforts have been made to introduce water management with involvement of the stakeholders in decision making. It is now recognised that it is necessary to create an environment, where the users are 'empowered' in management of water to maximise productivity, for the well being of the society. Most of the countries where population is still growing have majority of young people. Bringing about awareness amongst them in a focussed manner in respect of WR sector is an important task, as they will be the leaders of tomorrow, which is so critical. All stakeholders of different disciplines, will no doubt be increasingly involved in decision-making processes, so that they own, know and be responsible for the operation and maintenance of a system.

Women traditionally were not involved in management of irrigation schemes, while they were more dependent on irrigation water for their farms, where they put in lot of labour. They indeed manage the domestic requirement of water including that for vegetable gardens as well as tending of livestock. They have to be provided a big say in water management through water users associations alongwith other stakeholders.

User participation should be a central principle in identification, planning, implementation, operation and maintenance, as well as monitoring and evaluation. For this purpose it is necessary to activate existing community based institutions and creating new dispensations. NGOs and women groups can be instrumental in organising water users in the process and ensure that they all share costs and benefits. User organisations, when formed, have to be strengthened by legal backing of 'Establishment' to permit transfer of functions as well as assets, and defined water rights.

Financing IWRDM, Modernisation, Rehabilitation and Replacement

Basin wide IWRDM calls for correct assessment of both surface and ground water resources in terms of quantity as well as quality, their sharing, development, conservation, abstraction, recycling and reuse, in context of equity for users. It therefore calls for formulation of a financing policy, from development and implementation of master plans to ensuring optimum utilisation, to pricing, cost recovery, operation and maintenance, safety, modernisation, and replacement. Financing is required at all stages including institution and capacity building, decision support systems, information technology, automation, research and development, economic analysis, risk analysis and other aspects.

All these issues constitute investment in future prosperity for which besides the national Governments, public participation and weil-designed privatisation is necessary. Multilateral and bilateral funding although it concerns less than 10% of total investment may act as a catalytic agent for resource mobilisation. While it is desirable that the water sector is run as far as reasonably possible on economic lines, by way of generating revenue from the services provided to sustain the services and future development needs, it is not easily possible in developing countries due to prevailing socio-economic conditions. It is also necessary to acknowledge that most of the developed world has been blessed with favourable climatic conditions, which allow them to grow crops under rainfed conditions. Further agriculture is also highly subsidised. As such the production from irrigated agriculture in developing countries if subjected to full cost recovery principles will be much costlier. The predominance of small landholders and a large force of unemployed landless make the problems more difficult to handle. There is a widespread fear that treating water as an economic good in these countries can result in cash-rich industrial sector purchasing as much water as possible regardless of the price of water, reducing its availability for agriculture and thus endangering food security. The issue of cost recovery or pricing is to a certain extent linked to the economic status of a country, though partial or preferably full recovery of the operation and maintenance component will have to be the objective. The concept of full cost pricing or recovery is to be seen also from the point of view of subsidised global food prices, their impact on poor and marginal farmers of developing countries and food sufficiency - security concerns of large countries. The approach will have to be extremely cautious.

Large scale funding is required to provide for projected additional withdrawals of water as well as for the requirements regarding drainage and flood protection. But on the water management side, again lot remains to be done. Lack of regular annual maintenance results in systems falling into disrepair, increasing thereby the likelihood of breaches, and silting of distribution channels and congestion of drains. There is urgent need for modernisation of several large irrigation schemes in Asia besides replacement of old schemes, which will not only improve efficiency of performance, but also result in water savings which can be used for bringing more areas under irrigation which were uncommanded earlier. Financing of such schemes has a great potential to increase agricultural production. Sometimes, relatively small outlays on modernisation for instance on head-works, distribution structures and drainage outlets, can help raise production substantially even in small irrigation schemes. Participatory approach whereby farmers get motivated to offer their services in kind, if not in cash, helps greatly in modernisation efforts and have to be attempted in a big way in future.

The vision in all the three components envisages need for a higher level of funding in the next 25 years. One estimate calls for enhancement of present level of funding by at least 40%, not only for new infrastructure but also for replacement, modernisation of aging systems and imparting sustainability to them.

Equity, Efficiency, Efficacy and Economy

For IWRDM to become sustainable, it ought to have these four important components in the services provided. They are interdependent and bring in optimisation in use of natural resources, increase productivity per unit of land and per unit of water. They ensure that the fruits of IWRDM reach all stakeholders by way of supply of water when, where needed and that too in right quantity of right quality.

Low water use efficiency can be attributed to low level of technology, land management as well as deficiency of operation and maintenance. For instance in irrigation sector, lining of canals and distribution system, or use of low pressure pipes for distribution wherever feasible as well as introduction of efficient on farm facilities and practices can help achieve better efficiency. Adequate and efficient drainage is necessary to sustain high crop productivity and conserve land resources. It is also necessary to set up a system of real time monitoring of flows and water demand. Adoption of water saving sprinkler and drip irrigation systems may help to achieve not only better utilisation of scarce water resources, but also better output of crops due to application of the correct quantum of water at the critical stages of growth. Utmost economy in deployment of financial resources will therefore be a key word in the future. It would mean need for enhancement of productivity, water use efficiency, reversal of degradation of land and water resources already deployed. It also would mean enhancement of standards for new areas of irrigation and drainage and sustainable development of the rural area, for which financial resources ought to be earmarked. The major blame attributed to WR sector, is inequity in supplies because of technological deficiencies exacerbated by political and administrative weaknesses. Several solutions have been envisaged to obviate the ill and remove the imbalance. But the progress will be slow. To bring about efficiency, economy and equity in an effective manner in WR sector will be the key to the resolution of opposition and moving ahead to meet with the tremendous challenges facing the sector.

SECTION V

Resolving Controversies and Moving Ahead

Every human activity causes impacts, mostly to achieve some predetermined goals, sometimes leading to harm to some. On the balance, the impacts have to be positive. Alternatives have to be considered to minimise the latter, but proven ones can't be discarded. Progress can't be achieved by stalling ongoing implementation of decisions, as time is the essence. In the next 50 years, much more is to be achieved than what was achieved in the last 50 years. Adverse manifestations of WRD are to be removed. But it is to be realised that many are due to thin spreading of available meagre resources or due to deferment of some components of well thought out plans. So far, indigenous funding has largely taken care of needs, the world over. More investments are required in the next 50 years for rehabilitation of old systems, besides building additional needed. It has to come only from economic development and not by remaining stuck in controversies. Solutions are to be implemented and movement ahead ensured. Dams remain at centre-stage of innovations for WR sector. Major issues being voiced and debated are listed below.

Some Objections

Some people object to the top down planning and lack of participatory approach and/or lack of involvement of affected people, in planning, implementation and management processes. But don't see the many times more people who are benefited. Their rights and risks are ignored. Some believe that only small-scale development can suffice in full harnessing of the basin waters such as Narmada! An exercise in past had for instance indicated that only about 15 % of planned water could be put to use if only micro and minor projects were constructed accompanied by a lower reliability, more evaporation loss etc. Some others believe that micro scale harvesting is a viable alternative. Simple calculations disprove this concept.

The concerns are however more real on downstream side where on canal projects management has been tardy, causing problems such as: water logging & salinisation of crop land, inequity in supplies, farmers going in for cash crops rather than food crops thus utilising more waters and causing ill-effects and low irrigation efficiency. The issues of inequity, inefficiency, insufficiency and low productivity are listed as faults for all water use sectors.

Achievements and Need for Resolution of Difficulties

From a net importer of food grains 50 years ago, the country's status of self sufficiency in this decade is due to inputs of water and green revolution. India now has got the largest net area under irrigation surpassing that of China, but still it is a small proportion of cultivated area. So far, only about 50% of the controllable flow potential has been utilised. Drinking water supply covers 90% of urban and 97% of rural areas, but mostly inadequately. Sanitation water supplies are unsatisfactory and sewage waters are rarely recycled. Industrial water supply is a growing need, though at present fairly well covered. Hydropower potential of the country is tapped to the extent of 18 % only. In-situ harvesting and soil & water conservation effort has picked up momentum during the last couple of decades and has provided drought protection to some rain-fed areas and has dispersed the benefits to wider areas, which otherwise would not get irrigation.

Flood control is in-built as a major component but in only a few reservoirs. Most of them offer the advantage incidentally. Inland waterways are under development and may need more regulated release in future. Yet several dam projects are slowed down during the last decade, because of agitations, repeated fasts unto death, Jal-Samarpan threats, and such movements by NGOs and activists. Rate of growth of area under irrigation has

reduced. Food production has almost plateaued. Unless solutions to these problems are punish place, the situation can grow into a crisis.

Deficiencies

Sometimes submergence of valuable forests and good agricultural land takes place under reservoirs. This needs to be minimised. Some reservoirs have been silted up at a higher than designed rate. Some dams have failed due to unsafety. Displacement and R&R is not carefully planned and implemented. Catchment area treatment is picking up. While supplies have largely kept pace with demands, in future, the gap might increase with rapid growth of demands. Water use efficiency and hence productivity is low. Wastage of water is pervasive. Water logging and salinisation of land has taken out irrigated areas from production. Gap between potential created and that utilised remains significant. Irrigation supplies are not equitable between head and tail of canals. Command area development is deficient Waste-water is not adequately treated for reuse. Health problems have arisen due to poor quality and stagnation of such waters. For flood management, non-structural measures are not deployed extensively along-with structural ones. Flood embankments have caused problems at some places, but have proven immensely beneficial at several other places.

Difficulties in Development

Development of remaining potential is beset with many difficulties. Equitable sharing of waters of inter-State rivers, construction of joint projects, sharing of costs and benefits, displacement of people and their rehabilitation due to submergence, lack of a common rehabilitation and resettlement policy including issues of allocation of land for land required for public purposes, environmental concerns, loss of forest cover and land etc are some of the major issues faced in construction of dams. If dams are not built, environmental degradation occurs and perhaps faster than before, migration takes place in their absence such as from Nepal to India, resettlement problems of such people and their impoverisation continues. Thus social and environmental cost of building dams is often less than not building them. Wherever water resources development reached, local population got stabilised, migration was reversed, poverty was reduced, economy was strengthened due to secondary and incidental benefits.

SECTION VI

Various Voices

All these deficiencies no doubt need remedy. But they are not all pervading. Every technology and engineering facility have faced some difficulty or the other, which require treatment and upgradation of technology. This indeed constitutes the cycle of development. One can not wish it away. Due to the remedies, the cost of development will increase. But the benefits also will increase.

Some advocate that these are systemic deficiencies, which can not be remedied and hence this system of development, which is economically and socially indefensible should be discarded. They argue in different voices. "The water sector is a failure and a disaster" and hence altogether de novo alternative approaches are called for. Go for only micro or minor scale development. Go for only ground water. Adopt total participatory approach. Don't grow cash crops. Exclude rich farmers from irrigated areas. Use sprinkler and drip only. Don't use chemical fertilisers and pesticides. Don't go for GMF. Don't join WTO. Don't build large dams. Stop on-going large dams. Remove or reduce the height of large dams. Decommission dams. Use run-of- the- river mini and micro hydel plants. Scrap flood embankments. Don't displace people from their habitats for so called development. Don't destroy their culture.

Baby, Bath and Towel

But it is like throwing the baby with the bath and the towel. Bath water and towel have no doubt required to be changed. Deficiencies have to be removed. Alternatives have to be proven to be cost effective. It should be possible to put them in shape in the available time and most importantly, it should be possible to harness all the water resources in a sustainable manner. This is simply not possible by condemning everything. Limits of alternatives, the track record and the time constraint have to be well understood before taking desperate actions. The wish list of opponents of WR sector is long! I deal with some of the major ones.

Small against Big Dams

Depending on location and economical-hydro-geo-technical considerations, a large or a small dam is built on the basis of well-tested concepts. A terminal reservoir in a basin is made largest depending upon site conditions, to capture as much water as possible. In a basin, a discrete combination of large to small or mega to micro scale facilities is required. Some times with such combination also, full potential can not be developed.

Claims that only small size (or some claim only large) of dams be adopted are wrong, Only small dams don't capture all that water. In each basin, even if one wants, all dams can't be of only large or only small size. Each

size has its advantages and deficiencies. Planning tries to maximise advantages and minimise deficiencies to the extent possible. Size-wise capital cost of facilities in US$ per 1000 cub m storage, after Keller and Seckler is as follows.

Large storages: 8 to 110 US$, medium and small: 50 to 350, micro: 160 to 600, dug: 500 to 1200, desalination: 600 to 2000.

O&M costs differ for each size. Economic analysis has to account for opportunity costs and should help prioritisation of each scheme. Apart from cost: the issues of: mortality, reliability, dependability, submergence, displacement of inhabitants, loss of forest and cultivated land, adverse impacts, multiplier effects are to be considered while making the decision. A recent study of proposal to revive the old tanks of south India indicates that contrary to popular perception, it will be economically too expensive. All said and done, the National Commission has concluded that for the year 2025, it is necessary to complete all remaining intrabasin development. Inter-basin transfers will be required beyond for meeting with the needs of 2050 AD. Large dams will be specially necessary for such transfers.

Micro Watershed Development versus Dams

Both cater to different functions. The former captures rain in situ and supplements! conserves soil moisture for a longer period, whereas the latter hold the run-off in storages of surface waters and make it available through canals for irrigation. The former has a crucial role in treatment of catchment area and non-commanded areas of irrigation schemes. It recharges ground water for use in local drinking water needs. Also, it provides soil moisture to replace may be one or two irrigation waterings, in kharif season. Its main role therefore is important for the vast rainfed areas of the country, which will not be irrigated even in ultimate stage of development.

The former successfully operates within a narrow band of meteorological phenomena of intensity, duration, antecedent rainfall, potential evaporation, infiltration capacity dictated by topography, geology, slope, vegetative cover etc. Its contribution to increase in productivity of cropped land is rather limited. Both therefore are considered as complementary and not adversarial. Sediment generation is reduced in the former case. But erosion and deposition in downstream continues due to hydraulic phenomena. Dams hold bed load of sediment in the designed pockets. The economic analysis accounts for such facility. Peak flood is reduced for local watersheds but not for a group. Although claimed, it does not have impact on generation of floods.

Reduction of Flow into Oceans due to Dams

Dams hold floodwaters and release through the year according to needs. With all the development, runoff into seas no doubt will reduce. A part of storage will be lost into atmosphere due to evaporation. Globally speaking, when all the proposed dams are built, reduction in outflow from the land into the oceans will be of the order of 0.1 million BCM as compared to say 3000 million years ago. It will be offset to some extent by snowmelt from polar regions and glaciers due to global warming but would amount to a reduction of 0.003 % to the volume of the oceans which is about 3600 million BCM. The likely ultimate reduction is therefore not expected to cause any disruption of the hydrological cycle or sedimentation and erosion phenomena in the oceans.

Reduction of River Flow and Degradation of Quality

River flow in post monsoon season reduces if regulated releases are not planned through sluices- and or hydroelectric power-houses. Degradation of river water quality is mainly due to waste-waters which ought to be released after treatment. Releases only for flushing pollutants don't constitute economically prudent decision making.

Safety and Seismicity

All dams are rigorously inspected, maintained, repaired and rehabilitated. Safety record of India is at par with the world. Dam break analysis is done for old dams while refurbishing them, so as to visualise and introduce appropriate safety measures. Dams are designed for destabilising forces released due to native seismicity. Mega dams have been built in more severer seismic zones in the world. Reservoir Induced Seismicity (RIS) is debatable. But such forces don't exceed native forces. For new dams, a seismic design features are used. Rigorous analysis, both probabilistic and deterministic is adopted according to the needs.

Submergence of Land, Flora, Fauna and Bio-diversity

Cost of submergence is considered in BIC analysis. Compensatory measures are taken to neutralise adverse effects. Special sanctuaries are created. Bio-diversity can be taken care of by preserving specific genes in nurseries or gene banks.

Water Logging and Land Salination

Deferred construction of drains where essential, over-dose of irrigation waters and lack of adequate drainage causes these problems. Presently, about 10 % of irrigated area in India is affected by the twin malady. Specific investments are required to reclaim the affected lands. Structural and non-structural measures are being implemented. More efficient water application can reduce the problem considerably.

Run-of-the-River Hydropower Stations

They can be built downstream of large storages on perennial rivers for reuse of waters released through main power stations. Damage due to sediment also is reduced due to such facility.

Their reliability in post monsoon season is low, requiring shut-downs. Cost per unit power therefore goes higher.

Solar and Non-conventional Energy as an Alternative to Hydropower

Although undoubtedly the ultimate inexhaustible source of the future, the alternative sources at present are still in development stage. Present costs are unaffordable. In case of bio-mass based gasifiers which are claimed as options for hydropower, the largest generator in place is of 3 or 5 kw in capacity. They require land for growing bio-mass and hence their costing is of doubtful nature to replace hydropower.

Displacement and Rehabilitation

People living in submergence have to be displaced before dams rise during construction. They have to be rehabilitated in better conditions than before and have to be provided with land where available and wherewithal for resuming their livelihood at the new location. Certain minimum provisions are to be prescribed as per guidelines for project authorities by the Government of India. Each State might have different laws I regulations detailing the individual provisions. Displaced people need alternative means of earning livelihood, rather than getting lump-sum compensation. The package for rehabilitation and resettlement needs to be evolved after consultation with the stakeholders. Several countries have by now appropriate national policy in place. In India, it should be available soon. Meanwhile many projects have adopted liberal policies and have implemented them.

SECTION VII

An Emerging Crisis?

WR like other natural resources can be shared and administered for use to enable maximum good of maximum people. Long term averages like the global exercises described tell of a long term scenarios. Such availability is greatly affected by yearly variations and within a year in space and time. It is further affected by extremes of the cycle viz. floods, droughts and cyclones which have higher incidence in tropical climate as compared to temperate one. The global warming and consequent climate change looms on the horizon and threatens to exacerbate these phenomena further. When basic needs of growing societies do not get satisfied, scarcity manifests. It degenerates into a crisis if not remedied. As implementation and fruition is lengthy, long term water plans have to accommodate basic needs of the ultimate likely population. Short-term plans have obviously to fit within them. A crisis can extend beyond availability and affect development, augmentation, conservation and management. All water activities from planning to modernisation and replacement of facilities created, have to be directed to avoid development of a crisis situation, while ensuring fruition and avoidance of degradation of the resource base itself. Management of all these call for interventions normally woven in multipurpose development plans.

Water sharing within a river basin or between basins, can be harmonious if pressure of needs does not exist. Population density of the region can exacerbate the situation. Crisis situation can degenerate into a war like situation, if not dealt on time and with prudence. By and large, water has acted like cement and has enabled peace-making. Adequate laws, acts, conventions and institutional arrangement to implement are important.

Like in India, the emerging crisis elsewhere is not of waters, but is in mind and attitudes, it is due to promotion of negative thinking rather than encouraging proactive mid-course corrections, due to lack of courage to' make mid-course corrections, due to not following rational thinking and shedding romanticism. Crisis is of capacity in rising above the controversies, doing some pragmatic thinking and acting decisively in deciding what path to take. Crisis is in advocacy of dumping one proven option in favour of another, emotion-appealing, look-good alternative.

The country has passed through such situation, when we were only 35 crores and still were short of food grain production, when the country was commonly affected by famines and floods. No more. The efforts of last 50 years undid the crisis. It was not a bed of roses, anyway. A repeat performance is called for. This time, we need a 'blue' revolution (water-centric) if necessary accompanied by a second green revolution. If there are dark clouds, there are silver linings and openings, as well.

First - There is still enough unharnessed water available in the country basins. Intra-basin and inter-basin transfers of water, can augment availability.

Second - The opponents of present model have proposed alternatives. Their professional evaluation can alone enable decisions about choices.

Third - Schemes in progress must not be delayed endlessly all through the construction phase. They must be completed once undertaken, even if necessary after paying economic and social cost involved. Comparisons of dams with bombs or temples with tombs are funny and futile.

Fourth - Efforts at improvement in water management and efficiency being made first time in an organised manner must be accelerated.

Fifth - Fourth dimension - time - is the essence. World's and India's population might stabilise in another 50 years. We are at half way since independence. There is no time to lose.

THE PROSPECTS, ISSUES AND DESIRED STEPS

The following paragraphs provide lists for different sub-sectors.

Drinking Water and Sanitation

Urban areas: Quickly build the planned reservoirs. Deploy dedicated pipelines. Keep outlets for en route villages. Integrate surface and ground waters. Augment the latter to the possible extent by in-situ conservation. Improve treatment works. Capture all used water, lead it away and treat. Plan and use treated water for different needs. Implement policy of zero untreated releases. Improve O&M. Reduce losses. Rehabilitate old systems and modernise them, where necessary. Implement zero effluent norm for Industry. Evolve appropriate pricing and recovery mechanisms fitted within the policies of water basin/district authorities. Integrate fresh water, waste water and flood water systems. Ensure equity in supplies to the extent possible.

Use hand pump water for secondary uses.

Rural Areas: Plan regional water supply schemes rather than individual ones to effect economy. Tubewells ideally suited for regional ones. Base them where possible on en route urban schemes. Plan underground check dams for villages on banks of sandy streams. Deploy compartmentation within village tanks to reduce evaporation losses. Adopt harvesting techniques around them and sink wells for tapping filtered waters. Where hand pumps are in use don't allow deeper bore or tubewells around them. Repair facilities immediately. Lead away sullage for kitchen gardens. As chemical treatment is not yet largely possible, ensure fluoride, iron, arsenic and organic sources of pollutants.

Irrigation, Agriculture, Rural Livelihood, Well-being

Plan conjunctive use of surface and ground waters. Improve O&M of canals and structures. Ensure volumetric releases in rotation through Warabandi. Promote irrigators associations to take on O&M, recovery of charges, collection of produce, marketing, facilitating credit, implements, fertilisers, pesticides, agri-advice. Start from tertiary component of distribution system. Increase productivity of land and water by ensuring optimal balance of food crops, cash crops, vegetables, fruits, flowers according to the soil's compatibility. Deploy mechanisation in farming, pressurised irrigation systems, water saving devices, micro irrigation, glass I plastic houses for saving crops from frost damage and better yields. Where possible, encourage dairy, fish farming, pork and poultry rearing to supplement rural income and nutrition - which still stands at 80% of minimum needs for about 1/3'd of India's population. Bring equity, efficiency, economy and sustainability to irrigation uses, soon.

Ensure balance in cereals, carbohydrates, minerals, vitamins while the shift from cereals to meat and milk takes place with economic growth. Go for plasticulture, biotechnology, GMF/GMO wherever necessary with caution. Promote agri-based industry to wean away over crowding on smaller land holdings and employ landless thus stabilising populations in rural areas and triggering economic revival. By increasing productivity, proportion of people employed in agri sector would move to manufacturing and or service sector, thus causing growth of GNPI GDP in turn allowing more investments in rural economy. If cereal production rises from say 2 tonnes iha to 5 tonnes lha, food security will be ensured while releasing land for value added crops I bio-mass. lnduct crop insurance and ensure real time advice as the monsoon advances. Provide roads, markets, fuels, energy needs, fertilisers, seeds, implements, animal power, milch cattle, bio-gas plants, cold storages. Irrigation for rural development and food is a multidisciplinary business and needs to be tackled as such in future.

Watershed development in catchment and command both, will help augmentation of soil moisture to some extent. It is not an alternative to storages. In rain-fed areas which will be covering 2/3rd cropped area seven in ultimate stage of irrigation development, micro development will boost productivity to some extent. Soil conservation goes hand in hand with water conservation. Buld the movement to encompass natural disasters.

By following the strategy chalked out, India will, not only maintain food security but become exporter of high value agro-products, to raise contribution of agriculture to GDP. We have entered WTO as a part of globalisation, liberalisation and anti-isolationist process. Convert blind opposition into enlightened self interest.

Hydropower

Very few dams store water for producing HP alone. Mostly they are multipurpose and electricity is generated by releases for other purposes. Yet 80% of the potential is yet to be developed. Equivalent potential is awaiting development in Nepal through development of storages of waters, which otherwise are causing flooding and devastation in India and Nepal both. Where snow melt is available, run-of-the river plants can work, but sediments cause damage to runners and hence storages prove necessary for trapping sediment and passing cleaner water through turbines. In such cases, successive plants can use the releases for generation of HP.

As yearly renewable resources are used, HP is most economical and eco-friendly. It is available on tap and hence is used for meeting peak demands thus stabilising power systems. By pumping water back into the reservoirs during off-peak hours, same water can be used over again, thus allowing recycling of the resource. Presently about 30%of total energy generated in the country is used for irrigation pumping. HP is about 20% of total production. Both are complementary and have to be developed and used as such.

Other Uses

Navigational needs are small, but optimisation requires jacketing of rivers and investments. Recreation is incidental at reservoirs and on river-fronts. For the latter, it is necessary to improve water quality by ensuring treatment before releasing waste-waters. Everybody lives downstream of somebody and is to be cared for by way of ensuring quality and quantity supplies. Eco-systems along streams-rivers and estuaries-backwaters-wetlands and coastal areas need water releases. Costs involved are enormous. A balance is to be achieved between human needs, containment of adverse impacts on eco-systems and costs for ensuring sustainability of water uses. Over pumping in coastal areas has caused salinity ingress, which has to be reversed by restraint on pumping and by recharge. Conjunctive use of surface and ground waters can improve the in-land situation.

EPILOGUE

In past, the green revolution ably supported by irrigation, has helped in production of enough food for the growing population of the country. To make the revolution evergreen, we have to plan for needs of the ultimate likely population of the country. This objective can be achieved through second green revolution as claimed by many. But water, can become it constraint, if not prudently developed and managed. In fact to enable maximum productivity consistent with sustainability concerns, water has to be used much more prudently than before. This would be possible through a water revolution or a BLUE REVOLUTION as brought out in this lecture note. The lecture strikes a very optimistic note. It avers that it is not only possible for the world and India to meet with the ultimate needs of the population adequately, but the second green revolution can make it an ever-green one if it goes on hand in hand with a blue revolution. A country like India can increase the agricultural growth rate with GDP to put itself on the course of becoming a leader in economic terms during the next century. The task however is not easy. From funding to conflict resolution, strong will and confidence will constitute the basis for such achievement.

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The Development of Cable-supported Bridges in Hong Kong — My Personal Experience

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SUMMARY

Hong Kong has completed 3 large span cable-supported bridges, namely, the 1377 m span Tsing Ma suspension bridge, the 430 m span Kap Shui Mun cable-stayed bridge and the triple-tower Ting Kau cable-stayed bridge with main spans of 448 m and 475 m, respectively. Detailed design for the 1418 m span Tsing Lung suspension bridge is underway. An international bridge design competition concludes a 1018 m span Stonecutters cable-stayed bridge of which detailed design has began for construction in 2003. New bridge schemes linking Hong Kong with Mainland China includes few major bridges with span over 1400 m.

INTRODUCTION

The economy of Hong Kong SAR is largely based on trading which in turn rely heavily on its airport and port facilities. In recent years, there has been rapid development in China and in South East Asia generally. The region has become the most popular tourist destination in Asia, and the most attractive trading economy in the world. Hong Kong's airport is one of the busiest airport in the world. It also has the world's busiest container port and a fine harbour to receive vessels of all sizes from around the world.

In order to enable Hong Kong to achieve continuous economic growth and to maintain its important role as an international centre for business, Shipping, aviation and tourism well into the next century, Hong Kong has completed on a programme of infrastructure development in 1997 called as Airport Core Programme which is one of the world's largest infrastructure programme at a cost estimate of US$21 billion. An important part of the programme is the building of a new international airport at Chek Lap Kok to replace the existing airport in the urban area. A Disney Theme Park is being built at North Lantau for opening in 2005.

Building the new airport required the construction of a number of high-capacity transport links to serve the airport as well as the new industrial and residential developments proposed at Lantau. The route comprises two major bridges, namely, the Tsing Ma suspension bridge and the Kap Shui Mun cable-stayed bridge. The two bridges have double decks for road and rail traffic and open to traffic in 1997.

The fast growth in the cross border traffic required the construction of a direct link between Shenzhen and the western territory of HKSAR. The outstanding structure in this link is the Ting Kau cable-stayed with its 3 single legged towers with main spans of 448 m and 475 m. The elegant Ting Kau Bridge after its completion in 1998, has always attracted the interest of visitors who compare it with the neighbouring Tsing Ma suspension bridge and the Kap Shui Mun cable-stayed bridge. It is another good example of modern bridge design thus creating an ensemble of bridges, which complement each other.

A western corridor was planned to a new boundary crossing at Shekou of Mainland China and included a 1418 m span suspension bridge, the Tsing Lung Bridge. The detailed design of the bridge, having twin shallow streamlined boxes deck has been carried out and construction of the bridge is scheduled for 2004.

An international bridge design competition for the Stonecutters Bridge, a major element of a trunk road linking eastern and western parts of the territory, was completed in September 2000. The winning scheme is a cable-stayed bridge with chimney shaped towers and a main span of 1018 m. Detailed design based on the winner's scheme as a reference scheme has began. The construction of this world's longest cable-stayed bridge is scheduled for 2003.

The rapid economic growth in the Pearl River Delta in the Mainland China calls for the need for the construction of new crossings linking Hong Kong with the Mainland. The proposed routes require many large scale cable-supported bridges of spans even over 1400 m.

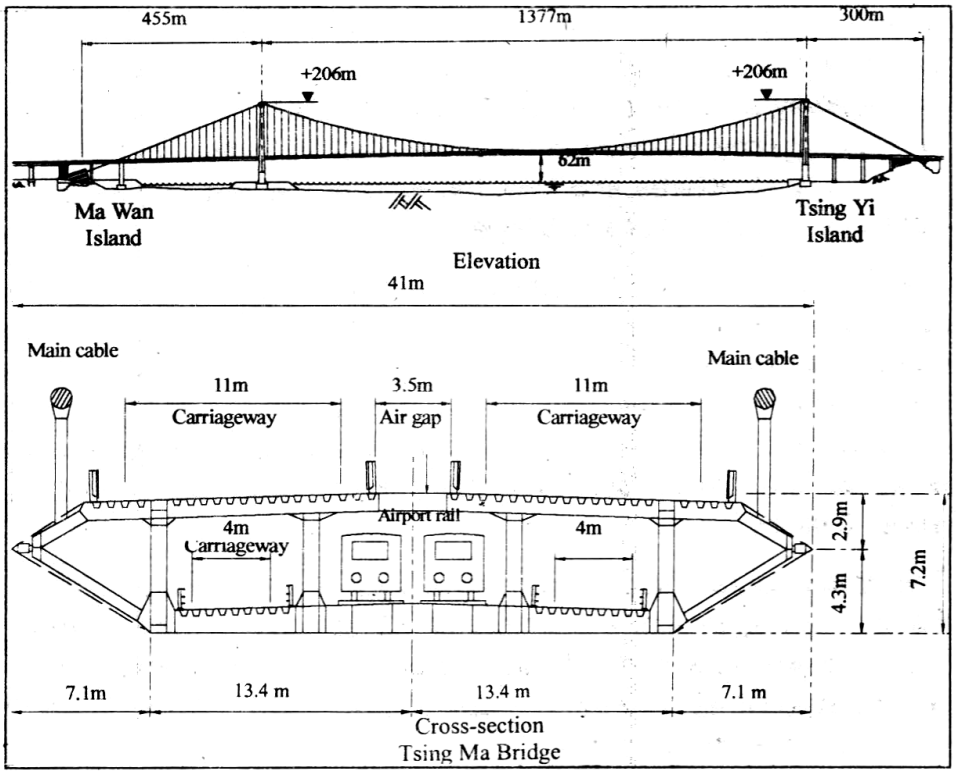
TSING MA BRIDGE

The Tsing Ma Bridge has a main span of 1377 m and is the world's longest suspension bridge carrying both road and railway traffic. The upper deck of the bridge carries a dual three-lane carriageway and there are two tracks of railway and a dual onelane emergency roadway in the lower deck. The two anchorages are gravity structures and take the load of the main suspension cables at either end of the bridge.

The Tsing Yi Tower Foundations are simple spread footings on rock and the Ma Wan Tower is founded on precast concrete caissons resting on a prepared rock sea bed in approximately 12 m depth of water. The two towers of 206 m height are of reinforced concrete and each tower leg is 6 m wide and tapers from 18 m to 9 m in the longitudinal direction. Each was stipformed in about 3 months.

The main cables were constructed by aerial spinning method. Each main span cable consists of 80 strands of 368 number 5.38 mm and 11 strands of 360 number 5.38 mm galvanized high tensile steel wires. The total length of wire is 160 000 km, enough to circle the earth four times.

Extensive wind tunnel tests have resulted in the adoption of faired edges and central ventilation openings for the deck to improve aerodynamic stability during typhoons. Structurally, the deck section is a hybrid arrangement combining both truss and box forms. Two longitudinal trusses to the full depth of the deck at 26 m centres act in conjunction with the steel orthotropic decks of the upper and lower carriageways to provide the vertical bending stiffness. Plan diagonal bracings at the upper and lower levels enable the trusses to provide lateral bending stiffness. Cross frames of Vierendeel form are provided at 4.5 m centres with every fourth frame being supported from suspenders. A stainless steel cladding along the outer edges of the deck is provided in order to control air flow across the deck, The final external appearance is therefore of a box with faired edges having continuous gaps along the top and bottom surfaces. Internally, it presents the appearance of conventional trusswork.



The deck is suspended from the main cables at 18 m centres. The suspenders consist of 2 lengths of 76 mm diameter wire ropes which are wrapped over grooved cable bands clamped onto the main cables. The carriageway at the upper deck is surfaced with 40 mm thick mastic asphalt over waterproofing and the lower deck receives a special 7 mm thick epoxy layer. The total steel required for the deck is 50 000 tones and was fabricated overseas, assembled in Mainland China, then transported to site and erected in sections weighting 1000 ton each.

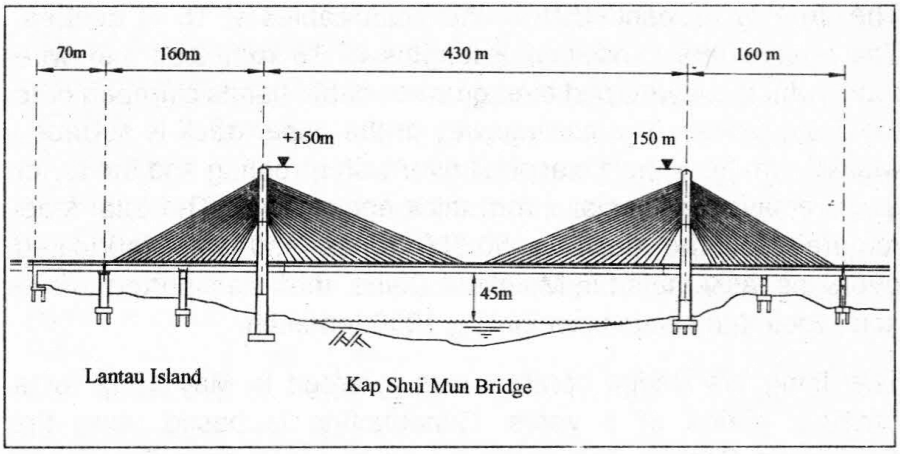
The Tsing Ma Bridge contract was awarded in May 1992 for a contract period of S. years. Construction is based upon the Engineer's Design. The contract was awarded on a fixed price lump sum basis at about US$900 million.

KAP SHUI MUN BRIDGE

The Kap Shui Mun Bridge contract was awarded on a 'design and build' basis because various cable-stayed bridge designs of similar spans and construction methods were available internationally. There was also sufficient time available for tenderers to prepare their own designs. On a design and construct contract, the tenderers compete by producing the most cost effective designs commensurate with their specialist skills and their resources.

The structural scheme proposed by the successful tenderer is a 430 m main span cable-stayed bridge with a steel/concrete composite main span, concrete side spans and concrete towers. On completion, the bridge became the world's second longest cable-stayed bridge carrying both road and railway traffic. The four side spans are of 80 m each, giving a 750 m overall length configured with 80-80-430-80-80 m spans.

The 150 m high towers are of reinforced concrete structures. The Lantau Tower is founded on a shallow spread footing on rock and the Ma Wan Tower is founded partly on 4 m diameter hand-dug piles and partly resting on rock. The contractor constructed the concrete side spans by incremental launr.ling from the outer ends towards the towers.



All field joints of the steel structure are bolted with high-strength trictlon grip bolts. The cables consist of 51 to 102 parallel mono strands of 15.7 mm diameter sheathed 7 wire strands with a tensile strength of 1770 N/mm2 after galvanizing. The total weight of cables is about 2400 tonnes and their total length is 11 km. The corrosion protection measures include zinc galvanizing, grease and 1 mm extruded PE sheathing. In addition, each cable is enclosed in an HDPE pipe.

The Kap Shui Mun Bridge and Ma Wan viaduct contract was let in November 1992 for a contract period of 4.5 years on a fixed price lump sum basis at about US$21 0 million.

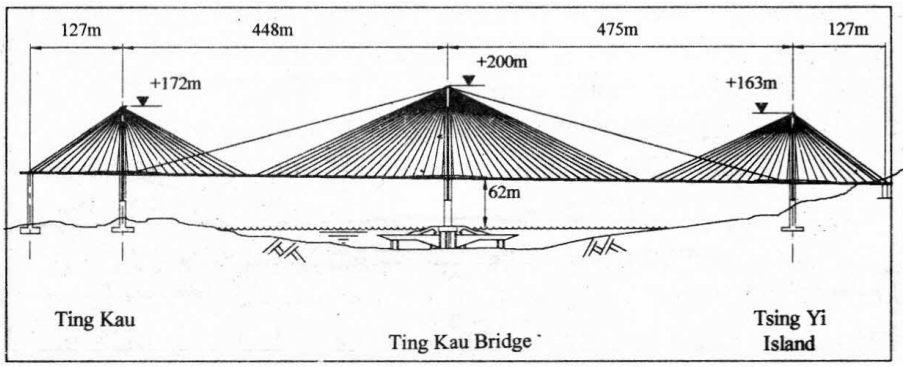
TING KAU BRIDGE

The triple-tower Ting Kau Bridge has an overall length of 1177 m with the two cabled-stayed main spans measured at 475 m and 448 m, respectively. The bridge has been designed to carry a dual four-lane expressway and comprises three single leg concrete towers. The central tower is located roughly in the middle of the Rambler Channel and the other two towers sit on the shore line.

The 200 m high central tower is stabilized with longitudinal stay cables connecting the tower head to the deck close to side towers in addition to the transverse stabilization cables. The towers are protected by ship impact protection systems which will ensure that all vessels are prevented from striking the bridge supports. From these towers, four planes of stay cables radiate downwards to support the bridge decks which are of composite steel and concrete construction.

The deck is formed from four longitudinal 1.5 m deep L-shaped steel plate girders, one on each edge of each carriageway structure, with steel beams spanning transversely between them at 4.5 m centres to form a simple grillage. the 230 mm thick pre-cast concrete deck panels are placed on top with in-situ strip between. The cross-girders are extended at 13.5 m intervals to link the two separate carriageway structures which are separated by a continuous gap of 5.8 m.

The contract was also awarded on 'design and build' basis to the lowest tender on a fixed price lump sum at US$225 million. The Ting Kau Bridge was opened to traffic in May 1998, 45 months after the contract was signed.

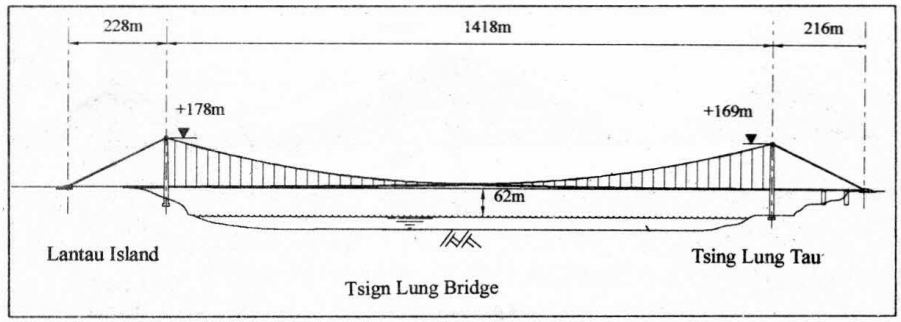


TSING LUNG BRIDGE

The Tsing Lung Bridge has a main span of 1418 m and will carry dual three-lane carriageway with full width hardshoulder at either side.

An Investigation and Preliminary Design Assignment was carried out in 1999 and recommended a suspension with span of 1418 m having a deep split-Severn type of deck. However, the consultants employed for the detailed design of the scheme proposed alternative deck configuration consisting of twin shallow streamlined boxes connected together by transverse box girders at 30 m centre, like the Messina Crossing in Italy.

The innovative form of deck using twin, shallow, streamlined and vented boxes has many advantages inc,juding significant reduction in the weight of the deck, hence, the loadings on the cables, hangers, towers, anchorages and foundations; improved aerodynamic efficiency; easy fabrication as units off-site in , controlled workshops; and easy for transport etc. The new deck scheme is innovative, economic and very pleasing in appearance. Apart from the benefit of safety, the provision of hardshoulder would enable inspection and maintenance operations to be carried out without frequent lane closure on the bridge deck. Construction is scheduled for 2004 and it will take 5 years to complete.



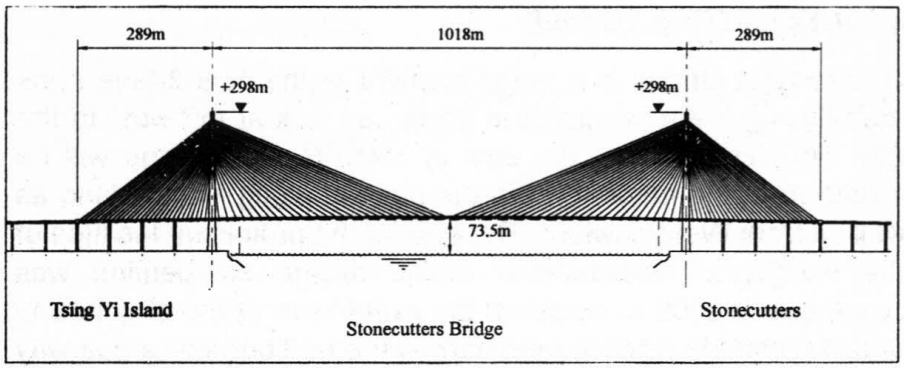
STONECUTTERS BRIDGE

Stonecutters Bridge is a major element of the dual 3-lane trunk road linking the new airport at Chek Lap Kok at the west to the Sha Tin New Town at the east of HKSAR. The" bridge will be visible from the harbour, from the peak of Hong Kong Island as well as from West Kowloon. Because of the prominent location of the bridge, an international bridge design competition was organized in 2000 to establish the exact form of the structure in order to provide a fitting landmark in the harbour and a gateway to the container port. Apart from the possibility of getting an innovative and attractive design, the competition will secure a reference scheme for detailed design and construction.

The announcement of the design competition was made in November 1999. 31 teams comprising 103 companies or individual designers from various parts of the world expressed their interest. Later 16 teams were prequalified on the basis of their long span bridge experience and the CVs and capability of the proposed designers in the teams. Prequalified teams were invited in January 2000 to enter stage 1 of the competition.

In February 2000, stage 1 entries were received, 11 teams submitted 2 schemes, the remaining 5 teams submitted 1 scheme, making a total of 27 schemes. 22 of them were cablestayed proposals, 2 were suspension bridges and 3 were of the hybrid type. The schemes were assessed by the Technical Evaluation Committee (of which I was the Chairman) and Aesthetic Evaluation Committee to a 70% technical and 30% aesthetic weighting. The schemes which scored the highest aggregated marks were selected to enter stage 2 of the competition. Five schemes were selected after the final meeting held in April 2000.

The five stage 2 submissions, all suggested cable-stayed type bridge form, were received in July 2000. Apart from a more detailed report, they included a medium size model and a small size model to be fitted into a background model of the surrounding area.



In early September, the winner was selected. It is a cable-stayed bridge with chimney-shaped towers and with a main span of 1018 m. The bridge deck consists of twin box girders interconnected by transverse girders. Consultants had been employed in early 2001 to carry out the detailed design of the bridge. The bridge scheme is scheduled to commence in 2003 and for completion in 2008. Upon completion, it will be the world's longest cable-stayed bridge.

DEEP BAY CROSSING

The dual 3-lane crossing links the Shekon at Shenzhen in the Mainland China with the Deep Bay area in Hong Kong side. The total length is 5 km and in the form of viaduct with span of 75 m, but at the two navigation channels, cable-stayed bridge are to be built. The two cable-stayed bridges all had a main span of 210m with only one side span of 95 m. Detailed design is in hand and the anticipated completion date is 2005/2006.

LlNGDING YANG CROSSING

The rapid economic growth in the Pearl River Delta and the Guangzhou-Shenzhen-Zhuhai Triangle, as well as the ever expanding economic and commercial ties between the Mainland China and Hong Kong call for the need for the construction of a major expressway across the Lingding Yang (Lingding Yang Ocean) and linking up east and west sides of the Pearl River estuary.

The proposed project consists of 23 km of viaduct over water and 4 km approach road. Both the expressway and the bridges will carry 6 traffic lanes. There are four navigation channels, hence, requiring 4 major bridges.

The East Lingding Channel is about 1.5 km to the west of Hong Kong with a designed navigation capacity for 200 OOO-DWT, hence, a suspension bridge with a minimum span of 1400 m is required. The West Lingding Channel has 100000-DWT navigation capacity requiring a bridge of 920 m main span. The other two channels require bridges of span 300 m and 140 m, respectively.

Feasibility design of the crossing and design competition on the forms of bridge structures were completed. However, there is no definite plan for the construction of this crossing.

HONG KONG-MACAO-ZHUHAI CROSSING

The alignment of the crossing is almost parallel to that of the Lingding Yang Crossing but is at much further south. The total length of the crossing on viaduct structure is about 30 km and the carriage width can carry dual 3-lane traffic.

At the west of the Lantau Island in the Hong Kong side, there exists a wide and deep valley in the sea. For bridge option, it requires a main span of 2 000 m. However, a submerged tunnel scheme could be considered as a better choice. Feasibility study of this project would be put in hand very soon.

CONCLUSION

I have been extremely lucky to get involved in these five bridges and the experience gained from the development history of cable-supported bridges in Hong Kong has few points of interest. The Tsing Ma Bridge is the first long span suspension bridge built in typhoon area that requires the deck structure to be aerodynamically stable in winds up to typhoon speed, meaning the one-minute mean wind speed of 95 m/s. As a result, streamlined box deck section with central ventilation openings has been proven to be successful. In addition, the double deck configuration can provide safe access for high speed rail and vehicles under abnormal weather conditions.

The adoption of 'Design and Build' form of contract for the Kap Shui Mun Bridge and Ting Kau Bridge resulted in time saving and financial benefits. It has also demonstrated that 'Design and Build' contract arrangement can give a simple and quick as well as an economical and aesthetically pleasing solution to difficult environment.

The Tsing Lung Bridge, using the twin shallow streamlined boxes deck, represents an innovative step in the development of long span suspension bridges. The shallow and streamlined deslqn.: with span-to-depth ratio in excess of 600, is characteristiced by reduced torsional stiffness, such that, the frequency separation of the vertical and torsional modes is reduced. This effect is counteracted by a better balanced of the aerodynamic focus on the vented twin-box cross section compared to conventional box girder scheme.

The international bridge design competition for the Stonecutters Bridge produces a 1018 m span cable-stayed form of bridge. It will be a breakthrough in the cable-stayed bridge technology. Had the traditional procurement procedure was adopted, the client would have received much less number of bridge options and the scheme would likely be of more conventional design.

Now, the visitors can stand on a single sheltered viewpoint and enjoy the master engineering achievement of the graceful Tsing Ma Bridge, Kap Shui Mun Bridge and Ting Kau Bridge. Few years later, they could compare them with the new neighbour, Tsing Lung Bridge from the same viewpoint. Adding the Stonecutters Bridge, these five bridges will make Hong Kong to become a life museum of modern long span cable-supported bridges and will' surely increase the public appreciation of the skill of engineers and contractors from around the world.

The plan to connect Hong Kong, Shenzhen, Macao and Zhuhai by viaduct will not only physically link up the Pearl River Delta but also will enhance the economic development of the area. To build such huge project over the sea is not easy and can be considered as a big challenge to the bridge engineers.

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Information and Communication Technologies (LCTS) for Development of India into a Great Society

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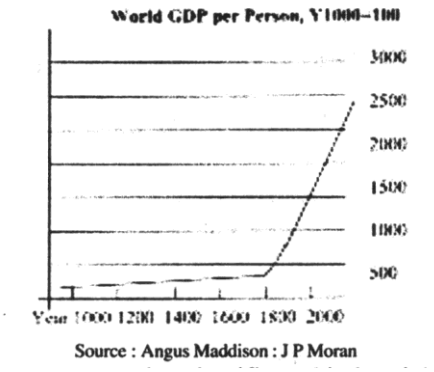
TECHNOLOGY AND PROSPERITY

Extensive use of certain inventions and great national projects had been responsible for the prosperity and power of nations. Some of these nations created knowledge i.e., discoveries through R&D of their great people; some countries use the knowledge produced by others. Creation of knowledge and its use requires that most the nation's citizens are educated, skilled and are inspired by great aspirations and visions. There are about 200 nation States as members ofthe United Nations Organization (UNO). 29 of them in the Organization of Economic Co-operation and Development (OECD) are called developed nations. A few like India are developing nations or newly industrialize (NICs). Many are categorized are least developed countries (LDCs). The United States accounts for 25% of the Gross World Product (GDP). The european Union's (EU) 16 States account for 20%. Together with Japan, these nations account for more than half of the world's gross product (WGP) No country whose people are hugely illiterate (not even Class V) and barely educated (Matriculation) has achieved prosperity and power. No country where Sand T have not been extensively used has become rich and powerful. The following will illustrate the fact of these statements. If the per capita world gross product could be taken as 100 in the year 1000 AD, in the next 800 years it grew to less than about 500 by the year 1800 i.e. it grew about 5 times in 8 years. In the next 200 years, it grew by more than 10 times and it is still rising very fast; in fact, non-linearly. See the graph, (next page)

Graph 1 World GDP per Person, Y1000=100



Source : Angus Maddison : J P Moran

The reason is the great surge in scientific and industrial discoveries and those the application of that knowledge and technologies extensively in every production and economic activity of the people in the countries where the discoveries and inventions came to be made i.e. western Europe followed by North America because of the scientific and industrial revolution and universal education and universities, the West European countries came to establish empires and dominate the world. Of course, the contest for the world's resources also led to horrendous wars but then the requirements of war also stirred R&D like for eg: nuclear bombs, and energy missiles and space-laboratories, spy satellites and automated and robotized production and electronic warfare. Extensive development of health sciences and medicare has reduced infant morality and increased life expectancy and therefore the population of the world also. As can be seen in the (Table 1) despite phenomenal increase in the world population in the last two centuries the proportion of poor has come down remarkably and will further go down stabilizing at about 10% to 12% (as in the USA).

Table 1 World Population and the Poor

Year	Population	% of the Poor
1820	1.1 billion	85%
1980	5 billion	30%
2000	6 billion	20%

The industrial revolution has been extensively exploited in western Europe, North America and Japan. Gradually other countries have also begun to benefit by it. The exceptions are the countries in Africa, some in South America and South Asia. While countries like India are also slowly industrializing, the already industrialized countries have advanced into a higher stage of civilisation which is based upon information and knowledge as the highest resource, more valuable than land, labour and capital, the classical resources for any country's prosperity. The industrial revolution extended man's physical power. For example, the automobile and the airplane and the rocket have increased man's rate of movement by ten, hundred and a thousand-fold. Production and construction processes have vastly benefited by the industrial revolution. Machines have come to replace manual labour and therefore productivity has increased, cost of production has come down and so, goods and machines are becoming commodities i.e. affordable for mass consumption. But the design and production of machines involves mental labour, information and knowledge. For example, robots used in automobile production have increased labour productivity by several orders; simultaneously, the quality has also become invariable and high. The design and deployment of the robots requires knowledge and the use of that knowledge and mind. Production, procurement and distribution of goods and appliances are on a gigantic scale, distributed across the globe. The various parts of Airbus aircraft are produced in seven countries and the final product comes up from one country. This operation requires extensive communication' and control across these countries. That is the exercise of acquiring information and using it effectively. If one is to depend upon Post Office or physical movement of documents, such a thing is not possible. The largest supermarket chain is that of the Wall Mart in the United States. It has nearly 5000 super and mega-stores spread through out the USA. Procurement, stocking, sales, replenishment and accounting of 250,000 different items in each of these outlets cannot be done manually. Today, the whole thing is computerized. Every item sold has got a bar-code. When it is swiped at the point of sale (POS), a microprocessor reads the bar-code, identifies the product, displays the price and the computer system goes on accounting for the number of pieces sold; at the end of the day the system determines what items are to be replenished to restocking levels; information goes to the warehouses and the trucking companies; replenishment I stocks are picked up from different depots by the truckers, advised by computer-print outs, and by the next morning, the stocking levels are restored. All this takes place without any human intervention. Telecommunications (optical fiber and satellite systems) link up the stores, the warehouses, he trucking companies, the purchase and payment offices and banks to the computers for organizing and managing the procurement, sales and payments.

(POST -INDUSTRIAL) INFORMATION SOCIETY

We are advancing from industrial society into an information society. The wealth that is produced due to extensive and intensive use of information and knowledge is growing in contrast to the wealth produced by physical labour. In the agricultural civilisation, about 70% to 80% of the gross domestic product (GDP) was from agriculture and the rest was from industry, whatever it was and services like education, entertainment and distribution. During the industrial stage of the society, contribution from agriculture declined steeply and machine production contributed huge amounts for the GDP. If huge quantities are produced, they require distribution, sales, accounting and so on and such activities are known as the services sector. When the production is automated and robotized, the value added due to production i.e. industry declines. The value added by knowledge increases. Labour engaged both in agriculture and industry declines and that in the services sector increases. The table below gives the composition of the gross domestic product in the developed and in the developing countries and India.

Table 2 Content of GDP

Countries	Agriculture	Industry	Service
Developed	<5%	25	70
Developing	30 to 40	20 to 25	35 to 55
India	23	24	53

Contribution of agriculture in India to the GDP declined from 70% in 1951 to about 23% now and the contribution from services has gone up from about 10% to 12% to more than 52%. Contribution from industry is now about 25%. The tragedy however in India is that the number of people engaged in agriculture and related activities is still 65% of the total labour force. 65% of the labour force contributing 23% to the GDP is indicative of the poor development and utilization of human resources. No wonder that the disparity between the urban and rural incomes is as much as seven times as can be seen from the table below. This on sequence has come about because of the nation neglecting education and the country missing extensive industrializing for absorbing the surplus labour free from agriculture related work. We are having the world's largest number of illiterates at about 380 million. They are also unskilled. Agriculture would not require and can not sustain this much labour force and their families. We do not have an industry which can absorb them. Even if we have an industry, these people do not have the skills and the knowledge to work with and on machines (How lop-sided our attitude for

the growth of skiUs can be shown by one example: Andhra Pradesh has 250 Engineering Colleges with an annual in take of 68,000; it has just 110 polytechnics with an intake of about 10,000. In Industrial Countries the technician to engineer ratio is 1:4; in AP is 1:0.4!). These people will be migrating to the towns and cities where only there is better chance of employment, at least for those who can acquire skills. The result would be massive migration of little educated, hardly skilled people from rural areas into urban areas. None of our towns or cities are having infrastructure even for current population. How will these masses coming to towns and cities live – no housing, no water supply, no electricity, not enough rooms, unaffordable health care, no schools and no work for all; all the open spaces will be encroached upon. The migrants will become voters and will be converted into incendiary masses by populist politicians, seeking power. Social instability, insecurity and strife would be rampant. Crime would become uncontrollable.

ELECTRONIFICATION AND DIGITISATION OF INFORMATION

Information and knowledge committed to paper and tens of thousands of the books cannot be kept in everybody's home but only in libraries. To borrow we have to travel. Besides, there is the problem of those printed in one country being available in other countries only after some time or not at all, because of political and state barriers (we may recall the COCOM regime during the Cold War). While the system of libraries and borrowing books and journals and their distribution by post is certainly better than any previous historic mode of transmission of knowledge, information cannot be within reach of every home, and every person, anytime it is needed from every source because of logistics as well as economics. If it could be de-materialised: ie., electronified and is transported in that form and reconstructed into readable or viewable form, then it is a revolution which enables every home to have access to every source of information and knowledge and if all the stores of information are linked together globally on the telecommunications network, they anyone connected to the telecom network can access" and down-load through appropriate devices, transducer information from all the sources stores. Mankind has already passed through two revolutions. The first one is agriculture and the second is the industrial revolution. The invention of agriculture led to settled communities and the development of culture an stable societies and nations and governments. Animal and manpower were what sustained agriculture. That lasted for over 10,000 years without much change. The industrial revolution beginning with the invention of the steam engine has been with us for the last about 300 years. Machine power replaced man and animal power. The conceptualization, development and fabrication of machines and the industrial production processes are all works of knowledge. New knowledge, new inventions, new production processes have come to mean more and more production of goods with less and less material and energy. (For example the first mobile telephones including the battery weighed 9.8 Kgs; now they weigh less than 100 gms, the US GDP more than doubled in the last 30 years but the energy consumption remained the same; i.e energy consumption for unit GDP halved). World trade between countries has been growing by leaps and bounds, bringing more prosperity to the countries involved. This happy outcome is due to extensive use of information technology and telecommunications for dissemination of knowledge and improvement of labour productivity.

In the last 100 years, slowly fist and very rapidly in the recent years, there has been a revolution in the generation, storage, exchange and transportation of information. The growth of knowledge is captured by the following finding and figures.

Galloping Knowledge:

- By the time the child born today graduates from college, the amount of knowledge will be four times as great
- By the time he is 50, it will be 32 times as great
- And 97% of everything known in the world will have been learnt since that child was born
- The memorising of reams of facts will not be necessary; they will be quickly available on computers.
- But future man will need great wisdom if only to know what is it he wants

TELECOMS AND INFORMATION INFRASTRUCTAURE

Primarily the digital technology consists of electronifying information, as contained in voice, text, images and data. Telegraph electronified what is written on paper, it was converted into electrical signals and transmitted at the speed of light. Then came the telephone which electronified our voice and put people in conversational contact over distances. Radio did away with wires. Voice as well as text and images went over radio waves. When broadcast, they cover the whole globe. Communications satellites from 1965 onwards enabled voice, text and images to be sent from any point on the globe to any other point annihilating distance and time. Telegraphy, telephony radio and TV broadcasting and the transmission of text are all based upon communication technologies, invented over successively diminishing time intervals. This is because of the rapidly with which information and knowledge are getting disseminated by the new communication systems and devices ranging from the simple Morse Key tele-printer, the telephone switches and telephones, vacuume tubes, transistors, integrated circuits (LSI, VLSI, MSI) computers (macro, mini, micro, molecular ..) communications satellites. Optical Fibers, software, packetisation, packet switching, compression, encryption /decryption, repeated use of

radio frequency spectrum, mobile communications, annihilation of difference between mobile and fixed and local long distance and international calls etc, solid state memories storing giga bytes of information. The storage, retrieval, transmission and exchange of information is becoming less and less expensive and so universally affordable in an increasing measure because of technological developments in telecommunications and information technology (solid state memories, computers and networking). How these developments are bringing down costs can be seen from the following:

Table 3 Declining Trans-Atlantic Telephone (TAT) Cable Costs and Cost/minute of Telephony

Year	Cable	Are/cct	Cost/Mnt
1956	TAT # 1	$213,996	$2.443
1988	TAT # 8	$10,285	$0.117
1996	TAT # 13 SDH/SONET	$1,080	$0.012

Table 4 Solid State – Storage/Sq in and Cost of Storage

Year	1989	1997	2001
Density (bytes/inch^2)	63.5 mil.	3 Giga	10 Giga
Storage cost/ Megabyte (bytes/inch^2)	$11.52	$0.10	$0.02

Table 5 How much memory (Megabits of DRAM Storage) a dollar buys

Year	1970	1980	1990	1999	2002
MB	0.0002	0.02	0.13	5.9	24

Table 6 Cost of One MB of DRAM

Year	1997	1999	2002
Cost in $	5.257	0.17	0.04

Table 7 Cost of Transmitting One Trillion (100,000 Crore) Bits from Boston to Los Angels

Year	1970	1999	2002
Cost in	$ 150,000	$ 0.12	$ 0.02

Note: *ultra-wave division multiplexing (UWDM) on optical fibers enables 160 laser beams; each carrying 40-Giga bits; a total of 6400 GBPS per fiber; there could be upto 400 fibers in a cable; an awesome transmission capacity of 2.5 Peta bits per second (see box below)*

Optical Fiber (9th wonder) Transmission:

• First installed for public telecoms 1977
• Buried length (global) 370 mil. Km (600 times the earth-moon distance)
• Current commercial systems: 80 chIs/fiber each of 40 GBPS i.e 3.2 Terabits/sex
• In the labs to factory; 160 chIs/fiber; 40 GBPS/chI or 6.4 TBPS/~ec. (Ultra Deep Wave Division Multiplexing-UWDM)

We now have a global network of high-speed broad-band telecommunications network which should more appropriately be called the electronic, photonic transportation system comprising of terrestrial and satellite microwave radio and terrestrial and submarine Optical Fiber cables (voice, images, text and data) transport and storage. This system connects continents, countries, cities and villages and homes. That within the countries is called the national information infrastructure (NIL). The Nil is extensive and broad-band, high-speed in some countries and less so in others like India. The costs for conversing across the globe as well as storing or transmitting electronified information have been dramatically coming down so much so that these are tending to be nominal. It can be said that carriage will be free but the content will be priced. This is what technologies are facilitating. It is now possible to have all this information / knowledge available to any and every person whether sitting in an office or staying in the home or moving on roads, sailing on the seas or flying in the air, at any time because all the electronified information is kept in solid state memories of computers all of which are coupled to the telecommunications network.

Laboratories and research institutions, factories, companies, homes, super markets etc, are all generating and exchanging information. For money we once had coins; we are having paper money; we are going to have

electronic money. Money can be transferred instantaneously. Every day one and a half trillion dollars worth of foreign exchange alone is being transferred across the world on the telecommunications network through computers, micro-processors. We need not have books and journals. We already have publishers asking us whether we would like the journals and magazines in electronic form or on paper.

It is necessary that people have devices which can be connected to the telecommunication networks so that the dematerialized, electronified information is accessed by persons. Telephones, Mobile phones, PCs, T V sets are the communication devices. These were traditionally connected through cables to the telecom network but electronics and information technology and wireless (radio) are enabling these devices to be connected to the network without any wires. This system has come to be known as wireless in the local loop (WLL). The wireless spectrum is limited. When once it is radiated it goes on and on. The more the power the farther it can go. The farther it goes, the less number of times it can be reused. Reduce the power, increase the sensitivity of the detection devices i.e. the communication terminals. The signal will die within a short distance and therefore the same frequency can be reused after some distance further. All this must happen without any effort on the part of the user. This is what is done in the Mobile Communications Systems. Cellular mobile telephony has become possible only because of the coming together or convergence of Telecommunications and Computers. Every telephone instrument has several micro-processors. These are communicating with the radio base station which serves a certain area support a number of simultaneous communications (voice and lor data). Increase radio base stations and put them on all the inhabited territory and then one can communicate from any place, at any time. We cannot put radio based stations on the sea or in the sky. A geo-stationary communication satellite is like a radio tower which is 36,000 kms. high; at the height the satellite would appear to be stationary and can view/radiate/cover one third the surface area of our planet, earthstations in this area can communicate with one another. Mobile satellites and a few hundred kilometers high like in the Iridium system. In the Iridium system, the hand held instruments for sailors and flyers are communicating thro' one satellite after another, as they traverse the horizon with the satellites which connect them to the terrestrial systems. So one is connected always to the network of computers and information stores, called websites which are like libraries, not of paper but electronic There are about two hundred million of these, growing about 20% p.a. So all the information that is being generated in the world is available in electronic form in these websites. Internet is the system which is a network of all these websites; electronic photanic highways interconnecting these websites all over the world.

TELEPHONE AND INTERNET

The Internet is the 8th and the most magnificent wonder of the world. It is network of networks of computers, to which the computers of individuals, Companies, Governments, Universities, Research Organizations, Newspapers, Publishers, Banks, Businesses .... are connected and their information stored on the websites. This is a convergent platform for telephony, video, text and data. The world wide web (www), the marvelous invention which is just over 10 years old is at the heart of the Internet. As of 2002 there are over 100 million hosts and 750 million users. 6 billion pages of information is stored on this www. Everyday about 2 billion pages are seen by the Internet users. There are over 500 million e-mail addresses and these are growing at 40% an year. 2 billion e-mails per day are being exchanged. Besides mails, company business, trade and commerce, financial transactions and transfers of money, international-citizen interchanges and transactions, auctions, merchandising, campaigning, advocacy, education, return-filing .....etc., every type of transfer of information besides broadcasting and telephony are taking place on the Internet.

The Internet now can be summarized to be : Post Office, Telephone, Broadcast Studio, Soap Box, Auction House, Sound Recording, Movie Theater, used car showroom. Insurance office, Distribution ware house, Studio for fashion designer. University Class Room ...., Political Campaign, Medical Diagnostics; Financial transactions and clearing house Information I knowledge is sitting in electronic form on the solid state memories organized into web sites on the Internet. The transportation network by way of global telecommunications reaching homes by wires and wireless is available, or should be made available, so that every home and person is connected. For that knowledge to be available to every person, he should have access to the network by wire or wireless and he must have devices both for putting information and retrieving the information, Information is an multi-media, voice, images, graphics and text. Either one can have in all this media or only voice or as simple data and text.

Various access devices with different capabilities are becoming available and fortunately and pleasantly at decreasing prices. The Telephone, the TV set with a set top box, the PC, the simple and the mobile broad-band handheld or pocket size telephone instrument, handset with a built in digital camera and what else become made be available we can not predict at this stage. For the development are so rabidly.

ICTS FOR THE CLASSES

ICTs can serve the classes i.e. highly educated and entrepreneurial professionals as well as masses comprising of just graduates (not engineers or programmers) and ordinary people in towns, and even villages. The first category of people i.e. the classes create wealth and our national policy should be to enable them to create

wealth. Since India is having a competitive as well as comparative advantage because of its large number of engineers and software professionals, Government has wisely made such policies which enable them to develop and deliver software products and services for the world markets (over 60 % of which are in North America). The setting up of the software technology parks (STPs) with dedicated broadband satellite telecom links to the USA, European Union and Japan has enabled about a dozen cities of India to be the world's preferred locations, initially for software services and by now IT enabled services and fortunately the demonopolisation of telecommunications and competition is leading to ICT Development centers. The continuous fall in the price for bandwidth both within India and from India to international destinations, has been brought about by privatisation and competition The carriage of information used to cost as much as about 25% of a software company's total expenses. It has come down to about 10% now, thus increasing our competitive advantage. The National Task Force set a target of IT and software exports at US $50 billion by 2008. It appears that the target is possible. The tables give the picture of our great performance:

Table 8 Indian IT Market: 1997-2002

Year	Size (US $Mil)	Share of GDP
1997-98	5,021	1.22
1998-99	6,014	1.45
1999-2000	8,356	1.87
2000-2001	12,410	2.66
2001-2002	13,783	2.87
2002-2003	15,494	3.15

Table 9 Indian IT Software and Services Exports 1997-2003

Year	Size (US $Mil)	Share of GDP
1997-98	1,759	4.9
1998-99	2,600	7.6
1999-2000	3,962	10.6
2000-2001	6,217	13.8
2001-2002	7,647	17
2002-2003	9,875	20.4

Table 10 IT-Enabled Services in India

Year	1999-2000	2001	2002	2,003
Value (US $Mil)	545	930	1475	2,400
ITES as % of Total IT	14	4.5	19.0	20.4
Employees	35,000	65,000	106,500	171,000

Table 11 India's Share in Software Exports in the over all Global Market

2001	2002	2003
1.5%	1.9%	2.82%

Even while there is considerable reduction in the consumption of IT services, in our foreign markets, Indian software exports have been growing at over 25% per year though until three years ago that growth was about 50%. In the last two years, India has also become the destination for outsourcing of much information processing work. This requires skilled and educated persons who are able to work on the pes and speak good English. It is estimated that India can have about $ 50 billion dollars worth of exports of call center and business process outsourcing (BPO) work. This will create huge employment for our non-engineering graduates. Just consider the scenario. By the year 2010, the world's gross product will be $40 trillion. Not less than 60% of it i.e. 24 trillion will be in the services sector. Supposing India provides 10% of the world's services; that amounts to $2.4 trillion. The wage content is between 15% to 50 % i.e. $ 360 million to $ 1200 million. At $5000 per person per year, the number of jobs that could be available to us would be between 72 and 240 million.

Prospect – IT Enabled / Created Services and Employment (India)

GROSS WORLD PRODUCT

In the year 2010	US $ 40 T
Contribution From Services (60%) of GWP	US $ 24 T
India's Share @ 10%	US $ 2.4 T
Emoluments Componen (15% to 50%)	US $360 To US $ 1200 b
Emoluments/employee/Year	US $ 5000

No. of Jobs (360/1200) b = 72 to 240 million
5K

The realization of this possibility requires acquisition of extraordinary talents and high quality of work making us the best in the world. The I T enabled services are such that they need not be rendered from our big cities alone. They could, in fact be rendered from even small towns, provided they have broadband bandwidth and good surface transport facilities preferably airlines connections and first class National Highways passing through them. Broadband optical fiber connectivity of all our 4000 towns is almost accomplished (by the way, it requires Rs30 million per km for National Highway; it requires Rs3oo,OOOOper km of broadband optical fiber transmission system. We are building first class National Highways. We can connect all our small towns with broadband optical fiber transmission system so that work can be taken to skilled people available in the towns and villages instead of they flocking to big cities.

For Indian towns to become the preferred destinations for foreign companies to out-source their work, and since these category of people are highly paid and therefore can afford good life, there should be good schools, good housing, good medical and entertainment facilities. Of course absolutely reliable and steady electrical power is necessary. It is those states whose Governments are ensuring the development of this soft infrastructure that are becoming attractive for the ITES and BPO services. The introduction of computer education as an obligatory component for students in the high schools in the last 4 or 5 years of schooling would ensure that all our educated people will be fitted to work on the ICT infrastructure. Progressive states like Andhra Pradesh, Tamilnadu and Kamataka have introduced this computer education in high schools. This is outsourced to be more cost effective and efficient. In Andhra Pradesh all the university teachers irrespective of what they teach i.e. literature or physics or history are being imparted computer skills and these colleges are provided with Internet connection. They would therefore, be able to access the latest information and knowledge from the millions of websites where new information, papers and articles are being accumulated.

The most difficult problem is the creation of content and that too, in different Indian languages for the use of the bulk of our population who are still engaged in agriculture and related pursuits. Private companies like EID Parry, Coramandal Fertilisers, Nagarjuna Fertilisers and ITC engaged in agri-related businesses are creating tremendous content with regard to inputs into agriculture and the markets for the produce. The states have to consciously foster and encourage their effort and our Agricultural Universities have to come forward to create the content in concert with the private companies. In Andhra Pradesh, call centers have been set up for the benefit of farmers in every district headquarters town. These calls are toll free. Agriculture experts fielded the questions from the people and advised on telephone.

ILLUSTRATIVE USES OF ICTS

Just see how ICTs can revolutionize banking and money transfers. A bank immediately recalls to us the picture of a nice building, very well furnished; restricted hours of business. Come ATMs linked by telecommunications and computers. People need not go to any bank to draw their money. Banking can be during all hours and banks can cut down expenses on buildings hugely. Even the tradition-bound Indian Post Office is having national and international money transfer not through money order but by using the telecommunications and computer network.

Stock-braking and share-trading are undergoing tremendous transformation. Previously people had to go to the stock exchange building and sell and buy in the trading ring. Consider the national stock exchange (NSE). It has got more than 2000 stock brokers, all of them sitting in their offices in different cities and dealing in stocks and shares. Earlier it was necessary to have a stock exchange in every city. It is no longer so. There can be one or two in the entire country but the stock brokers can be everywhere. More than one stock exchange can exist only for competition (like the NASDAQ and the NYSE in the USA) and not for facilitating people in different states to trade in stocks and shares.

The extent of information and communication technologies used in the war is also mind-boggling. For example, in the last decade, the nature of war has dramatically changed. Earlier, vast armies were fighting on the ground and bombers and fighters were flown by pilots. Both saw much destruction but in the last decade as a result of Reagan's launch of a program, "star wars", information and communication technologies have changed the nature of war. In the Gulf War-l , 1991, 8% of bombs and missiles rained on Iraq were laser guided. In the bombing of Serbia in 1999, this proportion was 38%. In the Gulf War-II March 2003, 90% of the bombs were

ICT - involving. Every US Tank was fitted with 4 million dollars worth of ICT equipment; each one could see the entire battle field and relay the scene at 50 MB per second to a satellite hovering above, to the command and control centers. The battle field commander has a view of every movement, engagement and can direct action in real time. Every tank in the field is in communication with every other tank. The whole onslaught could be seen and guided from the command and control center. Soldiers were least involved in combat. Machines are moved and aimed by ICTs. This is electronic warfare involving communication satellites and computers of awesome power. Geographical information (GIS) and geographical positioning system (GPS) are part of this equipment in the war. Of course, every one of these technologies is also used for non-war related i.e. peaceful, economic development and construction in the country as for example, micro-area planning at the village level.

One of the greatest uses of ICT for involving the public to influence Government is what is the practice of the Chief Minister of Andhra Pradesh, his Collectors and Superintendents of Police. They, field questions on the Radio and TV, according to a laid down timetable. For example, every Monday for one hour, from 6 pm to 7 pm, the Chief Minister of Andhra Pradesh is on the Radio and TV. The subject to be discussed is advertised and background material on the subject is published in the newspapers. For about 10 to 15 minutes, the Chief Minister introduces the subject and questions come on toll free telephone numbers. He will answer the questions. Those which could not be answered during this hour are answered by FAX and e-mail. This practice is driven down to district level officers. It is not that all these are perfected and totally satisfying to the public. But the lesson is clear that ICTs can be used for general public welfare. Public opinion can also be ascertained. We see that leading newspapers are posing a question everyday and inviting answers on the Internet. This is the daily public opinion poll. Presently, it is limited English-educated and Internet-accessing people. Surely, it could be officially patronised and extended down to the village when we have the village public-information centers i.e. Public Internet kioks. It should not be impossible for the Government to bear the expense of replies toll free i.e. charge free from the public Internet kiosks. This will be the edemocracy and empowerment of people for influencing Government policies and work.

The use of ICTs in every human activity enhances efficiency, reduces time spent, increases productivity and enables the users to extract I collect information, arrange it in any fashion, and access it almost instantaneously to enable decisions to be taken. There is no activity where it cannot be utilized. In the United States, the investment in ICTs overtook the investment in every other sector, (industry, agriculture, transport etc.,) by the first few years of the 1990s. The result has been, in the later half of the last decade productivity increased year on year by over 2.5% thus increasing the nation's competitiveness. Indeed one unwelcome effect has been jobless growth of economy i.e. more production of goods and services at less and less cost and with fewer and fewer worlders. That could be a frightening prospect for countries who have huge under-utilized and under-skilled labour force like India. Society will have to find an answer to tackle this jobless growth. It would involve stabilization of population, universal education and the acquisition of highest skills and proficiency, extensive use of K'Ts and therefore, competitiveness in a globalising economy. In the US, workers who lost jobs were retrained to acquire new skills and 95% of them were absorbed in better paid jobs in the services sector. Every nation will have to identify sectors wherein it has got comparative and competitive advantages. For India, it is in the services sector which totally depends upon information and knowledge Iand the ability to use, and process information and manipulate it. The world trade organization (WTO) has come into being in recognition of the fact of growing wealth creation in the services sector, far exceeding every other sector and therefore, the need to trade in services. The abundant production of goods dictated the trade in goods on a world-wide scale and the emergence of organisations facilitating trade in goods. Similarly, the growth in services sector dictates the need for global trade in services and its facilitation by multilateral agreements as fashioned by the WTO. It is in recognition of these facts that the Prime Minister constituted the national task force on information technology and software (NTF of IT and SW) in 1998. From its recommendations, emerged the vision and policies for complete liberalization of telecommunications, a broadband nationwide ubiquitous telecommunications network to serve as infrastructure for the storage, exchange and transportation of electronified information Gust like the national highways, railways, seaways and airways infrastructure for transportation of mass that is, goods).

State and Union Governments are involved in extensive implementation of electronic governance and use of ICTs in other sectors of economy and social development. Some of the important programs are:

• E-governance: State Wide Area Networks (SWANs) based upon optical fiber systems (example Andhra Pradesh and Gujarat) are implemented through private companies in partnership with Government. Apart from data and voice, these are used for video conferencing, between and among district collectors. Government secretariat and ministers, for management and Government work.

• Applications cover registration of documents and motor vehicles; issuance and renewal of driving licenses; procurement of goods and services (e-tendering)land records; treasury management; sales tax and commercial taxes, accounting and budgeting.

• Government to citizen (G2C) Services: A lot of welfare is administered by Governments. All the services rendered by Government to citizens are now being progressively delivered on ICF networks. What is branded as e-Seva in the capital city of Hyderabad and other 117 Municipalities of Andhra Pradesh (including Saukaryam in Visakhapatnam) is the best example of making the life of citizens less painful in the transactions with Government. Over 40 services including rail and passenger bus transport reservations and filing of applications for trade licenses and construction permits payment of electricity, water and property bills and taxes; birth and death certificates are some of the e-Sevas.

• Tele-medicine: Hospitals and primary health centers whether they be in the private or Government sector, are being connected over the information infrastructure and expert consultation from specialists in cities is being delivered in primary health centers (PHCs) and dispensaries in rural areas. Best example of this is of the Apollo Hospitals (matter to be lifted).

Bill Clinton and Aragodu Village

• School children in Aragodu screened- 34 had a hole in the heart.

• Dr Seshagiri Rao: "Your daughter has a hole in the heart. Send her to us during the vacation. We will fix this and when the school reopens she can join back".

• Bill Clinton (to Dr Pratap C Reddy): "Has tele-rnedicine advanced to this stage in the US?"

• Dr Reddy: "It has not"

• Bill Clinton: "It is a really wonderful thing that Apollo is doing. The rest of the world should follow your way, so that people in remote places can get the benefit of tele-medicine",

• E-education: One example is again from Andhra Pradesh. The number of engineering colleges was increased from 37 in 1996 to

250 by 2002. Some of these are opened in small towns. All the colleges are being linked through satellite, lectures are broadcast to them, initially from Hyderabad and later from other places with audio interaction. This is alleviating the dearth of lecturers and professors and good instruction. When all the phases are completed, a lecturer from one of the selected sites for excellence can be seen and heard and interrogated from any classroom in the state with all others also viewing the interrogation. In other words, all the 250 colleges in the State constitute one class room.

The geographical information and geographical positioning systems (GIS and GPS) are enabling the planning of our cities and the location of our underground treasures; informing the position of our fields and indicating to us how to move from one place to our destination; the several layers of the GIS are profoundly aiding human endeavour in peace and war and so is the GPS.

Aircraft flying at 1,000 mtrs are able to capture the elevations of objects on the ground to an accuracy of 10 ems. The laser beam is emitted at 2 kilo hertz, improved to over 30 kilo HZ and now, over 50 kilo HZ, the time when the reflected signals were received, the speed of the air-craft and its position (determined by the GPS) generate the GIS map of the areas flown over. No planimeter meter survey shows as much accuracy and definition as the this particular method.

Managing a Hyper-market Wall Mart is a chain of 4,750 super and hyper-markets spread all over the US and a few other countries. It has the largest company in the USA with sales of about US $ 240 billion; it employs 1.4 million sales persons and at least 82% of the American homes have made one purchase in an year from Wall Mart; it sells 250, 000 separate items. What it spends upon wages of its employees is about the lowest in the world, at 8% of sales. Whatever is sold at the Wall Mart 15% to 20% cheaper than anywhere else in the world. It obtains its wares from . several countries especially China and South East Asian at about the lowest prices in the world by ordering them in the highest quantities. It carries the least inventory; is able to replenish it without ever having to say to a customer, "sold out" or "come tomorrow". All this has become possible by intensive and extensive use of information technology and telecommunications. It all starts when an item which is bar-coded is swiped across the code-reader at the cash-counter what the buyers only sees is the price of the items but the computerised system goes on counting each the material that is sold and by the evening, the total number of tems sold is compared with the prescribed inventory levels; the replenishments are worked out; an order goes to the concerned ware-house and to a trucking company; the replenishments quantities are picked up in the night by the truckers and delivered at all the outlets by 0800 Hrs in the morning and are put in the counters by the time the market opens and all this is done without any intervention of man or woman. Of course, accounting, invoicing, payments etc., also happen. All the nearly 5000 outlets are linked by V-SATs to the company headquarters and a world wide computer network serving the company for e-procurement, payment, distribution and management.

The Japanese auto companies link up about 3000 of their parts' suppliers in the same fashion as Wall Mart and they have no more than 6 hours of inventory; the parts suppliers get orders on the computer network, without human intervention and the deliveries are made in the most economic and fastest rate.

Intensive use of the Rail Track in India: Between Church-Gate and Borivali and upto Dahisar the Western Railway has been able to run more and more sub-urban trains without expanding the tracks beyond 8 upto Mahim. It has introduced automated IT and telecommunications-intensive signaling so that the block length of track in which not more than one train can at any time be there, has been continuously reduced so that there are more trains on the track between two stations.

There are dozens of Island countries and Trust territories in the Pacific Ocean. No one singly justifies a university; some of them don't even justify colleges. How to deliver education to these Island populations? The answer is: a University of the Pacific head-quartered in Australia. All these countries are linked by communication satellite and lectures are delivered from a few resource centers. The class rooms are spread over all the Islands. Instruction is audio and video-interactive, online (by the way this is the model for the government of Andhra Pradesh to link up all its engineering, medical and other professional colleges).

The State of Utah in US has a sprawling area (210 Sq Km) with as sparse population (2.2 million) children were getting very much inconvenienced by having to be bussed to schools which were in some cases about 60 kms away from homes. The people voted on a proposition; should children to be bussed to schools or should education be bussed to homes. The latter was approved and this was accomplished over a broad -band Optical Fiber Telecommunications network, linking up the few resource class rooms and all the homes where there were children. This is a case of electronic classrooms. It is a feather in the cap of an Indian company, Satayam Computer Services which implemented this entire project scheduling which subjects should be taught, from where, at what time, in which of the homes switching the available bandwidth from telecommunications companies; all according to a computerized program.

Improving the load factor of a power system: State-wide management information system (MIS) based on telecommunications and IT, in the State of Andhra Pradesh enabled the load factor of generating stations to be improved from about 65% to over 84%. This improvement obviated the need to invest about Rs3000 crore for augmentation of power generation.

ICTs FOR THE MASSES

The Digital Divide: This is a phrase which is now being used by sociologists and politicians, especially the populist variety. Internet has immense potential to benefit any person provided he is educated and has affordable access to it. Those who are educated preferably with proficiency in English and have a telephone connection better still, a broad-band data connection (which can transport information from 8 to 8000 times faster than by an ordinary telephone conenction) and a PC or 3rd generation mobile telephone with a built in digital camera (that enables pictures to be taken and instantaneously transmitted over the, Internet to any desired person). These are the haves of digitized information knowledge from across the world. Since knowledge is power and is a great source they can become wealthy, healthy, powerful and dominant, not only within the confines of a state but world-wide because of the globalization of economies and trade under the regime of the World Trade Organization (WTO). For them the whole world is the market, the whole world is the resource, the whole world is the area of exerting influence and ingestion of knowledge. There are those who are not literate, not educated, not skilled to use any device or do not have the money to acquire any of these capabilities. The former category are the haves of the digitized knowledge. The second category are the have-nots of the digitized knowledge. The former will prosper rapidly and become richer and richer. The latter may improve only by the (questionable) trickle-down effect. The disparity between the digital- haves and the digitally connected on the one hand and those unconnected digital-have-nets on the other is what is referred to as the digital divide. As such a division is deeply de-stablishing and distressing, the policy-makers including engineers and the knowledge producers are exercised about this digital divide.

There are various types of divides not all of which are of equal concern and consequence. The divide between educated and uneducated; the urban and the rural; the wealthy and the poor; those who have electricity and those who do not have; those who have access to and can afford health care and those do not have either of these; those who have radio and TV and those do not have; those who have a telephone and those who do not have. Each one of these divides has a penalty and deprivation for the have-nots, In fact the "leftists" go on asking whether any information technology or the PCs are worth the investment of the nation, when there are so many people deprived of or lacking education, drinking water, housing, health care, bank loans, TV sets, etc. It is not for engineers alone to answer these questions and spend their time on removing all these divides, before or along with the digital divide. However, as common citizens we can agree that access to the digital network, to the Internet which is a repository of tremendous amount of enabling information and knowledge about every thing

from a job opportunity to a market for handicrafts, and for admission to different schools etc. as well as for obtaining services from Government from their immediate neighbourhood is a matter of consideration.

PUBLIC POLICIES TO DIMINISH THE DIGITAL DIVIDE

Years ago, first the engineers and the then policy makers were all concerned about the "missing link", a term that was used like "digital divide" now to make distinction between those who have telephone arid those who do not have it. In fact, the international telecommunications union (ITU) considered this issue at a plenary meeting; appointed a high powered International Commission which came be known as the Maitland Commission under the authority of United Nations. The report produced by it was titled as, "The Missing Link". Several studies were undertaken in different countries in the world to establish the relationship between . having adequate number of telephones per hundred of population or a telephone for common use by a community throughout the national territory of a country and its economic growth; the ease with which commerce and trade could be conducted etc. They were able to find a relationship between the tele-density i.e. number of telephones per hundred of people and the rate of growth of the economy; the penalties that people and communities and nations were suffering because of inadequate telecommunications for governance, for justice, for peoples participation in governance, for the conduct of commerce and trade etc. The ITU/ UN recommended that all Governments must make adequate investments in telecommunications so that they cover all the population centers including the remote and rural villages and communities. It was known then that there were people below poverty line, that many communities do not have protected drinking water, that health care was not there, that they even do not have roads. But yet, that the existence of a telephone in the community would vastly improve their life for economic exchanges and for getting services they needed was established. If there is a telephone in a village for the community use, what were the savings that were accruing because of avoided travel by bus or other means of transport; or wasted trips to get their agricultural inputs or sell their outputs or to get their entitlements and so on were established. If the existence of a mere telephone can mean so many benefits, how much more should be the benefits if people have access to all the information and knowledge that is available everywhere and anywhere in the world provided that is in the language that they can understand.

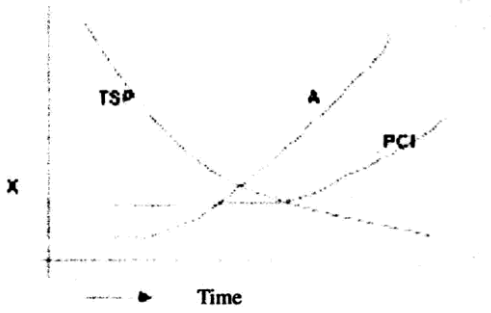
The missing link problem with regard to telephone is tackled in India in an admirable way. We decided that in a gradual manner, the telecommunication networks should be extended throughout the country and that a telephone should be placed for community use in every village. The larger villages are to get the public telephone first and then those with lesser population. Also, in order to reduce the distance for gaining access to a public telephone the criterion was not population but that no person in a habitation should have to walk for more than so many minutes before he could get at a telephone. It is on the basis of this criteria that public telephones (PTs) are being installed in our villages. Today about 450,000 villages out of 650,000 have a telephone. Nearly 90% of the rural population is now covered. The 200,000 untelephoned villages are mostly each with a population of about 100 and they are in difficult areas like the Rajasthan desert area, forest areas of Madhya Pradesh or hilly areas in the northeast and a few other places. Now that radio technology especially, low cost very small aperture terminals (VSATs) to work through communications satellites are becoming available, even these very low population centers will get a public telephone within the next one or two years. The existence of the telephone network is the basic requirement for digital connectivity i.e. to the Internet.

Even in urban areas there are millions of people who can't afford a telephone. Therefore public telephones are placed in huge numbers in the urban areas also. There are now about 1.2 million public telephones in the country 40% of them are in the villages. It is not the teledensity (that is, the number of telephones per 100 people) at 6.5 including the mobiles that is a true indication of access to the telephone whether every village has got a publicly usable telephone and in the cities and towns whether it is available in every street or not is a better indication of the equity in regard to the availability of such a facility for the public. In this regard we are doing extremely well.

The important problems tackled for providing the public telephone was where should these telephones be kept and how illiterate people who do not have any skill can use this telephone. This is a question which is equally relevant to the digital connectivity and the use of Internet because we still have lots of illiterate people, unskilled people and people who do not have the knowledge of English, even if otherwise they are educated. In regard to telephone, this was solved by putting the telephone in a common place, usually the village grocer or a tailor or teacher or a Government official any other person whose services are needed by and available for everybody, irrespective of caste. Such a person is sufficiently skilled or easily trained to dial or key the telephone number for illiterate and unskilled users, obtain connectivity and make over the handset for the caller to speak. It is this attendant and his skill and service that are getting over the problem of iJliteracy and non-skill among users. The Information Technology Task Force constituted by the Prime Minister in 1998, considered the problem of making the Internet accessible just like the telephone to every habitation. The answer was simple. Just upgrade the village Public Telephones (PIs) into Public Tele Information Centers (PTICs) by equipping them with Internet connecting devices like the PC and now, it could be the Simputer. Given sufficient training to the attendant of the upgraded public telephone, he can obtain the information which the seeker wants from the

Internet. Even if it is English, an English-knowing attendant would interpret to the illiterate or non-English knowing seeker of information. If the PIIC is equipped with a telephone - now it is the IPNOIP telephone - and also with a scanner and if the connection is broad-band enough, then electronic mails can be sent in any language and even video conference can take place. We wiJI just leap-frog from an unconnected disadvantaged village into a globally connected (for voice, image, text and data) facility. We have the technical means and system in this fashion to bridge the digital divide. The next question is: is it affordable? With 30%-40% of our people below the poverty line, obviously it is unthinkable that many could subscribe to a telephone, much less to the Internet. Due to our developmental plans, the per capita income will rise. Due to developments in technology, the cost of the telecommunications Network and Internet and communications will go down. Due to the combined effects of the rise in PCI and fall in the telecom prices, the affordability wiJI non-linearly rise. As could be seen in the graph:

Graph 2 A α PCI / Tele-Service Price



Note : PCI : Per Capita Income; TSP : Telephone Service Price; A : Affordability

What we have therefore to do is create conditions for telecommunications and Internet to be available throughout the territory of India in all the population centers and along the roads streets and lanes along which homes and offices are situated. Our aim should be to increase the affordability and therefore to create a system for the full force of competition to come to the market so that the use of ever newer technologies will reduce costs and therefore, the prices to the user. Just as more and more people are having first black and white TV sets, then colour TV sets and then cable TV, more and more number of homes will have a telephone and PC with Internet connection. In the meanwhile, those who cannot afford will use the community PTIC.

In the last eight years, we have been de-monopolizing the telecommunications. Private sector companies are being allowed to provide the full variety of telecom and information services including the Internet. There is competi :ion. There is domestic and foreign private investment into the sector. Unlike until 2-3 years ago, today one can have telephone on demand especially the mobile one. Unfortunately, we have made the service costlier than what it could be by imposing entrance fees, revenue share, cost-unrelated interconnection charges and high spectrum costs. None of these have got any relationship with the network or service costs. They are simply meant to generate revenues for the Government. The Information Technology Task Force viewed access to information and knowledge as promotive of human development and just as health services and medical bills are not taxed, the recommendation of the task force not to put any unrelated costs on Internet, were accepted. That is why for the provision of internet service (ISP) there is no entrance fee, no license fee, no revenue sharing. If all the telecom licenses are migrated from the present system where they have to incur extraneous costs to one like the ISP, then straight away, telephone would become cheaper by 40% and I reckon that the demand would be doubled. China has recognized the wisdom of not imposing external burdens on telecommunications and Internet service; This is the main reason why the affordability is growing up phenomenally. China is now adding about 50 million mobile and over 20 million fixed telephones a year compared to our figures of 12 million and 8 million respectively. It has over 50 million Internet user compared to less than 4 million in India. As one of the essential measures to reduce the digital divide. Government should do away with the entry fee, revenue share and the money gouging interconnection charges dictated by the high market power welding incumbent, namely, the Bharat Sanchar.

Rural areas are by conventional wisdom held to be unattractive for any telephone of Internet service provider company. The capital cost involved is high and the revenues are poor. When such is the situation it would be wise for Government to require any company or organisation wanting to provide a public telephone or an Internet kiosk in the rural areas to need a license. Any enterprise should be free to provide these just by registering with the TRAIIDOT, mentioning its area of operation and some details as to what services it would provide. The only condition should be that the technology that it uses for connecting the telephone or the Internet device to the network is compatible with the telephone or Internet system available in the area. It should

be left to it and the network operator to which he connects for the system of sharing of revenues and quality of service.

For the index of territorial coverage what is mentioned for our radio and

Door Darshan coverage is relevant for telephony as well as Internet. Now that wireless in the local loop i.e connecting a communications device like telephone to the network need not be by wire and cables but even more economically by radio, we should establish a large number throughout the territory of India, of radio base-stations to which the customer premises equipment, be they telephones or PCs or other communication devices are wirelessly connected. The radio-base stations form part of the information infrastructure (telephone exchanges or Internet). Then we can say that the Internet or the telephone is accessible on say 80% or 90% of the territory of India for say, 95% of the people. Whosoever whenever can afford a communication device, be it telephone or PC or equivalent can get connected to the information network-telephone or the Internet.

Certain progressive State Governments are wanting to give Education and health information through Primary Health Centers and Government schools. They are to have receive-only VSATs. Curiously and regrettably, the Telecom Regulatory Authority of India (TRAI) recommended that even these receive-only VSATs should be licensed and that there should be an entry fee and revenue share. This is totally anti-people. The recommendation can come from only a taxation consultant and not from a facilitative organisation. Receive-only matter is education and health, for human development and welfare. Why should they be taxed? In many countries especially in the 15-nation strong European Union, receive-only VSATs require only registration and not a license, much less any license fees. Government should reject the TRAI recommendation and also tell them it is not a taxation recommendation organisation.

If the Internet should serve the poorest of the poor people, for wanting to talk to their relatives elsewhere in the country, then Internet telephony is the cheapest voice communication. Government should therefore allow IP telephony not only from any Internet booth to telephones outside the country, but to any telephone within the country also. Current restrictions are to protect the interests of the incumbent and not the promotion of inexpensive telephony for the masses.

Governments are putting in extraordinary efforts to promote literacy (ability to read and write of 5th standard) and education (SSLC standard). If we are to do away with the dependence of an attendant for telephony or Internet use from the public telephones and public Internet kiosks, we must include acquisition of computer skills i.e. the ability to use a PC or an equivalent device to connect to the Internet, as part of education in all our schools for standards 8, 9 and 10. Governments ofKamataka, Tamilnadu, Andhra Pradesh and Kerala now (I am not aware of other State Governments) are introducing computer education by outsourcing the equipment and instruction to computer companies. In the State of Andhra Pradesh, for a 3 year course, it is coming to over Rs. 2,000/- per year per student. We do not spend that much on the whole on the rest of the education. We must rethink as to how most affordably Governments can impart adequate enough computer skills among all the literate.

We must provide a telephone and Internet connection and in all high schools (about 100,000 in India; about 12,000 in Andhra Pradesh alone) and other educational institutions. In the United States, by special efforts and an e-rate Cess on telephone companies during the Clinton administration, not every school but every classroom in all the high schools in the United States, a telephone and Internet connection has been provided. This may be unrealizable by us for quite some time, but it should be our aim, say at least in the next 15 years.

If the educational standards and employment and business opportunities in the rural and remote areas are not adequate, then the digital milieu will accentuate the divide. We believe that millions of I.T. enabled service jobs would be available to India. Should our educated young flock to towns and cities which only are having excellent telecom facilities, to get jobs? It is not necessary, if we extend the reliable, secure broadband, high speed electronic photonic (telecommunication) infrastructure to all our small towns and rural areas. Then the I T enabled services can be rendered from those places. Jobs for the educated and the disadvantaged in their areas of residence have a great value. They go to reduce the ill-effects of the digital divide. So we must have a specific plan to extend the network and to encourage IT ES companies to locate in small towns.

Telecommunications and information technology and Internet are essential for economic and human development. States are competing to attract business, industries and to create world class professionals. Connectivity is essential. Therefore telecoms can no longer be left to the exclusive jurisdiction of the Union. They should like education and roads be in the concurrent jurisdiction for within the state networks. Actually, all Telcos but the Bharat Sanchar have state-wide licences only. The Convergence Bill before Parliament must provide for devolution of regulation to the States.

UNIVERSAL ACCESS (TELEPHONE AND INTERNET)

The most important question is how do we fund the extension of the telecommunications and Internet system to the un-remunerative rural areas. As the revenues realizable will not meet the costs there should be subsidies. How do we raise the fund for subsidy and how do we administer and how do we carry out the obligation of providing universal access? People sometimes loosely talk of universal service. Universal service is internationally understood to mean a telephone (and Internet nowadays) connection in almost every home including those in the rural and remote areas with no discrimination in the quality and range of services as between the rural and remote area on one hand and urban areas on the other.

Universal Service generally means a telephone in every home. In advanced countries it has also come to include mean not only Internet connection but broadband Internet connection. We just cannot afford such a scheme with 40% of our people below poverty line.

Universal Access (UA) means that any citizen anywhere in the country must be able to make use of a telephone which is for the community and not of a private subscriber. We have been implementing this through what we have been calling the Village Public Telephone (VPT). Through a series of steps, we have graduated to the current position, namely, about a million public telephones with about 420,000 of them in the villages. Now that Internet has also come to be viewed as an essential enabler, our public telephones must be upgraded into Public Tele Information Centers (PTICs) by fitting each of them with a PC and giving them broadband Internet connection. Access to the PTICs which include the telephone also, for the public throughout the national territory of India must be defined as "Universal Access".

Because we have competition between interconnected Public Switched Telephone Networks (PSTNs) from Bharat Sanchar and numerous basic and cellular private telephone companies, a PTIC can be connected to the nearest network point, be it the telephone exchange or the radio base station of the cellular system. Access should be defined to include the equipment at the PTIC location and connection to the nearest network point, i.e. the telephone exchange of the basic telephone operators or the radio base station of the mobile company.

The connection or the "last mile" can be wired or terrestrial radio or satellite radio. The wires could be either copper or optical fiber. The equipment at the PTICs could be a telephone with a chip inside to give access to the Internet or a PC or a Simputer or a TV with a set-top box etc. The provision of universal access in the rural and remote areas and perhaps in some poor quarters of urban areas, is a social obligation of the Government. This will have to be subsidized. Raising the subsidy amount should be by imposing a universal access cess on the gross revenues of the telephone service companies, basic, limited mobile and mobile. This fund should not go into the Consolidated Fund of India but kept as a separate amount to be administered either by the Telecom Regulatory Authority of India or the proposed Communications Commission of India (CCI) or the Ministry of Information Technology and Communications.

Since rural and remote areas are held to be un-remunerative and since the general wisdom is that no telephone company would like to involve itself in loss operations, Government must declare that anybody can provide the universal access in any place(s) he chooses to the specifications of the MIT. It is ridiculous to require a company to take a license to provide a loss involving service. It would be sufficient for the universal access provider to register himself; the requirements of the registration should the fulfillment of the specifications for provision of universal access.

The revenue from PTICs will belong to the company to whose network the universal access facility is connected. In most cases, it will be the Bharat Sanchar because Bharat Sanchar has got 30,000 exchanges and in most cases the nearest exchange could be that of Bharat Sanchar and not of its P-TeIco rivals. Also, as the distance between the as yet un-telephoned villages and the nearest telephone exchange will be least for Bharat Sanchar, the capital required and ease of maintenance for providing the universal access will be least if the PTIC is connected to the Bharat Sanchar's network. But this choice could be left to the universal access provider.

The administrator for the provision of universal access may list out the villages, district-wise which are as yet un-telephoned and invite bids for the provision of universal access, defined in the previous paras, for a period of, say 10 years to the specifications (technical, operational and maintenance and interconnection) prescribed by the MIT. That company which asks for the least annuity for the ten-year period may be given the license to provide the universal access, in the specified area.

It is possible that a bidder may get several districts or even a State. It should not matter for us. The amount of annuity payable to the universal access provider is all that matters. It may be Bharat Sanchar in some States or Districts or its rival P-Telcos or absolutely a new enterprise. It should not matter for Government.

The amount required for the total subsidy i.e. annuity payments for blocks of three years might be worked out to assess how much money is, required to sustain the universal access. The universal access levy on the telephone companies may be varied in the light of these requirements.

The system described here is what is followed in its broad outlines in Chile and Peru. This is also like what we are doing for the National High Way Project. The National High Way Authority is inviting bids for stretches of the high ways for construction, maintenance and operation for a specified period and is awarding the contracts to the company which is bidding for the least annuity. The amount required for this purpose is being collected by levy on diesel and petrol. It is also supplemented by some loans. May be part of the vehicle tax will be utilized to service those roads. But in the case of telecommunications we may not require any loan. We may so fix the universal access levy to generate the required amount.

What are the services that PTICs provide can be periodically reviewed. It may be just telephone in some Districts for some period; it may include Internet connection; it may include even a Vide') Conferencing.

The PTICs can also be utilized to deliver electronic services - for example, the e-Sevas (40 of them of the Government ofAndhra Pradesh to citizens from e-Seva Kendra's). The PTICs can become agents for the e-Seva of the Government. They may levy user charges. In that case maybe, we have to review the amount of annuity to be payable.

The PTICs to be operated either by the universal access provider or they may be entrusted to physically disabled persons or to any unemployed person. Whether that agent or the service delivery shall be part of the universal access provider can be judiciously determined. There may not be a uniform solution. In fact the decision may be left to the network operator to whose exchange the PTIC will be connected because the billing will be done by that network operator. He would have to realize the money from the PTIC operator.

The system advocated is totally competition-neutral; technology-neutral; time-neutral and ensures the most economic way of discharging the public service obligation of the Government.

A GREAT SOCIETY

We are living in exciting and challenging times. Radio and Television, satellite and optical communication fiber systems are bringing news and views and all the world's daily happenings in real time into our drawing and bed rooms all the while. The amount of new knowledge that is produced is prodigious and happily all that can be accessed by the educated and equipped. The rate at which change is taking place is expressed in a new phrase, Internet time. meaning it is fantabulously rapid. During one's own life time startling changes are witnessed as for example the tonga and the bicycle and the "Phat phat" are fast giving way to the car; the post-card and the letter came to be replaced by telex; which got replaced by the fax; which is retired by the e-mail. People no longer need to go to the cinemas. The gramophone gave way to the tape –recorder which gave way to the audio and then video cassette and vide cassette has given way to the DVD.

It requires an agile mind and short memories order to cope up with such a rapidity of change. In India, we are having the changeless as well as the rapidly changing lifestyles and life's-tools coexisting. We have the most educated and enlightened and the least lettered and the the superstitution -bound; we have the discoverers and the no-sayers; there are most affluent and the most poverty-stricken and we are not few but a thousand million adding 15 million every year. We are globalising and the challenges of open and globally linked economy are stunning. Our educated and aspiring and globe-trotting are taking us into the post -industrial information age and the illiterate (360 million of them with their vote) are incited to demand to be equal and power-wielding; these are a challenge to the former, The challenge to the nation, in the information knowledge age, is how does this country with the second largest population and the most ancient history not only adjust itself to the new realities, with the global - linkages but once again recapture its 17th century status as the wealthiest and the most trading nation (See tables) and the greatest power and Jagat guru (teacher to the world).

Table 12 India's Share in the World

Year	Wealth	Trade
1701	22.6%	25%
1947	NA	2.4%
1990	NA	0.4%
2003	1.5%	0.8%

Table 13 Share of World's Industrial Production

	India	Britain
1830	17.5	9.6
1900	1.7	18.6

Table 14 Time taken to Double the Per capita Income

Country	Years	Since
UK	58	1780
USA	47	1840
Japan	33	1880
Indonesia	17	1965
S. Korea	13	1970
China	10	1978

Finally, How do we realize the great society that ICf can help us to build and experience? Not mere literacy, not simple education but excellence in learning and scholarship and analytical and creative talents are to be acquired by every person. It is only the fitted who will survive and thrive. Skills to use the leT devices must form part of our education.

We must undertake the following great and national projects to realize the vision of a great and strong India.

• National and State Highways

• Linking our Rivers

• National Power Grid

• National Information Infrastructure (Optical fiber. Terrestrial and Satellite Microwave radio, Undersea-cables)

• Education: 100% literacy and SSLC

• 50% of people in Age group 18-23 years in Universities

• Private Universities

• Population Stabilisation

• Morality, Ethics, Dharma, Heritage, History. Self-respect, selfconfidence, Patriotism, Individual endeavour, enterprise and integrity

be instilled as part of education

• Primary Health and Health Insurance (Apollo ...)

• Massive Housing, New townships (Migration of rural people)

• NCC in all colleges; ACCI Boy Scouts in all High Schools

The undertaking and completion of these projects can be greatly speeded up, properly managed and economically accomplished by ICTs. ICTs are not consumption material like water but enabling tools. In the information and knowledge society where most of the physical work will be consigned to automated machines and rabots and where food will be produced in abundance with the least labour due to deployment of science and technology; it is mind-power that has to be developed. The great society can be built in about 50 years. It will be characterized by the absence of devastating diseases and freeing and ennobling education and cultural pursuits. However, there will be some poor people just as 12% to 13% of the population of USA, the most affluent country in the world, are below poverty line. Those poor are a result of non-human causes and a structural part of any society. We as engineers are to have a vision and develop the skills and abilities and leadership and communication that will mobilize the nation to use the resources of our planet in the least wasteful way so that life as we know can be prolonged and our human species can still continue to thrive in the highest form of life. Our Upanishadic teaching is:

"Aham Brahmasmi" I am Brahman (the divine) and all of us can become superman as envisioned by sage Aurobindo, by acquisition of knowledge and that acquisition is facilitated by ICTs. Supermen, less and less demoniac and more and more divine, could lead divine life; more blissful than baneful.

The Seventeenth Dr Ajudhia Nath Khosla Memorial Lecture was delivered during the Nineteenth Indian Engineering Congress, Mumbai, December 16-19, 2004

The Seventeenth Dr Ajudhia Nath Khosla Memorial Lecture

An Infrastructure Development Model to Make Travel, Food and Shelter Virtually Free to All!

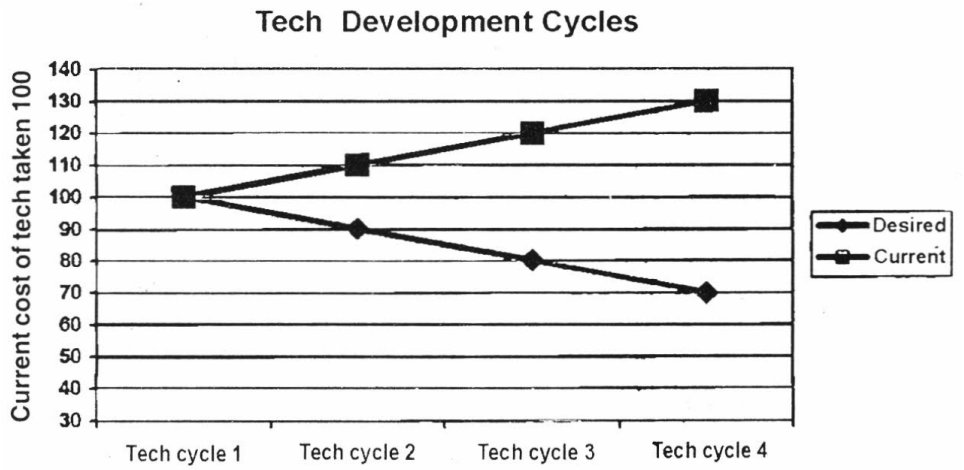
Shri B Rajaram

Managing Director
Konkan Railway Corporation Limited

It is the cosmic reality that human is part and parcel of the universe and neither owns exclusively the resources nor creates any, on his own. A trustee at best. but localised in time and space frame, causes distortions in access rights causing unequal distribution of wealth. Infrastructure development is the instrument through which the humans address the improvement of quality of life, and knowledge in action is the technology. which forms the driving engine to deliver the infrastructure. Intellect is the precious gift to humans, which used properly, can yield deve loprneru model, which progressively improves quality of life while reducing the costs of services, thus becoming a wealth generator-wrong approaches currently prevailing, lead to financially unviable models, effectively eroding value and wealth of one community to enrich another exploitative community, which in long term is unsustainable and makes all poorer. Through application of knowledge embedded devices and re-engineering known technologies, it is demonstrated how we can change the pace of infrastructure development to create a win-win strategy of self sustaining and wealth generating infrustructure, ultimately leading to a situation of virtually free travel, food and dwellings' A real life case of development of the Sky Bus Metro technology in our country is shown to be capable of making the urban transport virtually free with vastly improved quality of service' Such paradigm shift in infrastructure-development is unbelievable, but true!

INTRODUCTION

The most precious gift given to us, humans, is intellect, The way we make use of the same with proper attitude makes all the difference to the prevailing quality of life in terms of food, shelter, transport and communicaitons. Intellect has no barriers, nor limits - it is an eternally renewable resoure. From generation to generation, since the human species have learnt to pass on the results in the form of knowledge of their experiences from grandfather to grandchild, the cycle of intellect improvement is endless and continuously progresses on an upward curve. However, greed and desire to prevail over others is a constant ingredient amongst humans. The distortion in the societal development and again, amongst societies is visible in terms of disparities in living styles and access to and use of resources and the spectrum covers extremely poor people to extremely rich people with means of controlling the very processes of distribution and allocation of the resources. Exploitative mechanisms always rear their heads and history has shown cycles of transformation in our societies. Countries moving from peaks of achievements to downs, and those down and exploited, fight back and strive to reach the peaks.



INTELLECT AND INFRASTRUCTURE

The intellect is the running common thread in all these activities and infrastructure is the medium through which we draw benefits of resources delivering benefits to the society.

The backbone is infrastructure for humans to provide for their basic needs in an efficient manner conserving energy resources efforts and resources. The development in science and knowledge is put into action. which manifests as technology, which in turn controls the basic infrastructure of a community. A society's core strength, hence arises from the basic capability to generate newer concepts and newer technologies. which progressively meet the most important critical requirement of reducing input efforts, while increasing quantitatively and qualitatively the output in terms service or product. Alternatively to deliver the same level of service. the costs should progressively reduce.

INNOVATION

If the society is unable to innovate to find such technologies, which, progressively reduce costs and add value, then what happens is. We end up losing the basic wealth and burn our future for our current comforts. Obviously we cannot sustain such development model for long, the planet has a way of correcting the imbalance sooner than later.

In the matter of tele-voice communication. we are already seeing a revolution taking place within last five years! The prices have been steadily falling and those who adopt the competitive edge technologies are able to survive the crashing unit prices, and scales of massive utilization make the difference. The more expensive legacy wired systems charging phenomenal amounts have given away to virtually free conversation across continents!

The revolution is on. The digital revolution has similar impacts on other areas of traditional human endeavours provided we open up our minds and adopt as well as adapt.

KNOWLEDGE EMBEDDED DEVICES

It is time to now consider designing systems based on knowledge embedded devices, widely distributed and networked to handle multiple tasks, which otherwise normally handled by groups humans. The advantages are obvious.

• Productivity levels soar-beyond our expectations of old legacy development models.

• Quality levels get re-defined

• A paradigm shift in the way we think and work is caused

• All the rule based working is built in and fault tolerance and recovery processes built into the network.

Production systems, agricultural activities. road constructions, shelters. transport systems linking the material transportation covering movement or raw materials to production centres, finished items to consumers. city house keeping functions - all community services can be progressively managed by the knowledge embedded devices inter-connected to mutually consult, analyse and take actions based on consensus.

With no additional productivity-linked heightened expectations to be fulfilled as time progresses, in such economy driven by the knowledge embedded devices, the initial capital cost gets recovered in the initial years at current economic prices. and from then on the services will progressively cost less and less, in comparative economic terms. as proportion of the earning capacity or the community.

Ports : Can we make port operations cost less and less – bringing down the costs to virtually drop by more than 80%?

Can we make agricultural produce reach markets/consumers at progressively lowered costs?

The cost of production of energy: Can we make to fall continuously over a period')

General mass scale dwellings: Can we make them with falling unit eosts with application of known technologies')

APPROACH

The stress will be to make use of as much as possible known' proven technologies. re-engineer and adopt cross-disciplinc developments. breaking compartmental thinking .. thinking afresh the basic requirements and produce non-conventional but actually workable combination of technologies. This mode of thinking can produce tremendous boost to value-engineer cost-effective solutions, adding continuously to the wealth of the community,

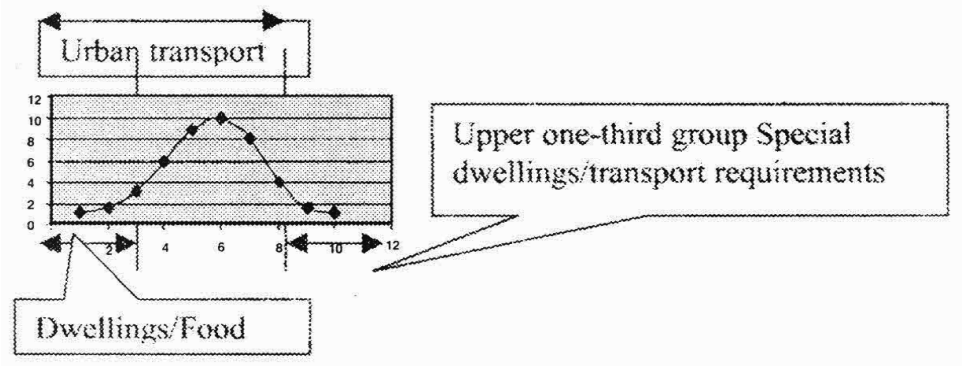
CARDINAL PRINCIPLE

It is time for engineers and technologists to impose upon themselves the cardinal requirement that their actions should pass the test that in creation and operation of assets forming the infrastructure for societal sustenance, should be such as to truly add value and wealth to the community, and not an instrument to transfer wealth out of the community,

POSTULATION - DIFFERENCES REMAIN

One should not confuse that by the above approach we are creating a society of "no-needs. hence no motivation to excel'. The postulation here is that. whatever we do the bell-curve of distribution of wealth and driving people to reach the better zone of the curve remains. To amplify. the above steps only addresses the populations at the lower one-third of the zone of the bell curve distribution. but the drive to go to the upper one-third of the distribution continues.

It is the upper one-third group in the society who create the bench mark levels to be attained by others and motivation levels remain to shift from lower lewis. The bell curve distribution remain •• and the shift as a whole lakes place in time. By addressing the transport requirements, we can see today take care of two-third of the urban population's requirement.



A PRACTICAL APPLICATION

We will now deal with a few areas of our infrastructure to demonstrate the above, mentioned concepts

Sky Bus Metro a paradigm shift in urban transportation

The model shows how over 5 to 7 years an urban habitat can virtually have free transportation within their community.

Transport requirements of new economy emerging in the new millennium - improve quality of life while reducing costs:

- History shows when technologies are outdated they actually become economically un-affordable, typical financial disasters
- A society which forces their future progeny to pay for today's comfort is not sustainable
- Today transport solutions based on last century's technologies like elevated/underground rail based systems are violating this cardinal principle - we should not rob wealth of our grand children!
- Human life and quality improvement at reducing costs should be perceived as the focus of the new millennium
- Infrastructure therefore has to cost less but deliver more to be a value generator: technology innovation alone can help
- Sky Bus Metro technology is the break-through in transport technology from our country to cause such paradigm shift to make transport costs to fall while quality of life improves for all including handling cargo - providing a holistic transport solution.

THE CHALLENGE

- Urban space remains frozen
- Populations are shifting to urban habitats
- Mass transit capacity
  - occupying less and less urban space,
  - while being pollution-free
  - affordable by common users
  - with point to point connectivity
  - be integrated. avoiding inter-modal transfers
  - safer than existing systems-value human life
  - better quality of travel
    - Air-conditioned
    - Noise-free
    - Virtually no-wait service

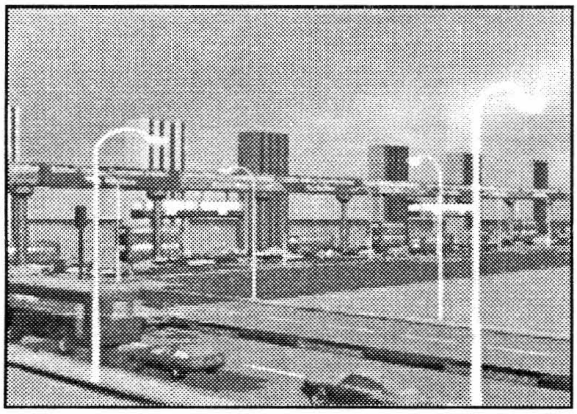
Sky bus technology as offered by Konkan Railway meets the above requirements. alld helps us re-define the thinking and planning for urban transport.

Description

Heavy 52/60 kg/m rails placed at standard gauge floating in elastic medium and damped by inertia of measured mass held in a 8 m × 2 m box enclosure. supported over a l m dia columns spaced at 15 m and located at 15 m distance from each other. in the divider space in between lanes on a road-way. at a height of 8 m above road surface. provides the support and guidance for powered bogies which can run at 100 kmph, with the coach shells suspended below carry passengers in air conditioned comfort, can follow existing road routes, while existing traffic on roads continue.

The fixed structure at 8 m height above road level is aesthetically pleasing and there is no concern of claustrophobic feeling for road users.

Aesthetic and eco-friendly, the Sky Bus can never derail. capsize nor collide by design as well as by construction, hence is safer than existing rail-based system. At Rs 500 m/km or US$ 12 m/km in India, the system is noise-free and pollution-free with 18000 pphpd. scalable to 72000 pphpd as required. With no signalling and having no points and crossings. it is a unique mass-transit system, which can be put up within two years in any crowded and congested city. In addition to moving people Sky Bus system can carry standard 20' containers. boosting its capacity utilization to double that of other existing systems.



LEGAL PROVISIONS

Sky Bus metro falls under tramway category, under Art 366(20) of Constitution of India. since it operates along existing roadways and within municipal limits, hence excluded from Railway Act. However all technologies are railway based and substantially provisions (If Railway Act apply with additional provisions required to operate safely in conjunction with road users, who are sharing the transport zone along with the Sky Buses over-head. So a special Sky Bus Metro Act has been drafted to cover the legal requirements.

THE COMPONENTS OF SKY BUS

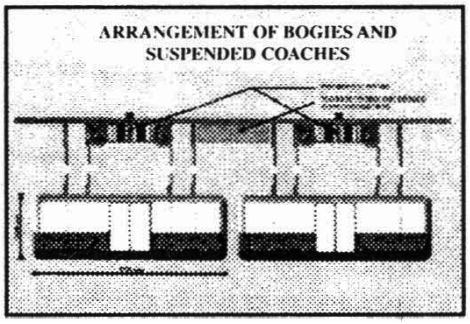
- Sky way
- Sky bogies
- Sky coaches
- Sky stations
- Traverser arrangements at terminals

Sky Way

- In the middle of road way pile foundations support 1 m dia column approximately 8 m high, and space at 15 m all along the roadway.
- The sky way consists of a concrete box structure carried over a series of piers at a height of 8 m above existing road level.
- Two rails fixed with appropriate fastenings within the concrete box support and guide the sky bogie.
- There are no oints and crossings.

Sky Bogie

- Standard two axle bogies used in metros for speeds of 100 kmph are used (but can have higher speeds, if required up to 160 kmph) of standard gauge.
- Linear induction motor technology is incorporated-with 4th rail driving which is above the bogie/or 3Ph AC motors with regenerative power capability.
- Third rail is used for current collection
- Braking-bogie mounted
- Regenerative
- Disc brakes
- Emergency mechanical brakes



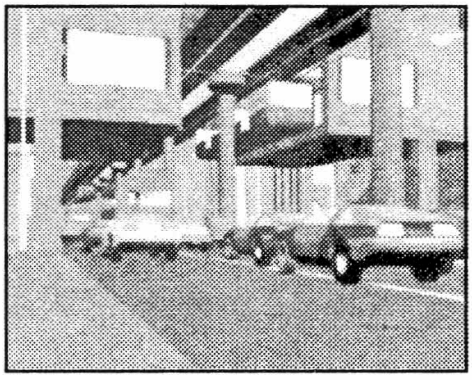
Design Loads

Max axle load 12 tonnes

- Weight of bogie-2 axle motor 5 t
- Tare weight of coach : 6.5 t
- Weight of equipment : 2 t
- Passenger load : 9 t
- Total for a bogie : 24 t
- Axle load : 12 t

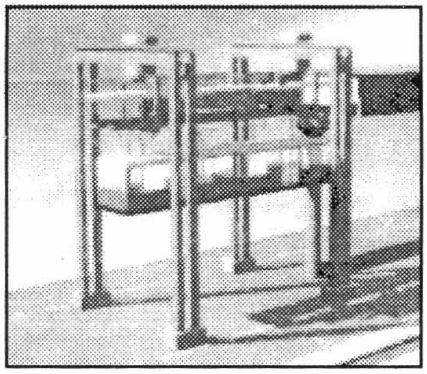
Sky Coaches

- Double walled light shells with wide large windows are suspended from the sky bogies.
- Controlled banking on curves - 100 m radius curves can he handled.
- Air conditioned and with automatic doors
- Audio visual information to passengers
- Special 4m wide sliding doors for quick entry and exit of passengers
- Each pair carries 300 persons and service every one minute or 30 seconds is possible.



Sky Station Description

- Unlike conventional" mass transit systems. Sky Bus needs smaller stations
- Service is every 30 or I min that is virtually no waiting time for passengers.
- Totally automated without drivers ~r guards and access control is also electronic by prepaid cards being swiped in.
- Stations act as only access facility, and not as passenger holding area.



Traverser:

There are no points and crossings. The traverser is the system which automatically shifts the sky bus units for balancing the loads / changing routes too as well as shift units to depot lines etc.

Proven technologies simple solution by engineering the constitute Sky Bus.

SKY BUS : PERFORMANCE, COSTS AND BENEFITS

- Passengers per hour in peak period 40,000 to 80,000 on a route
- Service every minute
- Rs. 500 m per route krn of double line capital cost for 40000 passengers/hour capacity during peak
- Two years construction period after financial closure.
- Capital can be recovered in 5 to 7 years.
- Full private funding possible, being financially viable.

Financials of a typical 10km route module of a Sky Bus Metro Network in a city.

1 Route length Double line 10 Km
2 Cost /route km Rs 500 m
3 Cost of the project Rs 5000 m
4 Realisation 30% of designed capacity 350,000 journeys
5 Ridership 300,000 journeys local commuters
6 Floating 50,000 day-travellers visiting/ non-monthly
7 Only Fare Box collections considered. No other income is assumed.
8 Incomes not considered: Advertisement, real estate leasing , city house keeping, container service
9 Monthly card holders travel at average 50ps par km
9.1 Sell monthly travel cards TWO for total km 1000 (peak 500+500 non-peak)
9.2 Both the cards can be used at any time travel, but charging rate depends on time
9.3 The TWIN cards issued to a family at total price of Rs 500
10 Floating occassional travellers
10.1 Min journey charges Rs 15
10.2 Day card of 50 km Rs 100
11 Est. revenues
11.1 Monthly cards 150,000 Rs 900 m
11.2 Daily journey trips 50000 Rs 262.5 m
Total Rs 1162.5 m
12 For standard 10 km route
Expenses on operation and maintenance(O&M)
1.Fees to KRCL for management 50 m
2.Engineers+staff 150 to 200 20 m
3. Energy costs major component 150 m
Repairs costs increased with age
O&M expenses increased with annual 1% increase
in volume of traffic for energy.

13 Assumptions to work out IRR
No inflation in unit rates for fares considered.
Volume increase in traffic by annual 1%.

14 Project IRR (20yrs) 18%

15 Tax & depreciation:
Depreciation at 5% 25 cr
Then net taxable income after interest and depriciation will be taxed at 30%

It is assumed that we should be able to maintain debt without redemption at 15% /annum comfortably over the 20 years.

Equity	30%	Debt	70%
Equity	1500	m	3500 m

16 Return on Equity : 24%

•Grid network covers existing roads-point to point service

Free Travel for Life to those Who Own Flats/Assets in the City After 7 Years

Once the capital is recovered over 5 to 7 years, the residents/ occupants. will be entitled for free life-time free travel, for one time payment of Rs 15 000.

For a 10 km route approximately. 2 lac users. when they pay, funds collected amount to Rs 3000 m. This is used as equity to expand raising debt of twice the amount, which means Rs lab worth additional network. providing annual 15% returns. Floating populations continue to be charged, which will be sufficient to pay for the operating expenses. The result is the urban travel becomes virutally free for life at a mere one time payment of 1% of value of his flat!

NETWORK OF SKY BUS METRO IN A CITY

- Any metro can be sufficiently served by a grid network of 100 km route length.
  - Two routes of 20 km length 40 km
  - Four routes across of 10 km 40 km
  - Four routes feeders of 5 km 20 km
- About 200 km^2 area can be served!
- The system can move 100000 to 200000 passengers/h III either direction with flexible transport transfer capacity
- At average lead of 7 km, the system can handle more than 6 m commuters every day assuming utilisation of 50% of capacity!
- The investment is of the order of Rs 500 b for this system and can be up and ready within 3 years! Provides integrated solution, handles cargo too!
- For such service, the current elevated/underground metro systems while being comparatively less safe, cost Rs 1200 b to Rs 2500 b, and also will take not less than 7 to 8 years to construct. Still requires inter-modal transfer costs to be incurred additionally. Pollution of trucks continues.

TIME SCALE OF DEVELOPMENTS

- The innovative concept paper was presented by Shri B Rajararn at a World Congress on railways at Bolgna University, in the year 1989 titled as 'Sky Wheels'.
- After due engineering, the Sky Bus Metro technology was presented by Shri B Rajararn as MD Konkan Railway, to the Government of India in the year 2000-2001.
- Dr A P J Abdul Kalarn, scientists like Dr Anil Kakodar as well as a working 'Commissioner of Railway Safety affirm technically the system to be feasible and safer than existing systems (year 200 I).
- Independent consultants like ICRA/PwC confirm IRR of 14% to 15% (year 2001-2002).
- Private industries expressed confidence by investing their own funds to put up Rs 7 cr worth Sky Bus prototypes – a miracle by itself (Year 2003) !
- Then Ministry of Railways authorised Konkan Railway to spend Rs 50 cr to put up 1.6 km test track at Margao-getting ready within the cost to be operated in August 2004.

WORLD POTENTIAL

- Market exists all over the world for the financially viable urban transport
- Even as on date expression of interest cases add up to Rs 500 b, simply based on the concept itself!
- Our country stands to gain from this market as more than 95% is indigenously manufactured.

IMPLICATIONS FOR INDIA

- Polluted cities causing wasteful fossil fuel consumption being congested lowering average speeds of vehicles, will become wonderful healthy places to attract more investments.
- Investment of Rs 500 b over next 5 years covering 1000 km of Sky Bus metro in to cities can save wasted fossil fuel worth Rs 50 b / annum and improve quality of life for all at affordable price.
- This funding could be fully outside Government resources - private funding possible being financially viable!

Industries Benefit

- Cement : 550000 MT Steel 2800000 MT
- Construction: Rs 150 b Manufactue : Rs 50 b
- Employment: 20000 permanent and 20()000 temporary/annum
- Financial Services : Rs 15 b Software/devices : Rs 20b
- Consultancy/design supervisor services Rs 30 b

With international market the above figures will be doubled, in 5 years!

The investment of Rs 500 b in India adds annually a surplus cash flow of Rs 100 b recurring only from the fare box collections!

SKYCON, SKY JET AND SKYRAIL TECHNOLOGIES

Sky Bus Metro technologies lead to other transport applications.

- Skycon is the application in Ports - the container handling and the Port operations get quantum jump in productivity almost five fold - causes a paradigm shift in designing and operati ng Ports.
- Skyjet is another application linking major metros bringing the metropolitan cities at 1000 krn within travel times of 7 h! Delivers containers too with the same speed! Hence high speed travel becomes financially viable in our country at affordable prices.
- Skyrail is an application for mountainous areas allowing almost vertical lifts and radius of tuming less than 20 m, with capability to deliver any defence equipment, free from climatic conditions.
- The scope of all these applications has not been factored in.

SALIENT FEATURES OF TEST TRACK FOR SKY BUS METROMADGAON

The world's first test track for Sky Bus Metro is being constructed at Madgaon in the open area along the Rai Iway Track near Madgaon railway station. The test track geometry and the structure has been designed to demonstrate the dynamic behaviour of the Sky Bus Metro. i.e, the oscillations of the coaches, rail wheel interaction etc and proving the cutting edge technologies proposed in Sky Bus Metro and Integration of various sub-systems of Sky Bus Metro.

The Test Track is proposed to be a part of furre Centre of Excellence for testing and certifying various sub-systems of Sky Bus Metro. Keeping this in view the test track is provided with dual gauge to conduct trials with borth Broad Gauge and Standard Gauge bogies. To facilitate this concrete block design with twin rail seat is developed. By shifting one rail from one rail seat to the other the system will change from Standard Gauge to Broad Gauge and vice versa.

Two types of elevated track structure are being tried. namely, Closed Box structure and Open Rib structure. These types enable understanding structure and vehicle interaction temperature variations in the guide way portion. noise reduction etc.

The following are the salient features of the test track

(i) Length of test track	1.6 krn
(ii) Maximum test speed	100 krnph
(iii) Steepest gradient	I in 50 (2%)
(iv) Radius of sharpest curve	100 m
(v) Radius of flattest curve	875 m
(vi) Maximum radius of vertical curve:	3375 m
(vii) Power supply	750 V dc 1500 V de through Third Rail
(viii) Gauge of the track	Standard gauge 1435 mrn and Broad gauge - 1676 rnm

ix) Elevated track structure is with two designs :

a) Closed Box Structure
b) Open Rib Structure

SKY BUS METRO - NEW MILLENNIUM'S TRANSPORT SOLUTION : AFFORDABLE BY ALL COMMON CITIZENS ON THE PLANET - A GIFT FROM INDIA TO THE WORLD

- Sky Bus is the first non- invasive rapid mass transit system giving benefits of rail and flexibility of follow roads.
- Unlike existing ones, Sky Bus technology carries cargo for city and eliminates trucks too!
- Urban transport is made financially viable and affordable by the common man today to be within his living means.
- The utilization of infrastructure created for urban transport of commuters, is doubled because the Sky Bus technology allows cargo also to be handled, providing house keeping functions also to the city - which existing metro technologies cannot render.
- The perennial financial burden that the current urban transport solutions are, will now become history, with the advent of Sky Bus Metro technology. The public administrations will grain and the common citizen is benefited.
- Skycon will revolutionise the Port working all over the world and the Skyjet systems will redefine the working lifestyles of people and cargo delivery time cycles will be influenced not only for industry but also for agriculture.

- The automated systems progressively bring down the costs of transport in the goods and services availability.
- Extensive use of knowledge embedded systems in a network configuration in the technology. lays the foundation for a future of falling costs, as is already happening in the telecommunication sector. The quality of service improves many fold.

INTELLECT, INSPIRATION AND INFRASTRUCTURE

The driving engine for cost reductions in the various servics can be provided by developing infrastructure as demonstrated above utilizing the technologies in an innovative manner. The intellect is the most precious assent given humans, to manage the cosmic resources in a sustained manner to create win-win strategy of application of knowledge to develop technologies to add value and not erode wealth with wrong technologies.

We should be inspired to liberate our mindsets to fully realize our potential to develop such technologies to create infrastructure which synergises with forces of nature for the benefit of entire human species by making transport, food and shelter virtually free.

This is incrementally visible to us when for improved quality of sevice, we are able to reduce the unit cost of service, while developing infrastructure. If we constantly strive to implement this principle, we shall move gradually to a world where

- Agricultural activities are managed by Knowledge-Embedded- Devices (KED)
- Transported automatically by KED driving the process
- Shelters mass manufacture through KED controlled processes! transported and mass erected through substantially KED enabled processes.

It is the responsibility of those upper one-third group of human society to ensure that through the application of their intellect and technology, ensure that the lower one-third group in the society shall have the access to the basic infrastructure at affordable prices. For gradually improving quality of lire at progressively reducing costs, measured in terms of their earning capacity. Every human at the lowest step of the ladder shall also become a supervisor in role of a system driven by KEDs !

FUTURE

It is well within the realm of reality for the human society to build a knowledge based society, where the basic infrastructure facilities like fine quality food, shelter, travel and communications will cost very negligible portion of value of their contribution to the society. Then the society will move to the next level of knowledge enrichment, freed from currently manifest day to day struggle with natural resources for survival.

The Eighteenth Dr Ajudhia Nath Khosla Memorial Lecture was delivered during the Twentieth Indian Engineering Congress, Kolkata, December 15-18, 2005

Micro, Nano, Tera

Lt Gen (Dr) V J Sundaram, *PVSM, AVSM, VSM* (Reid.)

Advisor (Micro and Nanosystcms) - National Design and Research Forum, The Institution of Engineers (India)

Micro. nano & tera are set to exploit the frontiers of technology for the benefit of mankind. (Fig. 1). Micro devices work in the micron regime while nano goes down to the domain of I to 100 nanometers where quantum effects and self-assembly are principal characteristics. The Tera" regime which lies ill between optics and microwaves will be presented in the later part. Designers now have to consider mechanical. Electrical electronic, optic, acoustic and biological elements to arrive at an optimum overall system.

Micro devices in the form of computer / electronic chips are already well integrated in our lives. Mechanical engineers are now making inroads with micro electro-mechanical systems (MEMS) and focus is on integrating electronics and mechanics in the micro and nano domain - the sensors in modern automobiles are excellent examples (Fig.2). Micro air vehicles (MAVs) which can sit on our palms are feasible (Fig.3) and can be used for surveillance in traffic control. Disaster management and security (Fig. 4).

Nano devices will be the result of convergence of science (at the atomic and molecular level) and micro technology resulting in better performance and new functions (Fig.5). The interlinking of nano, bio, info and cogno sciences will alter the perception of engineering applications for society (Fig-6).

NANOMATERIALS

Nanomaterials based fabrics will be used for

- Protection
- Health Care
- Energy Storage

Nanomaterials will also be used in artificial muscles and communication systems. The surface area available is very high and so they will be used in extremely sensitive sensors (chemical & bio) but unfortunately in more powerful munitions as well.

Biomimetic materials combine material science, chemistry and biology at the nano scale. Bioactive ceramics react with body fluids to form apatite which mimicks natural bone that body tissues accept and bond instead of rejection. We also get biocompatible polymers which resemble phospholipids (cellular membranes).

Nitinol, a shape memory alloy, is used to make stents with layer by layer deposition to get a smooth thin film on a surface followed by a nano-porous coating to reduce likelihood of triggering inflammation.

SENSORS

Sensors for imaging~ pressure, tactile forces, inertial navigation . acoustics and radiation as well as actuators will use a combination of micro, nano and nanobiotcchnologies. Typical examples are quantum well infrared photodetectors (QWIP) (Fig.Z), light sensitive proteins, like bacteriorhodopsin (Fig.B) as well as MEMS accelerometers (Fig.9) and gyros (Fig.10).

Optic flow rrucrosensors make use of Biomimetic ideas based on the visual systems of flies and honeybees coupled with processing using microchips (Fig.11). The ocelli and halteres of insects will provide more inspiration for simpler, smaller devices.

Adaptive optics using Nanoscale piezoelectric transducers in deformable mirrors coupled to a wavefront computer will enhance images for retinal studies as well as identification.

Biosensors that integrate biology and engineering (Fig.12) can be used in rnicroarrays for DNA, Lab on chip and explosive sniffers. Carbon nanotubes (CNT) with appropriate coatings as well as quantum dots (5nm) can be used as chemical sensors for a variety of explosives and toxic chemicals. They could also be used for early detection of diseases like cancer followed by more selective destruction of the malignant cells.

All this leads to the need for more research on the brain machine interface which will be invaluable in projects like the bionic eye and bionic ear (cochlear implant) being researched by'the Defence.

ENERGY AND POWER

On the energy and power front the power capacity of Lithium ion batteries is enhanced considerably by using Nano Li-Ti02 particles. Fuel cells based 0:-' hydrogen or methanol are business drivers for not only portable electronics and computers but also for electric vehicles (Fig.l3).

QUANTUM COMPUTERS

Quantum mechanics inherent at the nanoscale will be utilized in quantum computers which will lead to better prediction of diseases and pattern recognition (based on biometrics) Quantum cryptography is expected to give unbreakable security.

MEMORIES

Dynamic RAMs are likely to be replaced by much denser magnetic RAMs and millipede drives (using 10nm indentations) followed by holographic 3D data storage in layers with light sensitive cubes.

TERAHERTZ

Terahertz lies in between optics and microwaves and the wavelengths are in the micron range (Fig.14). The main advantage is that it is non-ionizing and hence safe for applications involving tissues, be it imaging or spectroscopy One application is in a bionic eye (Fig.15). It can be used for identifying DNA and other bioscience applications. Imaging for security has been demonstrated to detect anthrax "powder", counterfeit notes and weapons hidden under clothes (Fig.16). The main problem has been hardware. It is felt that with the advances in technology now available, appropriate robust hardware would be developed. The Terahertz tree is given in Figure-17.

TECHNOLOGY DEVELOPMENT IN INDIA

Microtechnoiogy

Microelectronic technology at 0.8 micron is well established in India. The need now is for 0.35/0.18 micron. Microtechnolgy for Mechanical devices has derived impetus from the National Program of Smart Materials (2001-06) a joint initiative of DRDO, DOS, DIT, CSIR and DST for the development of MEMS and Smart Materials in India (Fig.18). The program has established for MEMS, design centers at I1Scand I1Tsand basic fabrication infrastructure at SCL and BEL.Prototype sensors for pressure, acceleration have been fabricated. A second phase is proposed for development of devices to production level.

Nanotechnology

In the nano domain Prof. CNR Rao has indicated in a recent statement that 8 institutions have been identified for Nanoscience and 6 for Nanotechnology with an expenditure of about Rs. 50 cores so far. India would soon be having a major "Nanotechnology Initiative" involving institutions like.ll'Sc, IITs, Jawaharlal Nehru Centre for Advanced Studies, NPL, NCL and some industries.

Nanobiotechnoiogy

CCMB and CDFD (Hyderabad), NCBS (Bangalore), CFTRI (Mysore) and IMTEC (Chandigarh), who are the leaders in biology as well as NPL and NCL are major institutions with whom engineers should associate for joint development of bioengineering systems. Biosensor Society (India), registered at CFTRJ (Mysore) could be a focal point for some of these interactions.

Terahertz

A start has been made in the ECE department of I1Scand it is hoped that other institutions would join the efforts in this area.

TIME ESTIMATES

2010	Cancer Diagnosis and Therapy Longer life Batteries Higher Density computer Memory
2015	Advances in computer programming
2020	New Materials
2025	Nanomaterials which will increase efficiency of collection, storage and transmission of Energy
2050	Robots performing manual Labor

CONCLUDING REMARKS

Micro and Nanosystems are essential for Sensors

Microtechnology	Extensive use already
Nanoscience	Good understanding exists
Nanotechnology	In phases 5 - 15 Years
Nanobiotechnology	Adapt for use in Sensors
Terahertz	Holds great promise
Engineers and Biologists	Understand and Learn to Interface
	Plan
	Utilize

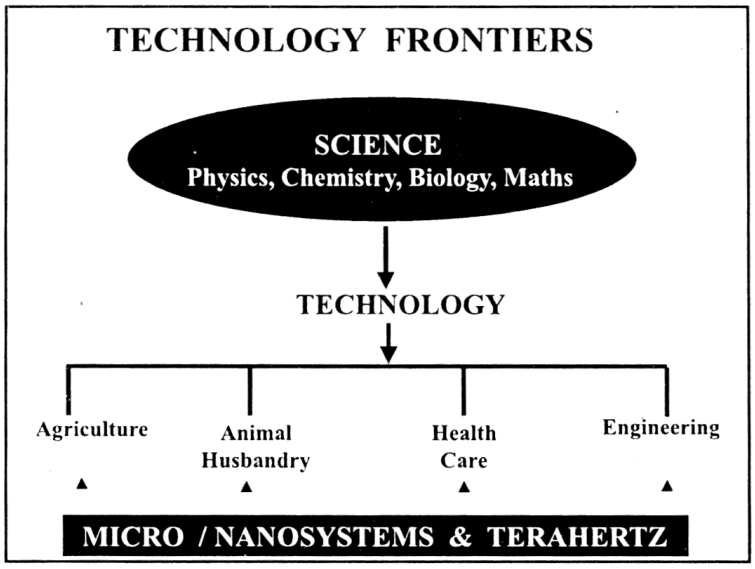


Fig. - 1 Technology Frontiers

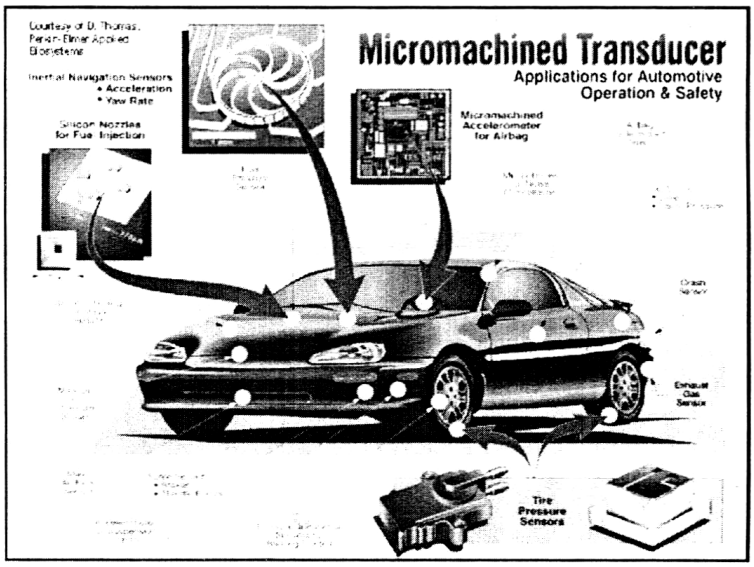


Fig. - 2 MEMS in Automobile

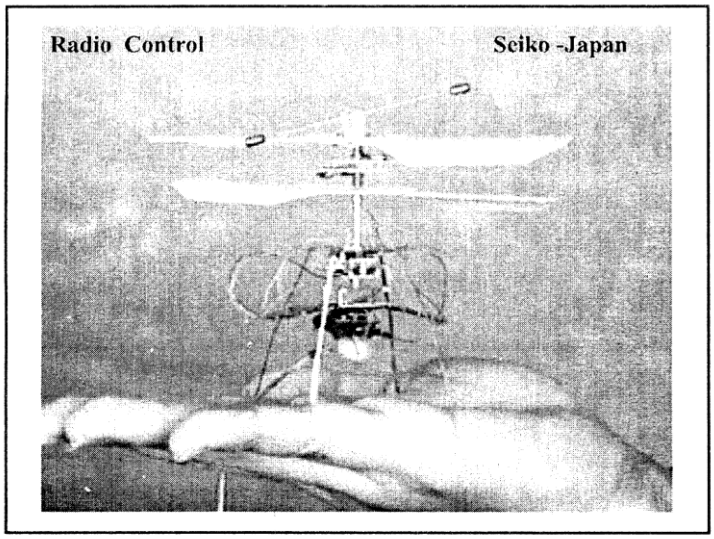


Fig. - 3 Micro Air Vehicle

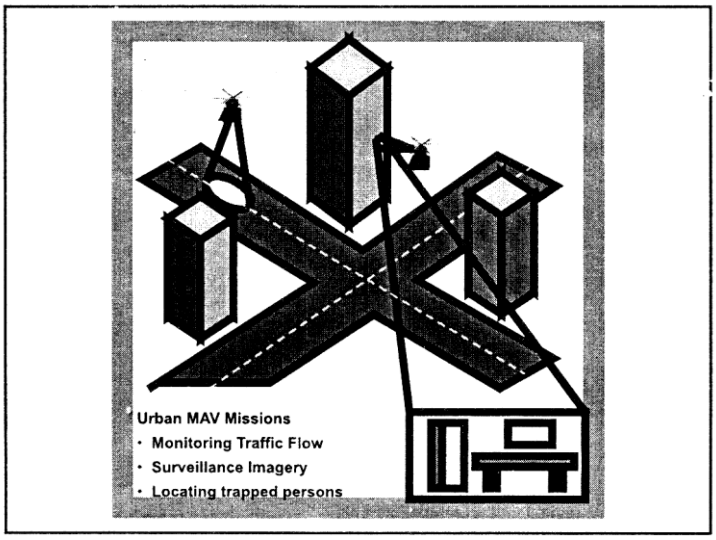


Fig. - 4 MAV in Surveillance

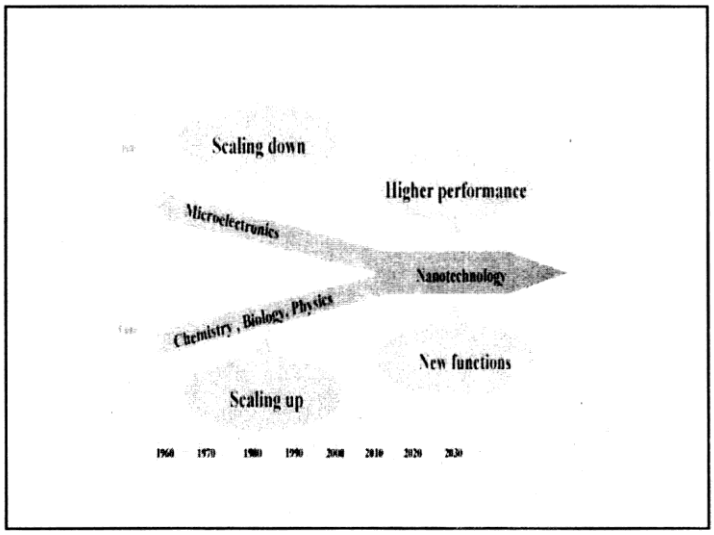


Fig. - 5 Convergence at the Nanoscale

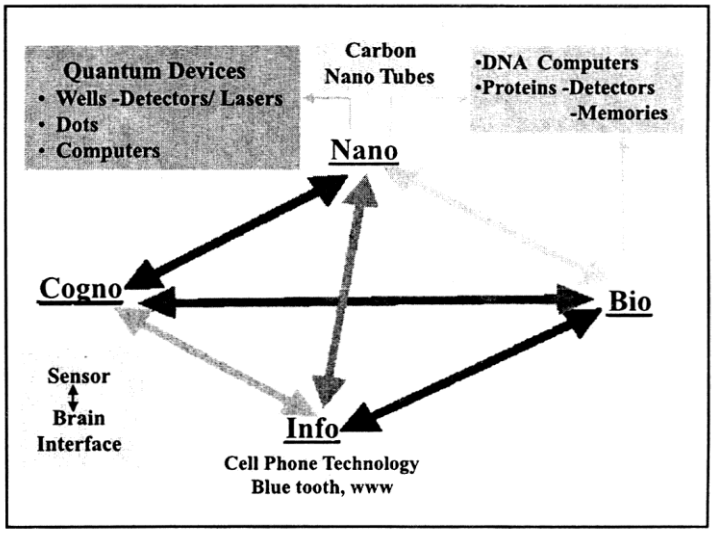


Fig.6 Emerging Technologies - Interlinking

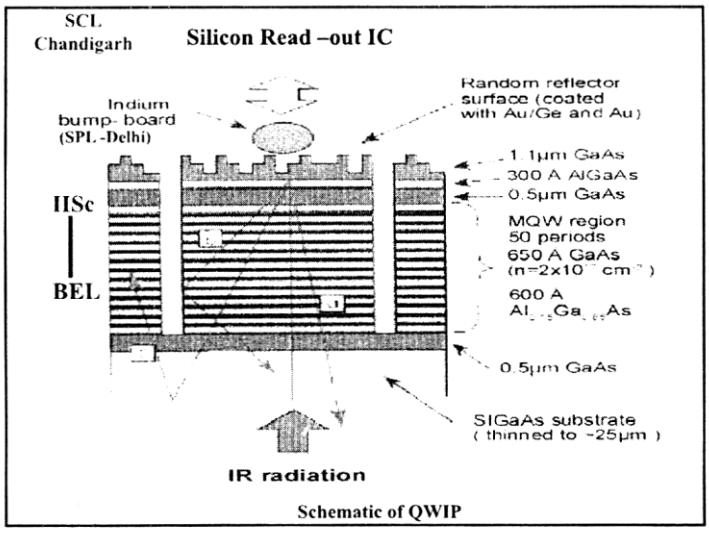


Fig.-7 Quantum Well Infrared Photodetectors (QWIP)

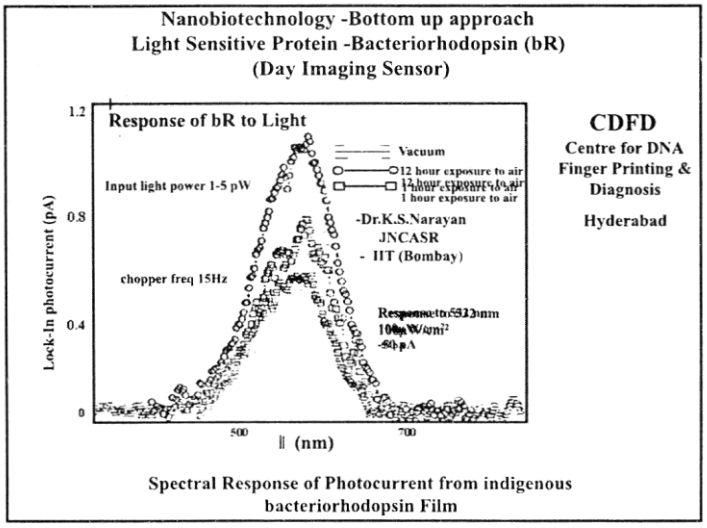


Fig.-8 Bacteriorhodopsin Protein

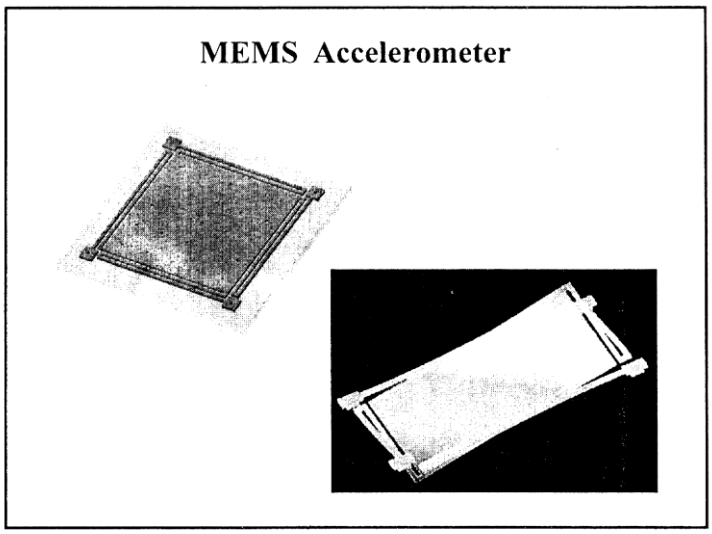


Fig.- 9 MEMS Accelerometer

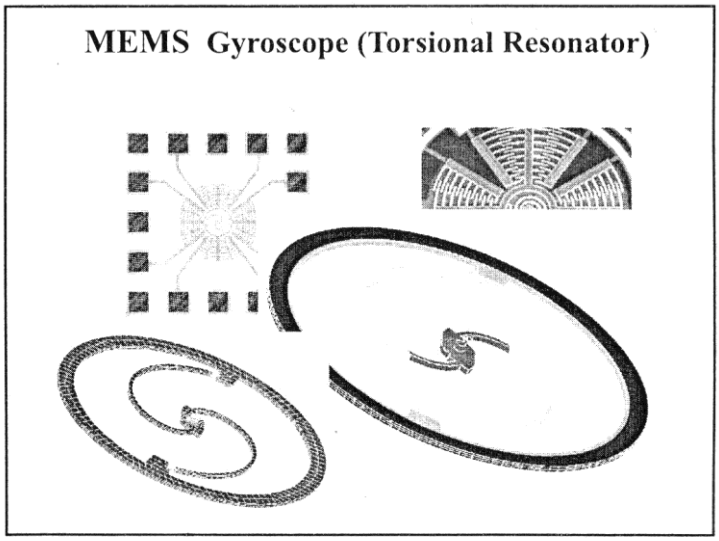


Fig.- 10 MEMS Gyroscope

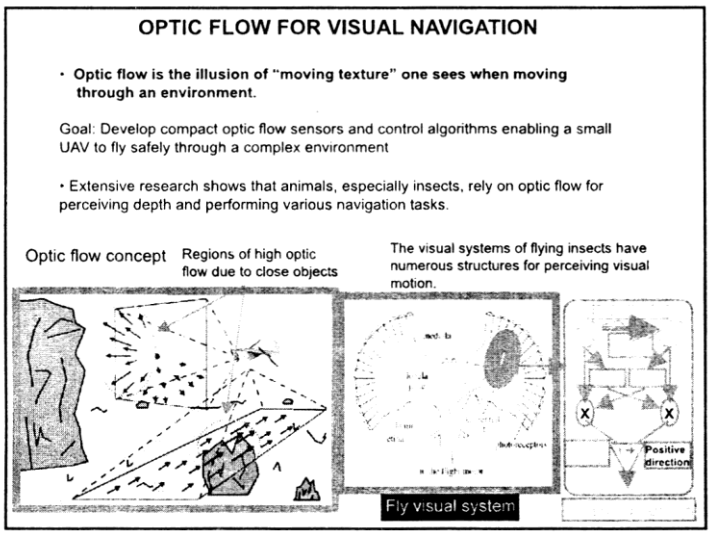


Fig.- 11 Optic Flow for Visual Navigation

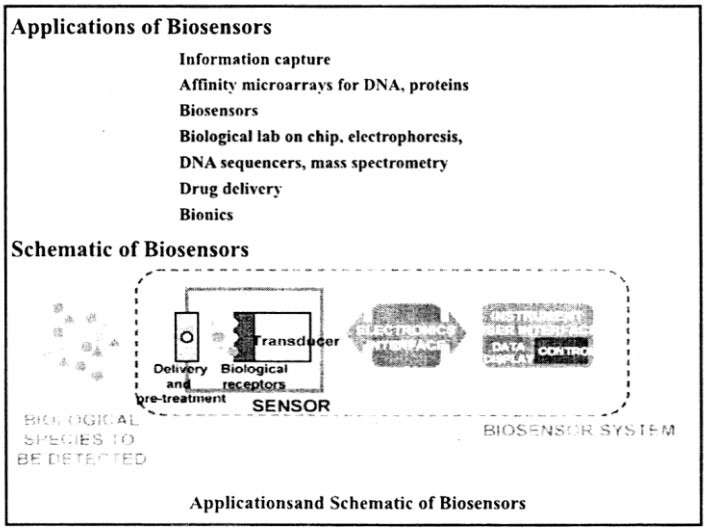


Fig.- 12 Biosensors

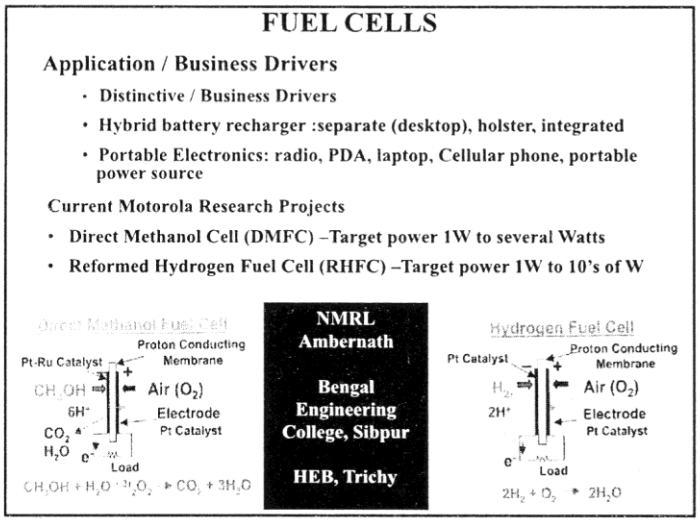


Fig.- 13 Fuel Cells

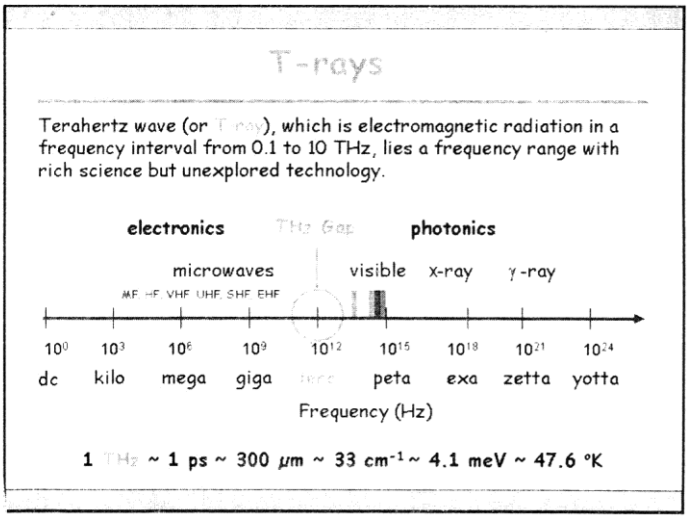


Fig.- 14 Terahertz

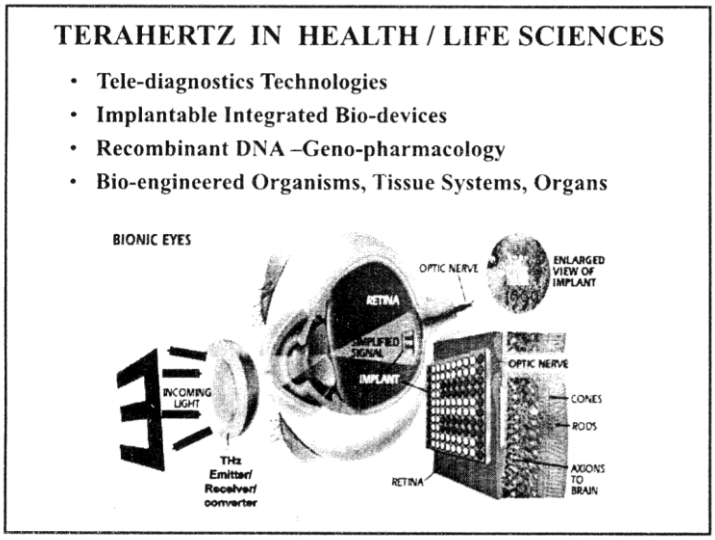


Fig.-15 Bionic Eye

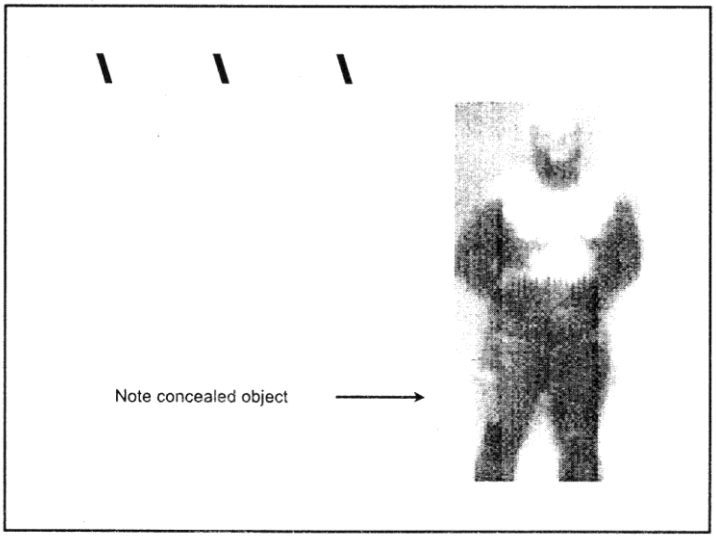


Fig.-16 Hidden Weapon

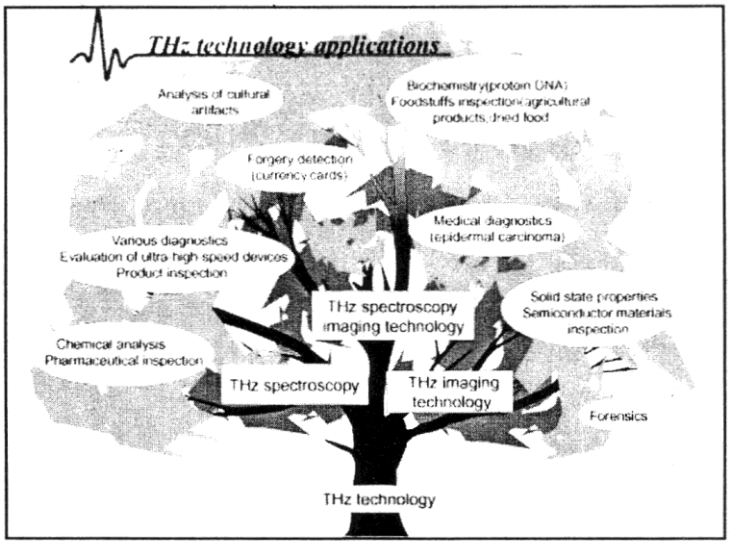


Fig.-17 Terahertz Technology Tree

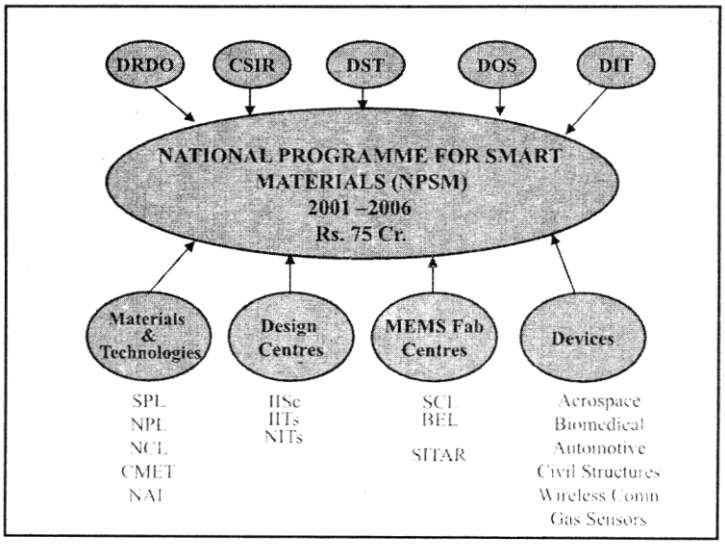


Fig.-18 National Programme for Smart Materials

The Nineteenth Dr Ajudhia Nath Khosla Memorial Lecture was delivered during the Twenty-first Indian Engineering Congress, Guwahati, December 21-24, 2006

Broad Band and its Effects on Society

Lt Gen D P Sehgal, *PVSM, AVSM, VSM* (Retd)

Member, Telecom Disputes Settlement and Appellate Tribunal, Government of India

It is indeed a privilege and singular honour for me to have been chosen to deliver the 19th Dr A N Khosla memorial lecture. Dr A N Khosla was an icon who earned uncountable credits and honours in his lifetime. He made many very significant contributions in the field of engineering and development, which went a long way in overall national growth. To name a few, his invention of 'Khosla Disc', survey on investigation connected with prestigious Bhakra Dam Project, Chambal, Damodhar Valley and Hirakud Dam created history. Dr Khosla displayed his inherent natural vision, particularly in the field of water resource management and therefore was truly called the father of river valley projects in India. He was a true engineer and this itself is an inspiration for me to give this lecture named after this legendary figure, Dr A N Khosla. Having 'been the President of the Institution of Engineers (India), Dr Khosla watching from the outer space must be very happy to see the extraordinary work being done by the Institution of Engineers. Needless to state that we, all the engineers do want to follow the foot-steps of Dr. Khosla. I wish to congratulate the Institution of Engineers for continuing their efforts towards excellence in the developmental activities in the engineering field. I was also lucky to be member of this great institution for a long time and therefore the pleasure is really multiple.

When the invitation from Prof Naik and Cdr Poothia came to me, I was wondering as to what subject should I speak and what should be the coverage and content like. I had informal talk with the President, IE(I) who suggested that I should speak on some subject pertaining to developmental activity, ;e which is giving rise and boost to the development of the nation which will be true recognition of Dr Khosla's work. Being a telecom engineer by profession, I thought of information and communication technology (ICT) as the subject since it is sweeping the world in the form of a revolution at a pace unprecedented and is touching every facet of our life. But, I noticed that the subject was covered by Shri T H Chowdry during 17th Dr A N Khosla Memorial lecture and therefore, I decided to touch on macro issue of ICT and cover an important subset of ICT, i.e broadband and its effects on society.

Ladies and Gentlemen, we the knowledge society are today living in an age when there is so much of information and data and so little time and inadequate infrastructure to manage it. There is requirement of information to be available at many levels parallely in the desired formats for use for specific applications. Information is power and everyone is vying for having it more and more ('Oil Mange More'), how to get it more in as little time as possible is the question.

Before I begin the subject proper, I would like to make a mention of a following technological advancements which have brought about major paradigm shifts in the society:

(i) Digitilisation: This is a process whereby any form of information, ie text, voice, pictures etc. can be transformed into digital form which lends itself to easy transmission. This has given rise to real convergence; convergence of terminals and convergence of media.

(ii) Miniaturisation: The size of the chip is reducing by the day with the processing power increasing exponentially in the inverse proportion of size. Nano-technology is the technology of the future.

(iii) Internet and Cellular Mobile Communication: These two communication systems have really shrunk the world into a small village. Today it is a reality that one can transact his business from wherever he is and while on the move.

Information communication technology is an important enabler and tool for development. We are aware that ICT is the heart of technology of acquiring, storing, structuring and managing the information; compressing and transmitting the information; finally processing and accessing and interpreting this information. ICT is today one fundamental force of change ever seen in the recent times, having many facets and dimensions of technology from computing and communication fields to education, healthcare, resource monitoring, management, rural development, business enterprises and even in the entertainment sectors world wide. Information and communication technologies have assumed a new prominence in development agenda of nations and societies after UN took it up as global priority in 2000. We have to look at ICTs as to how they will contribute to society and the people of our country based on the principles of creating intellectual resources for human kind, generating a source of national strength and safeguarding health and safety. In this context we have to develop and create a diverse knowledge base to lead society to be a developed society in very near future. This all has to be through sustainable development that strikes a balance between the environment and the

economy. We have to plan and utilize ICTs to create robust industries and sustainable agriculture that will continue to innovate. ICTs have to lead our policy planners and implementers to develop India in which everyone from the young to the old are healthy and prosperous. This will underpin strong economy.

Information communication technology plays a key role in development of economic, social and cultural ethics of people. It is a growth engine for development at global level, which is so very visible and evident from the progress being made because of ICT by the countries in our neighbourhood. We are also poised for information driven change and have already adopted the ICTs for the society to avail its benefits.

In every country where ICT has been employed extensively, it has increased employment and job opportunities. This is true not only in the West and Japan, but also in the South East Asian countries and China. ICT has made a large number of smaller enterprises and retail services, highly efficient and productive. In most of the developed countries, particularly USA, it has contributed to half of the productive growth and a third of the economic growth over the past five years. Additionally, it has helped those countries to contain inflation.

In the case of our country, we need to assess the extent to which ICT has touched India. Further, we need to employ it extensively to make the digital technology an integral part of our lives, working, government and industry, so that we can create value and employment. In other words, to transform our country from a developing to a developed nation. We started reforms in Telecom sector during 1991-95 when we opened the sector to private operators. Since then there has been no looking back. Today, India as such is a preferred and much sought after destination for foreign investors. Every one is talking of China and India, whereas India has really made a mark. In short time we have come a long way.

Let me start with telephones only. Starting with 70000 telephones in 1947, 8 million a decade back, today we have almost 160 million telephones and we are adding almost 4 million to 5 million mobile phones a month racing ahead to achieve our aim of 250 million phones by 2007. In August we added 5.9 million mobiles against China's 5.19 million. In September even this figure was surpassed. But, Ladies and Gentlemen, today, it is not only voice which is required, but data and video as well, to quench the thirst for more information and that too in a truly reliable and interactive manner, hence the broadband. The consumer today wants to avail of voice, data, e-mail, video simultaneously along with navigation through GRPS, audiovideo streaming and video games etc on single terminal. Thus, all require more capacity, ie bandwidth and the systems providing this are broadband systems in short called broadband.

Broadband has been referred to as the infrastructure of the knowledge economy, and is seen by countries around the world as crucial 0infrastructure for achieving their economic, social and scientific goals. High hopes have been placed for the revitalization of demand for the products and services of telecommunication sector through broadband, and many describe it as a panacea for a range of social and economic woes. Despite this, the take-up of broadband in many countries has been below expectations mainly due to its high cost and lack of appropriate policies aimed at promoting broadband.

The technological innovation and commercial development of telecommunications have gone hand in hand - particularly during recent decades - and the combined influence of economic, communications and technological developments are fast leading towards what is now-known as the 'information society'. Broadband telecommunications are beginning to feature highly among these technologies, and their growing prevalence is testifying to their future potential for users, businesses and governments alike.

As the effects of globalization are being felt by Indian economy, the broadband has become a key medium in creating opportunities for growth and development. We are at the take off stage of broadband; Government has already initiated its policy of broadband which aims at achieving 40 million Internet connections and 20 million broadband subscribers by 2010. At present, the broadband penetration is hardly 0.1% whereas the internet penetration is 0.5%. Therefore, concerted efforts are required on the part of Government bodies, service providers, industry agencies and consumer groups to cause a surge in the growth of broadband and internet services similar to the explosion recently witnessed in the telephony sector.

Definition of Broadband

Although there exist various definitions of broadband, which have assigned a minimum data rate to the term, it may generally be defined as transmission capacity with sufficient bandwidth to permit combined provision of voice, data and video, with no lower limit. Generally, broadband describes high speed, high capacity transmission for simultaneous provision of very high quality content rich voice, data and video (triple play)/multimedia services at very high speeds on all access devices through a common transmission medium in a truly reliable and interactive manner so as to provide an 'always-on' experience of being connected any time, anywhere to anything with any service for easy, uninterrupted access to all of one's information, entertainment and communication needs in a seamless way through convergence of technologies. As per broadband policy 2004, broadband in India is defined as 'always-on' data connection that is able to support various interactive

services including internet access, having the capacity of a minimum download speed of 256 Kbps to an individual subscriber from the point of presence of the service provider. This is in consonance with the definition adopted by the ITU. However, there is ever increasing aspiration, demand and requirement of speed and bandwidth and therefore according to me and Market forces will decide the actual speed. It can vary from 256 kbps to above 2 Mbps. 3G (third generation) networks support 2 Mbps and the next generation networks are planning higher speeds. A broadband user will require at least 2 Mbps for video streaming facilities.

For Governments, broadband is a way of promoting economic development and extending social benefits to the masses. However, for service providers, broadband offers a route to additional diversified revenue streams. For consumers, broadband makes possible a much wider and richer range of applications, specially when higher speed services are available.

For businesses, broadband brings the advantages of access to highspeed communications and the ability to reach a worldwide audience.

There are three major sectors, which are driving the growth and usage of broadband:

(a) Infrastructure for access
(b) Access devices
(c) Content

'Infrastructure for access' refers to connectivity that the end user gets in order to avail services. This 'infrastructure for access' includes, both down stream and up stream connectivity for truly interactive experience either on wire line or through wireless.

The Government policy of broadband visualizes creation of infrastructure. using various technologies like optical fibre, digital spectrum line (DSL), wireless using Wi MAX and WiFi and satellite using very small aperture terminals (VSAT). Wireless has an important role to play to create this infrastructure faster and cheaper because it has lot of flexibility which can be made use of to provide connectivity to inaccessible and inhpspitable terrain.

'Access devices' refer to the interface that the user has to interact with the network and its contents, i.e. terminal equipment of the user gets connected to infrastructure.

'Content' refers to the information, programmes, applications and services accessed by users. The above three factors are related to each other. Increased content creation further promotes demand for quality infrastructure, not only from content seekers but also from content providers looking for reliable hosting and provider services. This reinforcing growth cycle, or virtuous growth cycle, leads to achievement of selfsustained organic development.

The main reasons for promoting broadband can be given as follows:

(i) Benefits of Broadband to Society in General: Given the potential benefits of broadband to the various segments of society including reduction of digital divide, there is a need to frame specific and proactive policies for ensuring universal provisioning of broadband based services through direct financial support, so as to provide the most comprehensive set of capabilities to address the need for innovative solutions including alternate media/communication channel that can enable a range of interaction and interfaces including: (a) education and information; (b) vocational training and skill development; (c) agricultural extension, support especially in propagation of commercial agriculture; (d) micro financing and technology transfer and entrepreneurial enhancement; (e) e-commerce and trade along the supply chain leading to organised aggregation of supply and demand; (f) improvement in quality of life indices in rural areas to reduce the pressure to migrate, (g) improvements in health services, governance etc.

(ii) Benefits to Users: Compared with narrowband, the increased speed and always on nature of broadband enables the exchange of richer content, facilities improved, expanded and more rapid communication, and allows the sharing of a connection with multiple users.

(iii) Benefits to the Economy: Broadband connectivity is helping to establish an "information society". It encourages innovation, stimulates growth in an economy, and attracts foreign investment.

(iv) Benefits to Broadband Service Providers: Broadband holds the promise of new applications and value added services that will attract users and help service providers recover infrastructure development costs.

(v) Benefits to Businesses: Broadband can increase productivity by enabling transfer of large data files directly from local offices to head office(s) located in other cities or even other countries. Employees can access better training opportunities using broadband by logging on to corporate intranets and the internet to train for new product offerings or to refresh their knowledge on current products/services. Businesses can use high capacity internet to track shipments and seek out other export markets, enabling them to compete successfully with

markets outside. Newspapers or graphic design forms, which wan to keep their business in a rural community, can use broadband to send and receive large data files needed for production. Broadband can allow businesses to conduct net meetings or face to face meetings using video conferencing to discuss urgent decisions, minimizing travel costs for in person meetings.

BENEFITS OF BROAD BAND TO SOCIETY IN GENERAL:

Broadband services are changing our attitudes, life style and the way we conduct our business. High speed internet and multimedia applications bring with them new capabilities such as transmission of videos. This allows new vistas of growth in education, entertainment, health services and corporate communications. Broadband empowers internet as well as enhances the ability to use internet for a multitude of applications and provides quicker downloads for browsing, education interactive learning, online e-learning applications and services, e-commerce, e-health and entertainment services. Broadband services greatly enhance the capability of transmitting lot of information over internet and therefore, give rise to new means of communicating effectively. The main reason for adopting broadband is speed which is needed for data intensive applications and the main reason for not adopting the broadband is lack of access as well as it's being expensive. Where there is competition and higher population density, the prices tend to be lower and competitive though low broadband speed and download limits tend to limit competitiveness. Broadband adoption is driven by the combination of price, speed, access and the benefits/utility gain from broadband. All four attributes need to be achieved to realize the full benefits of broadband for the society. While the use of data intensive applications is still low in India, a higher level of awareness and training is needed to take advantage of it for improving efficiency and productivity by using applications like video conferencing, data casting, online education and research, online buying and selling, online banking, finance and insurance transactions. Broadband can also increase tourism opportunities by enabling online marketing resources to promote local and historical attractions. It also allows for online reservation systems. High capacity internet brings a larger audience and buyers t" local artisans and crafts people, allowing them to promote and sell their work via internet. Aboriginal communities can accumulate and disseminate their cultural information without the connectivity limitations they now face. Broadband can help ensure that families, businesses and young people in rural and remote areas are not forced to leave in order to find an economic and social future elsewhere. Therefore, the most important policy in stimulating increased use of broadband in society is to encourage technology providers to develop and make innovative broadband technology easy to obtain, and to help service providers develop robust business models that can be sustained in rural, regional and remote areas.

BROADBAND APPLICATIONS AND SERVICES

Voice Over Internet

Voice over internet protocol (VOIP) and internet telephony is not only bringing down the cost of communicating but it is also making possible new services on the web. Now it is possible for businesses to integrate their website and customers can contact the call centers if they have any queries as well as can receive telephonic support from the companies for completing transactions.

Telecommuting

The travelling employees of a company can access the companies' email, intranet etc. as well as video conference or attend e-Ieaming training sessions etc. while on move.

Education Services

Broadband access holds the real potential to replace the traditional methods of teaching. Audiovisual content can vastly enhance the delivery of educational material to children with the option for a feed back on the same. Students can take up educational courses not available in their cities, while availing onsite interactive learning services. Broadband can even connect the students at a location to lessons from experts at other locations using live video conferencing. Students in rural and remote communities can also easily surf the web to visit virtual museums. Broadband allows students to develop and post text, music and videos for school projects online. High capacity internet allows teachers to take advantage of many online resources and integrate them into everyday classroom activities.

Telemedicine and e-health

Development and delivery of medicine is another area where broadband connectivity is likely to provide immense benefit to mankind. The availability of videos and highspeed data transmission enables patients to meet specialist doctors from far away locations. Their reports and Xrays which require large data transfer capacity can be sent to the doctors before the meeting, allowing the doctor to provide remote consultation to the patients. For e-health and telemedicine to emerge as a viable alternative modality for delivering medical care and expertise, it is necessary to adopt information technology for networking hospitals and hospital management

systems. Broadband internet and telemedicine can be used as a style of practice for modem medicine rather than be exhibited as a technological showcase to achieve the slogan of health for all hitherto forgotten by our politicians, by making the information technology revolution happen in health care in India.

E-health promotes public participation in health care and leads to informed patients. Internet and broadband connectivity is the medium to deliver such information to practice and preach self care as well as preventive care. E-mail correspondence and online medical records could go a long way in establishing better patient-doctor relationship. Interactive broadband connectivity applications could help monitor and manage chronic illnesses / diseases effectively because broadband internet enables flow of up-to-date information in real time, facilitates centralized control for decentralized operations, ensures quality of health information and elicits patients /citizens feed back on services provided. It can also help capture key data in case of a major epidemic or a natural disaster and hence help in allocating resources effectively. National health surveillance can be implemented effectively by investing in broadband infrastructure to promote exchange of health information and planned coordination.

E-governance

It is the use of information and communication technology (leT) to promote more efficient and cost effective governance so as to facilitate convenient government services, allow greater public access to information and make government more accountable to citizens. Broadband can also enable a technology based customer service center that allows a onestop shop for business transactions including licensing, billings, permits and utilities' payment.

Broadband for agriculture, poultry, animal husbandry etc.

While growth in the adoption of internet is showing significant progress in many areas, there remains variation in broadband adoption. To the extent that production efficiency is affected by the adoption of information and communication technologies and broadband in particular, there is a concern about the impact on economic growth and distribution of wealth. Broadband can be adopted for suppliers of goods and services in agriculture, poultry and animal husbandry. The production in these areas can relatively become an intensive user of satellite broadband connection technology. Commercial farming operations can use broadband to network and connect barns, enabling the transfer of data between them using wireless communications. Custom crop spraying operations for grain producers can use broadband to enable voice communication and data transfer to and from operating units and equipments. Broadband can connect live stock farmers with workers in the fields, family at home and other operations using a wireless communication network. Information about the farming industry, growing conditions and animal health is more easily accessed with high capacity internet. Broadband opens up opportunity to access larger markets and expanded marketing channels.

Reliable interaction and richer content exchange

As the internet matures and moves from being largely a luxury towards being a basic necessity, faster access to richer information becomes more important to users. Broadband can offer significant time savings and can significantly reduce frustration levels for users. This is especially true for those who download large amounts of information from the Web.

Broadband enables users to access and exchange high quality graphics and other bandwidth-intensive content, such as 3D imagery in video games that would prove either impossible or difficult to use effectively over slower connections. There are many content rich applications that have been identified as potential drivers of broadband take-up. This ever growing list, for which many benefits have been cited, includes applications in voice, audio, video, e-commerce, e-education, e-health, government services, online gaming and file sharing.

As mentioned above, communication applications such as e-mail and instant messaging have been major drivers of internet usage. A key attribute of broadband in enhancing the effectiveness of these communication applications is that is can be offered as an always on connection, usually priced at a rate that is independent of the time spent connected. In addition, broadband does not tie up a telephone line as a typical dial-up connection does. Thus, broadband facilitates communication through increased availability.

BROADBAND - A CATALYST FOR ECONOMIC GROWTH

For many countries, broadband forms part of the goal for establishing an information society. The idea is that peoples' lives will improve as they have access to better information and applications concerned with health, education, finance and a range of other topics. For these economies, the promotion of broadband forms part of an overall plan to realize the benefits of access to information in digital form.

Broadband networks can also help to attract foreign direct investment. This brings new money into the economy and serves as a conduit for transferring technological know-how.

There is a direct co-relation between the benefits of increasing broadband penetration and growth in gross domestic product (GDP) of the country. Broadband internet has become a medium to communicate and deliver a host of applications and services to the users, because a technology has made it possible to simultaneously deliver voice, data and video at very high speeds in a truly reliable and interactive manner.

Broadband connectivity and services will impact education, health, governance and citizen empowerment, required to achieve the economic goals for all including the rural population that cannot be covered effectively using traditional brick and mortar solutions. Making appropriate and locally relevant e-education, e-health, e-govemance, e-commerce and entertainment services available through broadband connectivity to all cities, towns and villages of India will not only improve the quality of services but would also stop migration to urban areas by providing job opportunities in rural areas.

AWARENESS AND PROMOTING BROADBAND

Over and above differences in culture, landscape and technological development, economies that have been successful in promoting broadband have several key factors in common. A successful broadband economy will be characterized by:

a) Informing the Public about Broadband

Efforts to promote demand for broadband depend largely on the target market being aware of the products available and aware of what benefits broadband can provide them. Increased exposure to broadband should boost take up rates. Growth should be rapid once penetration reaches a certain critical mass.

b) Making Effective Use of Broadband through Applications and Content

Broadband adoption is much higher in countries where users make full use of current broadband applications. This may include increased usage of IP telephony, video/audio via broadband, online gaming and teleconferencing. Content in local languages also plays a key role. Policies that encourage these uses, should boost penetration rates.

c) An Environment that Fosters Broadband Innovation

Economies must have policies and incentives in place that create a fertile environment for broadband content and application development. This includes important issues such as thoughtful intellectual property rights protection, adequate government funding for internet research and consumers ready to participate in developing new, high bandwidth applications.

d) A Competitive Market Structure that Keeps Prices Low

There is no substitute for the true market competition in broadband to reduce prices. Subsidies, grants, regulatory obligations and other financial support are only temporary fixes and cannot replace a well functioning market. Efforts to ensure the market runs efficiently will have the greatest effect on prices and in turn on broadband adoption.

TECHNOLOGIES FOR BROADBAND

Digital Subscriber Line (DSL) Technology

Various variants like asymmetric DSL (ADSL), high data rate DSL (HDSL), very high data rate DSL (VDSL) etc. are available with varying data transmission rates in uplink and downlink directions. The maximum data rates in DSL systems depend on the length of the subscriber lines and their transmission characteristics.

Cable T V Modem Technology

Broadband access system realized over cable T.V networks can offer upto a maximum of 50 Mbps rate in downlink and upto 5 Mbps rate in uplink direction. However, normal speed available for a group of customers is 128 Kbps for uplink / upload and 500 Kbps to 2 Mbps for downlink / download. This technique is not very popular because of higher cost besides shared bandwidth.

3 G Wireless Broadband Technologies

They allow transmission of voice, high speed data and video simultaneously to wireless devices. Apart from giving high-speed data access, 3G technologies' networks are cost effective and have more traffic handling capacity when compared to 2G networks. A 3 G network can offer data speeds of well over 2 Mbps, which is 10-20 times faster than what is available on wireless phones having GPRS or even on broadband landline phones. 3 G with its faster multimedia based network architecture will radically increase the availability and diversity of always on content to see a paradigm shift in customer expectations looming on the horizon. With broadband being the driving force for industry and society in general, its penetration may expeditiously increase substantially.

Wi-Fi

Wireless fidelity is a wireless network protocol that allows computers / multiple devices to communicate wirelessly by sharing a single high speed internet connection over a distance of about 300 ft. It saves time in deployment and communication, prevents digging up land to lay expensive cables, provides mobility and makes operations more flexible.

Wi-Max

If Wi-Fi allows wireless access to the internet from a hot spot, Wi-Max goes further and provides high through put broadband connections / high speed internet access over a much bigger area with typical cell sizes of 2-30 kms i.e. 1 cell site can cover an area of over 750 sq kms, in a way similar to that of working of mobile phones. Wi-Max can provide wireless broadband access at 70 Mbps. Wi-Max technology can provide very high data transfer speeds of 10-15 times faster than the 3 G mobile services and at much lower costs on a wireless network with no hassles of wired last mile. Its biggest appeal and promise lies in connecting remote, far flung and even congested areas with a fat, wire free pipe in about 30 K.m radius, thus accommodating much more users.

Broadband over power lines (BPL)

A high speed internet access technology that uses power lines.

LOW COST BROADBAND IN RURAL AREAS

Rural areas are the last frontier of the information technology revolution. Telephone and internet penetration there remains a small fraction of what it is in the urban areas. Limited means of electronic communication with the outside world are just one source of isolation of rural communities and economies from the forces of national and global integration, albeit an important one. Without roads and electricity, the benefits of extending ICT access would be greatly diminished. Conversely, where these and other elements of infrastructure are in place, those benefits can be multiplied.

The costs of ICT provision to rural areas tend to be higher than to more densely populated urban areas, and the ability of potential subscribers to pay, is lower. In recent years, a number of interesting experiments have been initiated to extend low cost telephone and, in some cases internet access to low income rural communities.

TECHNOLOGY OPTIONS FOR RURAL BROADBAND ACCESS

The preferred technology, or technology mix, for providing low-cost broadband access will vary with local conditions. In any case, even using the lowest-cost technology available, cost of access provision is certain to vary across locations, depending on the degree of remoteness from the backbone network and central node, user density and clustering and the type of service and traffic. In this area, technologies are evolving rapidly, so what looks attractive technically and financially today may appear lesser attractive in a few years' time.

But fact is that 70% of Indian population lives in rural areas. Though the tele-industry is much less, varying from 1% to 5% in the rural area with over all tele-industry of 1.9% only, many ICT initiatives have been taken which are indicative of potential value of much improved broadband network access in rural area. These include

a) ITC e-choupal

This information technology based initiative offers farmers information about products and services they need to cut transactions costs and improve price realization.

b) Gyandoot

This is a low cost, community owned and self-sustainable rural intranet project to make government services more accessible to villagers.

c) MS Swaminathan Research Foundation (MSSRF)

The basic mandate of MSSRF is to impart a pro poor and pro women orientation to a job-led economic growth strategy in rural areas through harnessing technology for environmentally sustainable and socially equitable development.

d) n-Logue

n-Logue was established to serve the information and communications needs of people living in small towns and rural areas of India. A trust to promote n-Logue has been set up by several liT alumni and eminent persons from the ICT industry to provide internet connectivity in small towns and rural areas, using the corDECT wireless local loop (WLL) technology.

e) Sustainable Access in Rural India (SARI)

In this pilot project, applications and content are provided by wireless links to more than 80 sites in 50 villages in Madurai district of Tamil Nadu state. The concept is to tap India's relatively widespread optical fibre backbone networks which reach most towns and then bring low cost connectivity to surrounding villages.

f) TARA haat

TARA haat or 'Star Marketplace' is an internet portal that supports a network of franchised village telecentres in rural India. The portal connects village users to information, social services, entertainment and markets, customized into local languages.

Telecos and IT companies are exploring rural market for broadband services. Hughes and Microsoft have decided to set up 5000 broadband kiosks across 200 small towns and rural areas. These will use satellite as the medium. These kiosks will be operated on franchisee based model, offering budding entrepreneurs across the rural areas for e-commerce, education and e-governance. This will provide B2B and B2C services. These kiosks will act like business hub, offering services like educational programmes, railway and airline booking and tourism, besides value added services.

E-Government

Several other important initiatives are underway. In particular, we note the National E-Government Action Plan (NEGAP) and the associated initiative to develop state-wide area networks (SWANs), that are to provide a foundation for e-government applications. We also note the Andhra Pradesh broadband network initiative - a public private partnership that is expected to rapidly roll out a broadband network as a platform for e-government services in the state of Andhra Pradesh.

Technologies for Rural Telecommunications

The primary telecommunications access technologies that are currently being used in rural India are: traditional wireline; radio-based access systems; satellite (VSAT) systems; and COMA-based wireless local loop. Other technologies that may be deployed are: GSM cellular mobile; cable TV upgraded to handle two way traffic; and new broadband wireless technologies such as WiMAX, which is a new standards-based wireless technology that offers broadband over longer distances than the "hot-spot" technology of WiFi.

POLICY AND REGULATORY ISSUES RELATING TO BROADBAND

Competition

Competition is the key to growth and innovation in telecommunications market. The creation of a competition policy, therefore, becomes important because it induces service providers to become more efficient and to offer a wide range of services at lower prices. Appropriate competition policy can prevent imperfect competition, monopoly behaviour and market failure and improve economic efficiency. The competition related focus of regulators is on established operators with market power. Two different types of government interventions are used to apply competition policy - behaviour intervention, in which a public authority attempts to modify market activity through regulation of a firm behaviour, and structural intervention, in which the government actively intervenes in the market to effect the overall structure of the industry.

A difficulty for regulators is that broadband seems to be pulling together previously distinct markets, thereby changing the entire communications landscape. This converged market place now includes, amongst others, telecommunication providers, cable TV companies, satellite TV companies and ISPs. This makes efforts to ensure a competitive broadband market complex and highly dependent on the overall environment.

Convergence can increase competition by promoting inter modal competition, but in certain circumstances, it can also reduce competition because multiple services can be provided over the same network. This may serve to strengthen monopolistic tendencies. While market prices for broadband depend on many factors, there are three elements of successful markets that are common among successful broadband economies.

(i) Competition via open access: Prices invariably fall when DSL and cable providers are compelled to open up their networks to competitors. This process is sometimes called unbundling the local loop (ULL).

(ii) Strong competitive carrier: While open access is a first step, the best way for prices to fall is when there is a competitive carrier with deep pockets, which is strong enough to compete effectively with the incumbent.

(iii) Inter-modal competition: In addition to competition within a sector, prices fall when several broadband technologies compete for the same customers.

Competition has had profound effects on broadband markets eg., in Korea, Japan etc., where strong competition on all fronts had an astounding effect in achieving lowest broadband prices in the world. Policy makers around the world can use competition regulation to help foster other successful broadband markets. A level playing field and competition regulation are the only answers for growth, investments and sustainability. Once level

playing field is established, the regulator should allow market forces and competition to take over. With least entry barriers, low duties/ taxes, free imports etc., it is advisable to expose the broadband sector to competition regulation rather than to continue with any protection. Therefore, government and regulators can playa very important role in promoting and enabling faster growth of broadband by:

a) Creating the right policy environment by removing entry barriers.
b) Creating national backbone infrastructure.
c) Effectively implementing national internet exchange in the country.
d) Permitting unlimited competition for broadband.
e) Encouraging international players to setup Gateways in the country.
f) Funding community investment in broadband in uneconomic, remote, underserved, rural and isolated areas.
g) Stimulating demand.
h) Formulating national, regional, and local programmes, universal service policies.
i) Leveraging Governments own demand and setting example by being online leader.
j) Extending special tax concessions for equipments and access devices used for broadband.
k) Promoting facility-based competition by lowering market entry barriers and ensuring level playing field.
i) Reducing the cost of connectivity and permitting infrastructure sharing among different service providers for optimum utilization and cost optimization.
m) Allowing captive infrastructure of utility companies to be used for public broadband service.
n) Leveraging on evolution of alternate last mile technologies and reducing the bottlenecks in last-mile access by facilitating deployment of alternative technologies, like cable TV network, wireless, power line etc.
o) Reducing the cost of bandwidth for domestic and international connectivity. '
p) De-licensing and facilitating radio spectrum for broadband access
q) Permitting broadcast infrastructure like DTH to be used for broadband access.
r) Leveraging on mobile technology developments
s) Using V-SAT for broadband Access
t) Providing fiscal measures to reduce the cost of access devices, infrastructure and service
u) Defining the norms and regulating the quality of service for broadband

China Syndrome

People do ask me about China as to why their telecom and economic growth is faster than India. Let me tell you that in 1990, China and India were same in per capita income, PC penetration and telephone density while they were ahead of us in literacy. In 2002, they went ahead of us by a multiplier in every count and per capita income. There is no denying the fact and all of you know that China started its reforms much ahead of us and that much of time lag will remain for us to catch up. We are not doing badly we are on the right track with national telecom policy 1994 and subsequently in national telecom policy 1999, we took some initiatives. We really marched ahead by opening up the sector to privatisation and there has been no looking back ever since. It will not be out of place to mention that China started its reforms in 1978, whereas we waited for almost more than a decade to do the same. Secondly, the governance in-China is entirely different from the democratic set-up in our country. The decisions of the government are entirely implementable in China as compared to our country where a consensus of most of the parties is required. Can you imagine that we can implement the policy of population where China could easily implement one child norm to correct the imbalance at that time. It is for these reasons that though we have been trying to get the manufacturing base of telecom equipment shifted to India, most of our manufacturers are traders of Chinese equipment. These are some of the reasons that our country, like others is happily trading and marketing and selling Chinese goods.

Conclusion

Because of the diversity of terrain and population being scattered in inhospitable areas, it has not been possible to create a network giving access to these far placed villages. The effort therefore has been concentrated in more urban areas. Action is now on to maximum use of technologies like WiFi, WiMAX, satellite and other wireless to provide access to these unreached areas. I had the opportunity to take part in the Asia IT Summit hosted by our government at Hyderabad. As a part of my deliberation and presentation, I myself spoke on the theme "Wireless is the Answer". The same is applicable to our country. Things are looking up and there is lot of promise and potential. The Prime Minister's initiative to provide infrastructure in our villages and also our President's approach of PURA are worth mentioning. There are a few challenges which we need to meet.

Spectrum is another challenge which is being much talked about. Government is taking necessary steps now to get the spectrum vacated from defence for use in the civil sector for commercial purposes. When I was Signal Officer-in-Chief, I had written to then Chief of Air Staff to change over to optical fibre which is now taking place.

The government policies have to be equitable for all which will give rise to healthy competition.

We keep on talking about IT without realizing that there are not enough personal computers available to exploit IT for the benefit. PC penetration has been very very slow. We have to have PCs on an affordable cost and also applications at affordable cost for common man to make use of information communication technologies.

At the same time, awareness also needs to be caused amongst people for use of ICTs. Today a common man is just content with voice which is primitive by today's standards.

Things are rosy, looking up and we have bright future. We do have dreams and we are racing ahead to realize them.

Thank you.

DIGITAL SUBSCRIBER LINE SYSTEMS

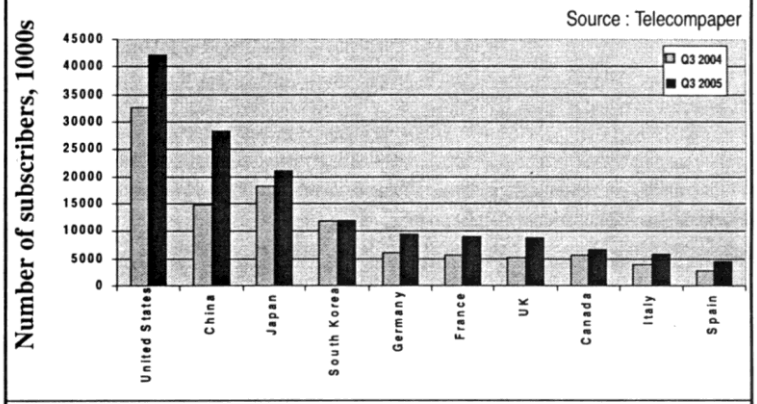
THE MAXIMUM DATA RATES IN DSL SYSTEMS DEPEND ON LENGTH OF SUBSCRIBER LINE AND THEIR TRANSMISSION CHARACTERISTICS

Acronym	Data Rate	Mode	Maximum Distance, km	Number of Wire Pairs
DSL	160 KBPS	Duplex	6	One
HDSL	1.544-2.048 MBPS	Duplex	4	Two, Three
SDSL	1.544-2.048 MBPS	Duplex	3	One
ADSL	1.5 to 6.144 MBPS 16 to 640 KBPS	Downlink Uplink	4 to 6	One
RADSL	Adaptive to ADSL	Do	4 to 6	One
VDSL	13 to 52 MBPS 1.5 to 2.3 MBPS	Downlink Uplink	0.3 to 1.5	One
(A) DSL LITE or UDSL	1.5 MBPS 512 KBPS	Downlink Uplink	6	One

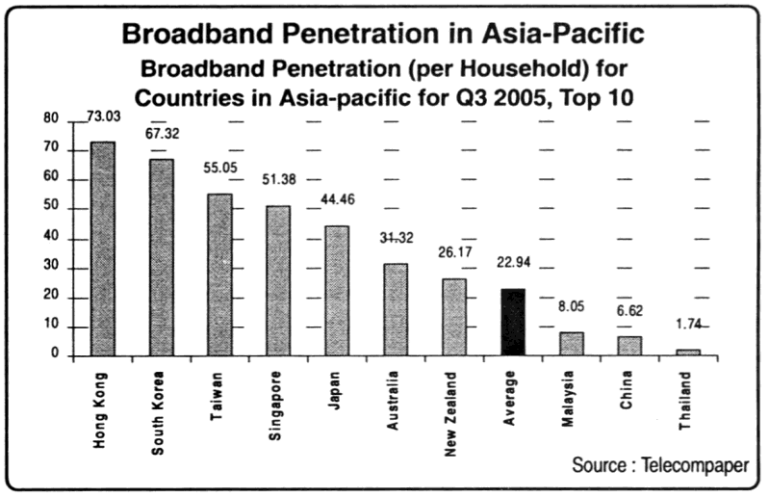
Top 10 Broadband Countries (Total Subscribers)

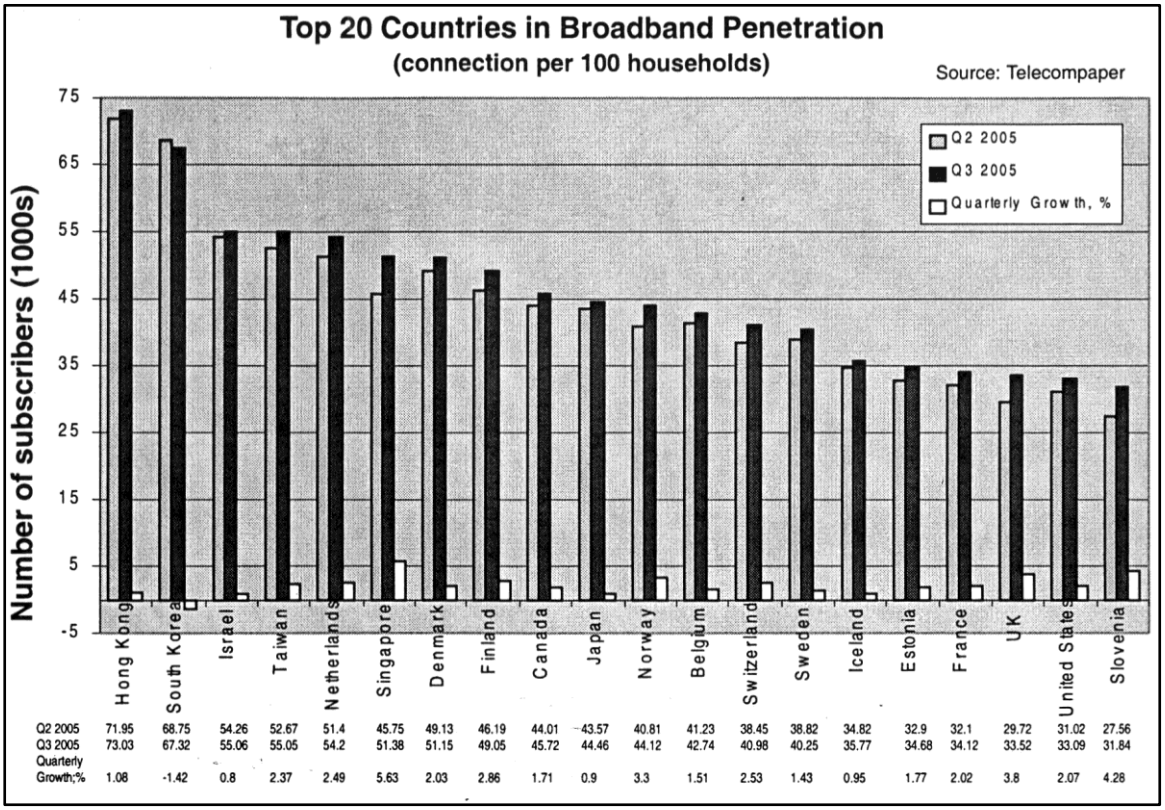
Top 10 Largest Broadband Countries

Source : Telecompaper



	United States	China	Japan	South Korea	Germany	France	UK	Canada	Italy	Spain
Q3 2004	32670	14786	18206	11802	5991	5555	5057	5580	3908	2786
Q3 2005	42172	28182	21056	12054	9451	8894	8856	6641	5783	4448
Growth %	29.08	90.6	15.65	2.14	57.75	60.1	75.14	19.01	47.98	59.66


Broadband Penetration in Asia-Pacific
Broadband Penetration (per Household) for Countries in Asia-pacific for Q3 2005, Top 10
80
70
60
50
40
30
20
10
0
73.03
67.32
55.05
51.38
44.46
31.32
26.17
22.94
8.05
6.62
1.74
Hong Kong
South Korea
Taiwan
Singapore
Japan
Australia
New Zealand
Average
Malaysia
China
Thailand
Source : Telecompaper


Top 20 Countries in Broadband Penetration
(connection per 100 households)
Source: Telecompaper
Number of subscribers (1000s)
75
65
55
45
35
25
15
5
-5
Q2 2005
Q3 2005
Quarterly Growth, %
Hong Kong
South Korea
Israel
Taiwan
Netherlands
Singapore
Denmark
Finland
Canada
Japan
Norway
Belgium
Switzerland
Sweden
Iceland
Estonia
France
UK
United States
Slovenia
Q2 2005 71.95 68.75 54.26 52.67 51.4 45.75 49.13 46.19 44.01 43.57 40.81 41.23 38.45 38.82 34.82 32.9 32.1 29.72 31.02 27.56
Q3 2005 73.03 67.32 55.06 55.05 54.2 51.38 51.15 49.05 45.72 44.46 44.12 42.74 40.98 40.25 35.77 34.68 34.12 33.52 33.09 31.84
Quarterly Growth;% 1.08 -1.42 0.8 2.37 2.49 5.63 2.03 2.86 1.71 0.9 3.3 1.51 2.53 1.43 0.95 1.77 2.02 3.8 2.07 4.28

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Self-Reliance in Emerging Defence Technologies

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Director General, Electronics and Mechanical Engineering,
Integrated Headquarters of Ministry of Defence (Army),
Government of India

INTRODUCTION

To provide national security, the Indian military must be able to dominate the complete range of military operations. Key to achieving this full spectrum dominance, will be the ability of defence forces to acquire technologies that enable it. Technological superiority being the decisive factor in future battles, it is imperative to build indigenous technological capabilities relevant to specific requirements. It is becoming increasingly important for a country like India to be able to exercise its own independent foreign policy in the interest of its national security. This can be achieved only through a sustained effort to technological self-reliance that would not only enable the country to have an independent techno-military strategy for defence but also provide the nation with the vital techno- economic strength.

In the complex matrix of achieving self-reliance, the role of Defence R&D is to provide the 'Critical Technologies' for defence needs and to build the 'Core Competence' for enriching the technology base in the country. An effective long term 'Self reliance', implementation plan therefore must advocate selective investments in 'Critical Technologies' that would help in realising the self-reliance objectives specific to national needs. The development of technologies in line with a comprehensive and realistic security doctrine could radically alter our entire strategic and tactical vision, not only on the conventional and subconventional battlefield, but in every aspect of the national enterprise.

TECHNOLOGY FORECASTING

Technology forecasting enables to identify the likely opportunities and threats and to develop a technological roadmap for the future. Technology forecasting is now getting importance in India due to the structural reforms introduced in our economic system with a view to create a market driven economy. Technology forecasting is used for the purpose of scanning the technological environment, anticipating emerging technological changes and identifying suitable technologies by evaluating various alternatives.

To enable the military to meet the challenges of future battlefield, we need to initiate research and development in some of the emerging technologies like Nanotechnology, Directed Energy Weapons, Smart Munitions, Biomimetics, Micro-Electro Mechanical System / Micro-Opto-Electro-Mechanical System, Artificial Intelligence and Armour Materials.

NANOTECHNOLOGY

Nanotechnology is the miniaturization of technology to one billionth of a metre (10 –9m), to design and manufacture intelligent miniature machines, programmed to perform specific tasks. The reduction of size into the nanometre area often results in characteristic properties of substances and materials undergoing changes which can be exploited for new applications. Nanotechnology, the science of designing microscopic structures in which materials are machined and controlled atom by atom, has the potential to produce further miniaturization of weapons. The use of nanotechnology in defence equipment opens up ways to improve the weapons, innovative materials and new application areas.

In vehicles and aircraft, conventional structural materials could be replaced by more rigid and lighter materials. Improvements could also be achieved in direct (armour) and indirect protection for military vehicles (camouflage through colour changes with ‘intelligent’ surface coatings). Important impact of nanotechnology can also be expected in the conversion and storage of energy, ie, suitable membranes and catalysts for operating fuel cells, and enhanced battery performance. There are many possible applications in military reconnaissance based on the use of nanotechnology components in sensors, sensor systems and sensor networks. Weapons and munitions are also being directly affected by the improved sensory capabilities, enhanced computing power and storage capacity due to nanotechnology. Another option is the development of nano scale powders for the use in propellants and explosives, enhancing the energy yield and speed of explosion. The impact of nanotechnology is expected to be greater than the combined influences that the silicon integrated circuit, medical imaging, computer aided engineering and man made polymers have led in this century.

BIOMIMETICS

Biomimetics (imitate life) is an inter-disciplinary effort aimed at understanding biological principles and then applying them to improve existing technology. This process can mean changing a design to match a biological pattern or actually using biological materials such as proteins, to improve performance. The scope of biomimetics appear to vary widely depending upon the specialized discipline of the investigator. Electronic companies are supporting biomimetic research with a view to learn the way biological systems process information. Material scientists view biomimetics as a tool for learning to synthesise materials under ambient conditions and with least pollution to the environment. Engineers attempt to explore the relationship between structure and function in natural systems with a view to achieve analogous synthetic design and manufacture.

Another interesting case of learning to design from nature pertains to characteristic feature of fish, which has the ability to accelerate very fast, has low turning radius of only about 10%-30% of its body length, high velocity and the conservation of energy during a dive to lower levels. The tail of the fish pushes the water backwards and creates a column of moving fluid called a 'jet'. The jet includes the vortices and derives its propulsive efficiency which is about 86%. In contrast, the propeller driven under-water ships reaches an efficiency of only 40%. It is the body of the fish, rather than the tail, that creates the strongest vortices. Based on these observations, a swimming machine with a flapping tail has been constructed and submarines and boats with a flapping tail are likely to be seen soon.

Sensors capable of detecting electro magnetic radiation across the spectrum from the infrared through the visible and into the ultraviolet regions have become integral part of military weapon system. There are biological systems possessing sensing capabilities unmatched by current technologies. The infrared sensitive beetle (Melanophila acuminate) is attracted by fire and smoke from 50 km away. The forest fires emit infrared radiation that the beetle detects through a specialized infrared sensor known as the infrared pit organ or infrared sensilla. By understanding the mechanism and the biological process involved in this infrared sensor, one could develop new and improved materials and sensors for various applications.

ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI) is the capability of a machine to imitate intelligent human behaviour. The conventional AI includes methods such as expert systems, case based reasoning and Bayesian networks. Expert systems process large amount of information and provide conclusions. Case based reasoning is the process of solving new problems based on the solutions of similar past problems. It has been argued that case based reasoning is not only a powerful method for computer reasoning, but also a pervasive behaviour in everyday human problem solving.

Bayesian networks are used for modelling knowledge in medicine, engineering, image processing, data fusion and decision support systems. The military application of AI includes target extraction in images (pattern recognition), identification friend and foe, multilayer neural networks, testing of intelligent systems, and autonomous robotic systems.

Use of Artificial Intelligence for Decision Making

Increasing amount of information available from surveillance, reconnaissance and target acquisition systems makes it a near impossible task to collect and analyse. This job has to be done by a computer. Computers are becoming more and more capable of making decisions of which weapons to select and when to fire them. The concept of using computers for making important decisions has been on the anvil for a long time. Neural cells are being utilised to make smart decisions whether they are for force structuring, adopting the most suitable doctrine or form of warfare.

DIRECTED ENERGY WEAPONS

Directed energy weapons have very useful capabilities in the battlefield. Charged or neutral particles can travel close to the speed of light in vacuum, but travelling through air slows them down to about 1000 km/s. A highly directional beam should be able to pick up and destroy a single enemy target without damaging friendly forces nearby.

The function of a directed energy class of weapon is to place on target, sufficient energy to inflict lethal damage or at least disable some critical component of the target. Laser directed energy weapon thus has two levels of applications, one for Electro-Optic-Counter Measures (EOCM) where relatively low energy laser is used to disable hostile sensors or front-end optics. The other is the use of high power laser for direct structural damage to attacking enemy platform or weapon systems. A high-energy laser sweeping across the battlefield could be a potent psychological weapon, particularly when inflammable materials catch fire. It may be militarily useful against soldiers with little protective clothing. Attack on battlefield sensors with modest-power laser beams, cause them to lose track of what they were observing.

A high-energy laser takes somewhere from a second to several seconds to do enough damage to 'kill' a target, though actual times are classified and will depend on the type of target. An intense charged particle beam could

do the job in a single short pulse. There are many types of physical or mechanical damage that could be lethal to a military target. Missiles and aircraft could be destroyed by rupturing fuel tanks and causing explosions, and enabling some critical components to malfunction. As the intensities needed to cause mechanical damage are much higher, the requirement of making such high power lasers battlefield worthy is of importance. The Tactical High Energy Weapon is a high-energy laser weapon system that uses proven laser beam generation technologies, proven beam-pointing technologies, existing sensors and communication networks to provide a new active defence capability in counter air missions. It can provide an innovative solution not offered by other systems or technologies for the acquisition and close-in engagement problems associated with short-to medium-range threats, thereby significantly enhancing coverage of combat forces and theatre-levels assets.

MEMS/MOMS

Micro-Electro-Mechanical System (MEMS) includes mechanical and electrical elements that convert one form of energy into another, operating by transduction. The transducer is a device that is actuated by energy of one form and supplies energy of another form. Transducers encompass both sensors and actuators. Microelectro mechanical devices are made of extremely small parts or microchips. This miniature device comprises mechanical elements, activators and electronics on a common silicon substrate, which is fabricated using micro systems technology. Micro sensor converts a non-electrical quantity, for example, pressure, temperature, gas concentration or magnetic phenomenon, into an electrical signal. Actuator converts electrical signal back into nonelectrical quantity.

Micro-Opto-Electro-Mechanical System (MOMS) overcomes challenges posed by MEMS, it offers higher bandwidth, lower cost, smaller size and an easier integration. MEMS pressure sensors and accelerometers are being used for missile applications, rate gyro's, and measuring exhaust emissions.

BATS AND NANOBOTS (ROBOTS IN COMBAT)

Talking about robots in combat, such a robot, the PackBot – was actually deployed in Iraq and Afghanistan. It entered caves, scouting around and reporting to human operators using wearable computers. In the future, its role could accommodate combat duties and such robots could be loaded with explosives to blow up locations not accessible to soldiers. Thanks to its 802.11b connection, the PackBot can also be operated over the internet, allowing remote operations. Another DARPA (Defence Advanced Research Projects Agency) funded project, dubbed the High Mobility Tactical Microrobot (HMTM), is in the work. Weighing just 2 kg, it is being designed for surveillance and reconnaissance. The HMTM has a camera on top of a periscope to look around corners, in addition to an inbuilt homing device that will work even if its 802.11b connection breaks.

SMART DUST

Smart dust can help reduce casualties, which was a primary goal during the Iraq war. The central idea is to replace people with machines that could gather intelligence. In Iraq, the US military used smart robots and small UAVs to reduce danger to personnel. Another DARPA-supported technology, called 'Smart Dust', could possibly reduce casualties and gather information even more effectively.

Smart dust is an 'autonomous sensing and communications device in a cubic millimetre' package. A millimetre has not yet been achieved, but the goal is to package a light sensor, power supply and circuitry, a communication device, and a programmable processor into a small space. On achieving the desired apparatus, a plane can 'spray' smart dust over a conflict area. The specks would be light enough to stay afloat and monitor the movement of enemy troops, or perhaps the presence of biological or chemical weapons. In a recent test, a smart dust researcher controlled a drone about 20 cm long flew at 100 kmph for 18 min, carrying a camera that sent live feeds back to headquarters!

SMART MUNITIONS

Smart ammunition is the one, which, after being fired, can be controlled to a certain extent, towards the terminal part of its trajectory, incorporating homing system, guidance system and target seekers. The sensor fuzed ammunition has fixed intelligent sensor which identifies a target and fires a projectile towards it.

The sensor used in this ammunition is a millimetric wave radar in which millimetric wave frequencies of 35-94 GHz are able to penetrate poor weather conditions and battlefield smoke to give high target signature resolution. The infrared detector sensor identifies targets through their hot spots and creates an image. Targets can be perceived through adverse weather and smog. The dual mode seeker sensor is potentially more cost effective due to its lower false alarm rate and increased tolerance to counter measures.

The brilliant munitions employ multi sensors and have many steerable surfaces. Owing to their bulk, these are delivered as submunitions by large caliber guns (203 mm) or by rockets. These submunitions autonomously seek targets with freedom of flight direction enabling it to locate targets within a large radius of the dispensing

point. Also, these munitions provide first round hit against a universal target set including hot and cold, stationery and moving, and hard or soft targets.

ARMOUR MATERIALS

The armour materials presently in use and under development are steel armour, aluminium armour, titanium armour, composities and ceramics. The synergistic combination of aluminium armour with outer layers of hard steel has been adopted to provide greater protection than that afforded by a single type of armour. Where space allows, the effectiveness of aluminium steel combination can be further increased by separating the two armour layers by an air gap. As an alternative to steel, there is also possibility of combining aluminium armour with plates of titanium. The ballistic performance of titanium and the prospects of its cost coming down have encouraged its greater use particularly as hard outer layer over softer aluminium armour structures.

Ceramics are ballistically effective because of their hardness, which is considerably greater than any other material, and also they are lighter than steel. Titanium diboride will serve as protection against projectiles of the future having cores of tungsten cobalt composites. Flexible ceramic armour, consists of small ceramic spheres embedded in an electrometric matrix. The damage in this kind of armour would be confined to a relatively small area instead of spreading across, which enables the armour based on them to withstand multiple closely spaced hits.

WAY AHEAD

Research organizations must take initiative in developing these emerging technologies required by army. Memorandum of understanding and agreements in the field of defence technologies must be undertaken with major foreign partners. The technologies developed by research agencies should be transferred to industry for production.

Where ever it is technologically feasible and economically viable, effort should be made to locate and develop broad based indigenous supply sources both in public sector as well as the civil trade for sophisticated and complex equipment. A significant change should be brought out in the role of private sector/ civil trade in the field of indigenisation, ie, from the role of supplier of raw materials, components, and sub-systems, they should become partners in manufacture of complete defence equipment/ systems. The defence industry sector, which was so far reserved for the public sector, has now been opened up for participation by the Indian private sector. The Indian companies are now eligible to apply for license to set up defence industry for manufacture of all types of defence equipment. There is also a need for a major overhaul to convert the defence PSU's into unprotected competitive entities to succeed in the new environment of economic reforms and open market competition. The self-reliance in critical technologies should be a ‘National Mission’ for a country like India, with co-ordinated efforts at national level and commitment from R&D organizations in the country.

Technology change will revolutionize warfare in this century and India cannot remain a mute spectator to this syndrome. The fact remains that countries that can expertise emerging technologies and synergise the same with the innovative operational doctrines and organizational adoption could achieve far high levels of relative military effectiveness.

The Twenty-second Dr Ajudhia Nath Khosla Memorial Lecture was delivered during the Twenty-fourth Indian Engineering Congress, Mangalore, December 10-13, 2009

National Growth, Security and Technology

Shekhar Dutt

Deputy National Security Adviser

Good Morning Ladies and Gentlemen,

It is a rare privilege for me to be delivering the A N Khosla Memorial Lecture. I say so, because I am aware that I am addressing the foremost engineering talent of the country and that too on a platform which embodies the evolution and growth of engineering in India.

I am neither an engineer by training or by profession, yet I have had the good fortune of seeing the marvel of engineering at work when it transformed scientific models into actual defence capabilities. I make this honest confession to highlight the generosity and the spirit of accommodation that I have felt amongst you. I am also aware that I speak in the memory of a towering engineer who pioneered research and experimentation and a pioneer who contributed immensely in India's pursuit of growth. I may mention that in one of my assignments I had an opportunity of drawing inspiration from his research on 'The Design of Weirs on Permeable Foundation'. I wanted to be educated on seepage flows and found a wealth of knowledge in his work. Even today the design of weirs for purposes of irrigation, are based on the ones that he developed. The Bhakra Project symbolises his engineering skills.

The theme on which I have been asked to speak is both contextual as well as relevant. Economy, Security and Technology, which are underlined in the chosen theme, deserve a separate talk even in their individual manifestation. I will, however, make only some brief comments on security as well as economy and focus primarily on the inter-linkage between them.

Since I wish to highlight the challenges that confront us and offer some priority forthright suggestions to confront these, let me set the frame by monitoring that issues of Security, National Growth and Technology require a long term and continuous endeavour at all levels. Let me start by sharing my view on the overall context of Indian policy making and our approach to long term perspectives. National Objectives and National Interests are intrinsically linked to the 'National Will'. In democracies with representative forms of Governance, 'National Will' has traditionally been accepted to be represented through the 'Political Will'. The index of this 'will', can be further related to the spontaneous view and ideological confluence on a particular issue. Constitutionally, it is reflected in the unanimity that the issue or a bill enjoys in the legislatures. This unfortunately remains a factor of general awareness of our chosen representatives and the interest on the subject. There is therefore likelihood of a mismatch between National priorities, and Political priorities, especially where aspects of long term strategisation are to be juxtaposed with short term expediency. Influence of demographic inadequacies, thus, dilutes the actual definition of the National Will. The concepts of National Power and National Security have a long term orientation and in fact demand short term costs and sacrifices', to further long term 'interests and goals'. Whether this can be built into the reality that Indian Democracy is; remains a moot point. There are far too many compulsions of the short term, for democracy in India, to change its orientation unless systemic and structural imperatives are built into our practices. The maturity of the democratic system and awareness of National issues is vital, if National Power is in fact to be realized. This can come about only through serious and wide spread debate on platforms that allow the 'Public Will' to be formulated and articulated. In India, debate on issues relating to the concept of National Power has been lacking. This exclusivity has to be demystified so that accountability is linked with authority and responsibility.

Since vulnerability to individuals and society is a common concern, let me highlight that the Indian mind is comfortable with change and connectedness. I mention this discussion because, historically and culturally, the country has always been predisposed to Peace and Harmony. I am convinced that India presents a unique opportunity to the world. Our way of life, a country of a billion people with all the religions of the world being represented in this vast country of ours, trying to carve out their salvation in the framework of an open economy and an open society, is an experiment that is conducive to global integration and regional peace. I think such a thing has never happened in human history before and therefore, this 'Idea of India'– a tolerant, inclusive and humane civilisation is an idea, which in the 21st century acquires a great deal of relevance when people are talking in terms of clash of civilisations. India proves to the world that the future of the world does not lie in the clash of civilisations, but in the confluence and dialogue among civilisations. This is a value system, which we are attempting to nurture. The enabling environment created since the mid-80s, has allowed India's entrepreneurs and professionals to leverage change and create wealth and employment on an unprecedented

scale. There are other global factors too, that have made India more inclusive to the opportunities and challenges of the world. The linkage between security and National Growth is wound on these two realities.

Let me also make some brief comments on the very concept of 'Security'. The traditional view has been that security is focussed on the application of force at the state level. In today's context it is a very narrow view. It is now widely acknowledged that there is more to security than purely military or policing factors. Today's definition of security acknowledges political, economic, environmental, social and human, among other strands that impact the concept of security. In the most basic terms, the concern for security of the lowest common denominator of every society, namely the 'human being', has resulted in the development of the concept of 'human security', which focuses on the individual. Therefore, the definition of security is definitely broad and is related to the ability of the state to perform the function of protecting the well-being of its people. This formulation harks back to the days of Chanakya and Arthashastra.

However, the problem with such a broad definition of security is that anything that generates anxiety or threatens the quality of life gets labelled as a 'security problem', with a consequent loss of focus. In a democracy, it is the concern of all of us, to ensure that priority and focus towards this is always retained. We cannot afford to tackling particularities and lose sight of the large picture.

Whether it is technology or Security, both these are a dimension of affordability. Let me emphasize that the environment for India's development has never been as favourable as it is now. Increased resources can flow in only if safety and security are ensured. This requires peace, tranquillity and the rule of law. The challenges we face on the internal security front arise partly as a consequence of the unevenness of our growth processes, the inequalities that remain in our social institutions and the shortcomings sometimes of our political institutions. There are other complex issues like language, ethnicity, caste or religion or cultural rights as well. In this complex world, that we live in, all these facets have to be taken into account.

A democratic government has to distinguish between the genuine and legitimate expression of dissent and disaffection and the manifestations of anti-national, anti-social and anti-people threats to our democratic way of life. Often these challenges also arise because we are an open society and have allowed free expression to dissent of varying degrees. This is not our weakness. This is our strength. But in this also lies the challenge that we need to deal with and grapple with effectively. We need to recognise these different facets of the security threats we face and develop effective policies designed to address them.

I am convinced that Science and Engineering are only different facets of the same entity. Basic research leads to new knowledge. This should be considered as the scientific capital. It is from this capital, that we need to draw out practical applications to boost our economy, improve the lives of our people as also secure the environment so that this process can be pursued vigorously. Engineering, faced with unsolved problems, demands knowledge and this further stimulates scientific investigations. It is this interplay of science and engineering, of discovery and invention that has brought about the evolution of machines and techniques to meet the demands of modern society. Electronics has provided industry with devices which are swifter, more accurate and with much larger memory than the power of the human mind. Nuclear energy provides an alternative to meet the future energy needs of the mankind. Similarly, advances in the field of bio-technology, nano technology and cellular research are providing competencies at a pace unthought of in human history. As an overview, it is the coming together of science and engineering which is giving us the technology of today and the hope of tomorrow.

Technology is the driver of Economic predominance. A small analysis about Science & Technology, or S&T, in India may be apt at this stage. The scene in Indian S&T is somewhat mixed. On the one hand, in areas like space and nuclear energy, the public sector in India has demonstrated that it can be an effective international competitor. It thus has a proven technology delivery system. It has even favourably altered international opinion about India's inherent strength. There is no doubt about the availability of excellent human talent in the country, and there are examples, in both the public and the private sector, in harnessing that talent. It follows that shortcomings, if any, are due to some traditional mind sets. These are now being corrected. I feel that it is just a matter of time that Talent, Capital, Infrastructure and Policies will synergise to make India a front runner in Technology.

Our consideration about Technology and National Growth rests on our focus on 'Innovation'. Leadership in innovation is essential for Indian prosperity and security. In a global, knowledge-driven economy, technological innovation the transformation of knowledge into products, processes, and services is critical to competitiveness, long-term productivity growth, and the generation of wealth. Pre-eminence in technological innovation requires leadership in all aspects of engineering: engineering research to bridge scientific discovery and practical applications; engineering education to give engineers and technologists the skills to create and exploit knowledge and technological innovation; and the engineering profession and practice to translate knowledge into innovative, competitive products and services.

Unfortunately, technological innovation in India does not seem to be emerging with the vigour that India needs. Current trends need to be reversed. The accelerating pace of discovery and application of new technologies and the education of a technical workforce, and an increasingly competitive global economy are challenges for which India needs to be prepared for. Our prosperity and security will be impacted by the concern that we show for it. Although many current measures for technological innovation are being taken, these are far from adequate. Percentage of gross domestic product invested in R&D, number of researchers, level of productivity, volume of high-technology production and exports are indices of this inadequacy. There seems to be an increased emphasis on short-term applied R&D. Industry and even government-funded research at the expense of fundamental longterm research. This has continued for far too long. The signs of these trends include the declining interest of Indian students in engineering, science, and other technical fields. The country also oes not seem to have the ability to retain gifted engineering and science students from going abroad.

Considering the magnitude and complexity of these challenges, we simply do not have the option of continuing to conduct business as usual. We must change how we prioritize, fund, and conduct research; how we attract, educate, and train engineers and scientists; how we consider and implement policies and legal structures that affect intellectual property rights and related issues; and how we maximize contributions from institutions engaged in technological innovation and workforce development (e.g., universities, corporate R&D laboratories, government funded research institutions and organizations, and national laboratories).

Of course, major undertakings in anticipation of opportunities are always difficult, but India has a history of rising to the occasion in times of need. With this history in mind, and with full recognition of the magnitude of the effort needed to prepare India for long-term technological leadership, I have a few recommendations.

Long-Term Research and Industry

Long-term basic engineering research should be established as a priority for Indian industry. The Central Government should design and implement tax incentives and other policies to stimulate industry investment in long-term engineering research (like, tax credits to support private-sector investment in university-industry collaborative research).

Engineering Research Infrastructure

Central and state governments and industry should invest in upgrading and expanding laboratories, equipment, and information technologies and meeting other infrastructural needs of research universities and schools of engineering to ensure that the national capacity to conduct world-class engineering research is sufficient to address the technical challenges that lie ahead.

Quality of the Technical Workforce

Considering the importance of technological innovation to the nation, a major effort should be made to increase the participation of Indian students in engineering. For this there is a need for a systemic correction by professional societies, industry, central agencies, and educators at the higher education and research levels to align the engineering curriculum and engineering profession with the needs of a global, knowledge-driven economy with the goal of increasing student interest in engineering careers. Engineering education requires innovations, not only in the content of engineering curricula, but also in teaching methods that emphasize the creative aspects of engineering to excite and motivate students.

All participants and stakeholders in the engineering community (like industry, government, institutions of higher education, professional societies etc.) should place a high priority on encouraging women and under-represented minorities to pursue careers in engineering. Increasing diversity will not only increase the size and quality of the engineering workforce, but will also introduce diverse ideas and experiences that can stimulate creative approaches to solving difficult challenges. Although this is likely to require a very significant increase in investment from both public and private sources, increasing diversity is clearly essential to sustaining the capacity and quality of the Indian scientific and engineering workforce.

Discovery-Innovation Institutes

It is not farfetched to consider establishment of a multidisciplinary discovery-innovation institutes on the campuses of research universities to link fundamental scientific discoveries with technological innovations to create products, processes, and services to meet the needs of society. Funding for the institutes should be provided by central and state governments, industry, foundations, the venture capital and investing community, and universities.

In such a model, the States could provide capital facilities and land. Industry would provide challenging research problems, systems knowledge, and real-life market knowledge, as well as staff who would work with university faculty and students in the institutes. Industry would also fund student internships and provide direct financial support for facilities and equipment, or share its facilities and equipment. Finally, the venture capital

and investing community would contribute expertise in licensing, spin-off companies, and other avenues of commercialization.

Some of the existing centre sponsored engineering research centers or DRDO establishments may serve as a starting point for the development of discovery-innovation institutes. The multidisciplinary scope and scale of the research, education, innovation, and technology-transfer activities of fully developed discovery-innovation institutes will create a far larger impact than institutes like the IITs or RECs.

CONCLUSION

Let me end by saying that the country is at a crossroads. We can either continue on our current course–living on incremental improvements to past technical developments and gradually increasing the technological gap to the more advance countries or we can take control of our destiny and conduct the necessary research, capture the intellectual property, commercialize and manufacture the products, and create the high-skill, high-value jobs that define a prosperous nation. India has the proven ability and resources to maintain the global lead in innovation. Engineers and scientists can meet the technological challenges of the twentyfirst century, just as they met the challenges of an under developed India by creating the tools for military victory and just as they mounted an effective response to the challenge of advances in space.

In the end let me recall the contributions made by Engineer Ajudhiya Nath Khosla who contributed immensely to the developmental surge in India, as an Engineer, as in-charge of Bhakra project, as the first Chairman of Central Waterways Commission, as the Vice Chancellor of the present Roorkee University, as a member of the Planning Commission and as the Governor of Orissa. May his memory inspire us in our efforts towards making India a leader in Technology. In this process, India will automatically become Secure and Economically developed.

The Twenty-fourth Dr Ajudhia Nath Khosla Memorial Lecture

Korea NP Technology, Self-reliance and Nuclear Silk-road Cooperation

The Korean Lamp Illuminated by the Atomic Energy

Young S Hahn

President
The Korean Professional Engineers Association

Rabindranath Tagore, the great poet of India thankfully dedicated a poem for the people of Korea in April, 1929, namely, The Lamp of the East.

'In the golden age of Asia
Korea was one of its lamp – bearers
And that lamp is waiting to be lighted once again
For the illumination in the East.'

Did the great poet foresee the future of Korean lamp illuminated by the atomic energy?

In the year 1959, after 30 years, the Korea Atomic Energy Research Institute (KAERI) and the office of Atomic Energy were established and ground breaking ceremony was held for the foundation of nuclear reactor meant for research purpose (TRIGA MARK II).

After 50 years, the first commercial nuclear reactor, Kori#1 became operational, followed by the construction of 21 nuclear reactors one after another, which accounts for 34% of the electric power that lightens Korea.

In December 2009, the exportation of nuclear power plant to UAE was confirmed which gave Korea the opportunity to illuminate as the lamp of Asia. It is exactly 80 years since Tagore foresaw it and this will go down in modern history of atomic energy power.

Further the success of Korean Nuclear Power Plant in UAE created a ripple worldwide and triggered competitive bidding among globally well-known major nuclear vendors like AREVA and Hitachi-GE. Somehow the little-known Korean nuclear entities managed to put their name on the map for the first time.

Many people have asked, 'Can you please explain how you Korean did it?'Today's Korean nuclear power is not a gift sent from Santa Claus. It is indeed a consequence of numerous trials and sufferings.

Korean peninsula has small area of land and large population and geopoliticaly has frontiers with four powerful nations, such as, USA, Japan, China, and Russia, as well as confrontation between North against South Korea. Moreover, petroleum resources are scarce and Korea also lacks energy and materials resources except for few low-quality coal reserves. At the very beginning, Korea was one of the world's poorest country which became independent from Japan in the year 1945 and then experienced Korean War during 1950 to 1953. The GNP of Korea during sixties was only $76. The issue was then just how to survive. What we Korean still have are zeal for children's education, diligence and firm will to better ourselves.

The only exit way for a country without natural resources was exportation. The first priority was to raise essential manpower and to secured energy access as national priority. It seems that the dream of nuclear power is in line with the priorities of the nation, namely, essential, energy sources and the defence measures.

The development of nuclear power technology in Korea, however, abruptly stopped owing to some situations in the year 1974 like Indian nuclear experiment. Korea Atomic Energy Research Institute changed the name to Korea Advanced Energy Research Institute and the research concerning defence was scattered. The researchers had to find new jobs out of the research institute or had to jump in commercial nuclear power projects. There is an old saying that 'turn evils into blessings'. Putting aside the worries, the researchers of the national laboratory, the high quality manpower at that time was utilised in new projects.

The research oriented projectors and/or producers succeeded first in localization of Canada Deuterium Uranium (CANDU) nuclear fuel and subsequent localization of Pressurized Water Reactor (PWR) nuclear fuel. The result was possible due to the researchers' work in a rigorous schedule of six days a week and more than 12 hours a

day. Thus Korea gained confidence. With the momentum, the Oriental Lamp challenged localization of nuclear power technology.

My country was fortunate to have its highest political leaders consistently supporting nuclear energy policies, from Rhee Syngman, the first President of the Republic of Korea, to the current President, Lee Myung-bak through their personal commitments to nuclear energy.

Critical moments came in the eightees when the national NPP technical self-reliance policy was put to action on a fast track with the construction of Yonggwang 3 and 4 units, which became the benchmark model for the subsequent 10 units of Korean Standardized Nuclear Plants (KSNP) built and operated in Korea.

It all started with the localization leadership from the National Nuclear Research Center (KAERI) which supplied the brain power, whereas the state owned electricity utility, Korea Electric Power Corporation (KEPCO) provided the management oversight and necessary funding.

They were able to formulate a unique scheme in overcoming shortages of experienced manpower, time, and budget which would typically prevail in a developing country. Through repeated construction of the standardized NPPs, Korean entities learned the know-how's from their US mentors (notably Combustion Engineering) in fast track mode, then moved on to their own new generation of advanced pressurized water reactor technology (APR-1400),reflecting improved safety and economics for the competitive world market.

The Korea Nuclear Inc's localization of NPP technology and approaching strategy to the world markets are as follows.

- To select litle known combustion engineering (CE) as the PWR technology licensing partner against industry giants like Westinghouse Electric Company and Framatome in the year 1986.
- To negotiate the most unusual technology licensing contract terms with CE including the royalty free clauses for the third country export cases in the year 1986 following the Chernobyl disaster.
- To adopt and implement the joint design approach with CE to expedite the technology transfer process while constructing Yonggwang 3/4 simultaneously.

Particularly over the next 20 years, constructing 12 repeat projects of Korean Standardized Nuclear Plant (KSNP), Korea will be the fifth largest nuclear electricity producing country after the US, France, Japan and Russia .

The case study report of International Atomic Energy Agency (IAEA) published recently pointed out that nuclear energy in Korea played a crucial role in realizing the economic miracle. The main contents of the report are as follows:

- Korea's nuclear energy results 2.2% added value to the G DP.
- Nuclear technology self-reliance was demonstrated by the development and operation of KSNP (OPR 1000 and APR 1400).
- A successful example of transforming its status from agro-society to hi-tech state enjoying several world-best commodities.

Korea was a recipient when IAEA was established but now enjoys the status of a representative donor country.

The nuclear accident in Fukushima, Japan owing to severe earthquake and Tsunami last March was a curse on modern engineering by the power of the nature which was beyond expectation. We are perturbed whether international nuclear society gets another dark age and whether Korean nuclear program is going to be influenced by it.

In December 2004, Madras Atomic Power Station (MAPS), in India also suffered due to severe earthquake and Tsunami in Sumatra, Indonesia, but there was no nuclear accident, such as, leakage of radioactive materials.

The President of USA clearly attempted to sustain the previous nuclear policy even in the situation when Japanese nuclear accident worsened. Also, France, Russia and Canada stressed that there is no change in the choice of nuclear energy based on the importance of it.

Nuclear accident at Three Mile Island which was followed by Chernobyl made many countries delay or stop their nuclear power plant plans including U S A. As a result, business of world's two best companies deteriorated and consequently GE and Westinghouse were merged into Japanese enterprise. Think about it! What if Korea also hesitated at that circumstances? Are today's achievement of Korean nuclear power technology and the success of the order of nuclear plant at UAE would have been possible?

Wind and solar energies are considered to be prospective renewable energy resources, but they too are dependent on natural circumstances, thus making electric supply vulnerable, which is the reason why they cannot be the mainstream of energy area.

James Lovelock, an expert on environmental issues pointed out that we do not have time to continue experiments with future energy without any promise of when to realize. He determined that nuclear power plant is the only way to at least delay the catastrophe from climate change.

Korean nuclear power will have no choice but to continue its journey. This is the time to make sure that there is no negligence of the security aspects of nuclear power usage. Therefore, the government strengthened the security of nuclear power plant by establishing Nuclear Safety and Security Commission, who is directly responsible to the President, on October 26, 2011.

In 2012, Seoul summit on nuclear security' is going to be held. In summit, basic agendas which will be discussed are response to nuclear terror, defence of nuclear material or nuclear facility, and prevention of illegal transaction of nuclear materials as well as issues highlighted since Fukushima nuclear accident such as safety of nuclear power plants and security measures to protect nuclear terror threats and so on.

The ancient Silk Road was a crossroad of civilization from Europe to Asia over a millennium forming the commercial and cultural bonds of Eurasia. Brave merchants and adventurers risked their lives to travel the long journey to cross the Pamir Mountains and Gobi deserts in caravans of camels and horses on the overland routes.

Big ships sailed though the Red Sea, Persian Gulf, and the Indian Ocean, then through the Strait of Malacca to reach China, Japan and Korea along the coastal routes. Not only the silks and glassware were traded, but also technologies like the gunpowder were transferred. When UAE signs the contract with Korea Electric Power Corporation (KEPCO) and Turkey is negotiating for the new NPP with Japan, suddenly the old Silk Road is coming back to life with nuclear new builds in the 21st century. Japan and Korea have already built up their fleet of NPPs from the indigenous nuclear power technologies delivering major bulk of domestic electrical energy.

India and China have the most ambitious nuclear power program than any other place in the world today, testifying the coming of the nuclear renaissance in a big way. China is all out for transfering PWR technologies from the US and France to set up their own nuclear power technology infrastructures as Japan and South Korea did several decades ago. Only differences is that their scale is bigger and the pace is faster. 100 GWe of new capacity is said to be on line in China alone by the year 2030.

India is following suit not far behind encouraged by the recent easing of nuclear trade barriers from the US.

Additional newcomer countries of Asia may soon include Iran, UAE, Turkey, Vietnam, Indonesia, Malaysia, and Bangladesh. Not all have enormous financial wealth, but they all certainly have the national will for nuclear power and thriving economy to back it up. If one plot at the announced NPP sites of these countries superimposed with the old Eurasian trade routes, the new Nuclear Silk Road can be visualized. Today the Emirates Airline makes daily flights from Seoul to Dubai in a A380 super jumbo carrying some 500 passengers per flight. Soon enough the container freight ships wil sail from Korean ports to Braka NPP site in UAE along the Silk Road and sea routes.

Messages are clear. The nuclear renaissance is coming in a big way in Asia in the old Silk Road countries. The new market is big enough for the major nuclear vendors of today. Interconnectivity among the newcomers and the supplying countries needs to be strengthened further beyond the commercial boundaries to assure absolute safety and security for all operating NPPs in the region. Keeping in mind that just one accident anywhere means the same accident everywhere, international cooperation is needed more than ever before. True meaning of the ‘Nuclear Silk Road’ is to fulfil the promise of peace and prosperity with safe and economic nuclear power in the years to come.

Recently, Korea and India signed an agreement vouching for cooperation on peaceful uses of atomic energy on July 25, 2011. This led to the foundation for mutual cooperation in transacting nuclear power plant design, construction and operation between Korea and India. It is highly promising that the two countries cooperate in nuclear energy successfully.

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Education and Best Practices

Dr S S Mantha

Chairman, AICTE

In the connected world where we live, it is imperative that education is treated as the only glue that can ensure that the world flourishes. Education itself is a best practice that can happen in ones life. It should teach us humility and benevolence and a clarity of mind and purpose. I am reminded of Bhirthrihari the celebrated author of Shatakatrayi who wrote in Sanskrit

भवन्ति नम्रास्तरवः फलोद्गमैः

नवाम्बुभिर्भूरिविलम्बिनो घनाः ।

अनुद्धताः सत्पुरुषाः समृद्धिभिः

स्वभाव एवैषः परोपकारिणाम् ॥

Translated in English this means "With fruits, trees bend, i.e. be humble, with water, clouds hang low, i.e. wealthy good men maintain humble posture, and hence are seen to be benevolent."

In my view it is not unfair to suggest that institutions of higher education have always been created and shaped by the interests of the ruling classes and elites in the societies in which they existed. This means they serve to reinforce the economic, political ideological, and cultural interests of those who create them, fund them, and populate them. We need to take a hard look at this proposition and make education available to everyone who needs it. Atruly inclusive system is in everyone's interest.

Private, public and governmental participation has been steadily increasing in the education sector. Forecasts suggest that, if current patterns of participation continue, more than 30% of today's school leavers will experience higher education in 10 years from now. A GER of about 15 % would certainly need to be revisited and the Governments endeavour to push it as high as 30% is indeed noble. I wish, we attain a figure of 50% in probably the next 20 odd years. Higher education will shape individual lives, the economy and society. Such an activity must be the subject of broad and informed consideration and debate. We need to create a knowledge society. Knowledge is all pervasive and it is said about Knowledge, again a couplet by Bhirthrihari,

जाड्यं धियो हरति सिञ्चति वाचि सत्यं

मानोन्नतिं दिशति पापमपाकरोति।

चेतः प्रसादयति दिक्षु तनोति कीर्तिं

सत्संगतिः कथय किं न करोति पुंसाम्।।

Translated "Knowledge removes lethargy of the intellect, invests truth in the speech, enhances the greatness and casts off sin; cleanses the mind and spreads the fame all around".

We need to empower the youth with education that promotes knowledge and promotes meaningful employment based on this knowledge as applicable to a certain environment. Any activity that promotes this is a best practice and such a pursuit will always benefit the society we live.

It is a challenge to be able to pen down best practices in education. The times we live in are full of flux and recounting any number of best practices of today can at best be a mere perspective. I would like to treat that subject in two stages:

1. How to identify what is best.

2. How to ensure that the produce from the colleges hits the ground running to meet employment and opportunity.

3. The purpose of education is to ensure progress. I would like to choose to lay the foundations of understanding how to record the best practices. How to identify what is best.

The foremost three aspects of education are:

1. The student

2. The faculty and

3. The institution

If there were a way to plot these three properties individually and then have a map that plots all the institutes on a single page; it shall enable us to develop a credible system of rating. drawing up a median and then identifying need-gaps in colleges that remain below the median will help us improve the performance of the colleges and reduce the base area of the education pyramid. Indeed there are underlying layers that form the crux of each of the above aspects.

1. the student: financial, regional and aspirational mapping

2. the faculty: financial, regional, innovational and aspirational mapping

3. the institution: Its ability to create impact in its local vicinity, national and global realms, promote research, retain faculty and consistently out-perform its outturn each year.

While there are no quick fixes to what ails, we need to recognise that access to higher education is much better today, though the systems have become more complex and hence more challenging.

There can not be a "one size fits all" formula and understanding of need gaps when analysed against a backdrop of the best performing teams of faculty, institution and student will help us deliver a system that is optimised for results. From here shall emerge the best practices.

How to ensure that the produce from the colleges hits the ground running to meet employment and opportunity.

The other challenge is the lack of right metrics and planning that do not tie in the produce from the colleges to the available opportunities for the students outside in the commercial world. This leads to lopsided education imparted, unemployment leading to restive youth.

Just as there is a method of forecasting GDP and growth and use available data around FDI, industrial, farm outputs and service industry, similarly, the output of students and skills can be planned to meet such development midway. For that truly would be the exacting of the demographic dividend.

A country blessed with great numbers of youth in productive age can also be severely undercut if they are not in the mainstream. An example would suffice the seriousness of this statement. Over 50% of youth fail between 10th, 11th and 12th grade and probably out of the education scene for ever after that. They surely must be contributing to the growth of the Country in some way as much as contributing to the muck.

An out of box approach and a possible best practice could be to allow them to pass the grade with minimal intervention. The Government's move to exempt Xth grade examinations is truly out of box, critics apart, and worth a million in the bullion market. We need more of that.

Assuming an incremental value addition happens to the entropy of the Universe, it is still worth it apart from the collateral advantage of higher GER's and overall growth in economies brought about by an exalted youth.

We need not have delusions of our education systems on what we need to do and what we have done in the past of managing our education systems. As Sant Kabir said, "Maya Maya Sab Kahe, Maya Lakhe Na Koye, Jo Manase Na Utare, Maya Kahiye Soye" Everyone talks about delusion. No one understands what it is. The one that wraps the mind should be identified as delusion.

For real progress, we need to lead our education paradigm upfront inspired to conceive beyond the norms, into new paradigms of learning, with aspirations above what has been previously achieved for teachers, trainers and learners and transforming the same into behaviours that realise the aspirations and inspire development like Sant Kabir said, "Karata Raha So Kyo Raha, Ab Kari Kyo Pachhataye, Boye Ped Babul Ka, to Amua Kaha Se Paaye". You were about to do this. But why you did not do. You had sown seeds of babul tree. Therefore you should not expect mangos from the tree.

One great incongruity in our system has been development of an orgainsed sector of barely 10% when the developed world over, the figure is in the excess of 80%, and a total neglect of the so called unorganised sector whose development, in reality has unheard potential for many of the ills of this country.

Hence, skills development, both in the organised and the unorganised sector and training as an education imperative is an extremely important activity for a growing economy such as ours. Every student who goes through higher education will be well served if he or she has additional skills acquired along with his / her studies. It enhances the employability opportunities. On the other hand, skills, acquired by a student who does

not go through a formal education, would provide a means of self employment and also a chance for employment in the formal sector. Focused skill development, with employability as the maxim, is the need of the day.

A scheme for Vocational Education where a student can learn competency based skills along with general education at various certificate levels initiated early in the school going, all the way up to a diploma or a graduate level is probably the way to go. With a Bachelor in Vocational Education now duly constituted by UGC is expected to play the catalyst to an otherwise saturated system. A student in this mode is expected to study for a Diploma or a Degree in Vocational education along with acquiring skills. The most important feature of a framework created by AICTE is that a student could also avail of multi point entry and exit between formal or vocational education and the job market. Setting up Community Colleges, either new or in the existing polytechnics also needs to be pushed aggressively so that competency based skills with basic life skills is imparted to enhance the employment potential of our youth.

Private, public and government participation has been steadily increasing in the education sector. Forecasts suggest that, if current patterns of participation continue, more than 30% of today's school leavers will experience higher education in 10 years from now. Higher education will shape individual lives, the economy and society. Such an activity must be the subject of broad and informed consideration and debate. We need to create a knowledge society. Knowledge is all pervasive eventually moving to a truly egalitarian society that provides education for all.

We also need to realise that our youth coming from the kind of financial means that they have, would need to be sustained on some minimal financial incentive to pursue skills for employment and hence we need credible financial models to sustain education for youth. Let me suggest a model for our planners. Out of more than 11,500 institutions that we have in the technical education space, even if we select 5000 under the community college framework as a subset of NVEQF, for the conduct of VE programs the opportunities indeed are massive.

If 100 students are trained in competency based skills, fifty a batch, thrice a week for three hours a day for 48 weeks in a year at least half a million would be trained every year with an increase of 5.3 points in GER. If each of these students, assumed poor, is provided Rs 50/day to take care of travel and food for the period of the conduct of the program, the Grant required on account of this will be Rs 720 Cr/annum. With an annual grant that may be provided to institutes that train these students amounting to Rs 150 Cr/annum the total Project Cost could be estimated at Rs 870 Cr/annum, a small sum considering the employability potential of the scheme notwithstanding the political gains that accrue. This could even become a subset of the hugely successful scheme of MNREGA with yet untapped political gains as well.

We need to inspire, achieve and engage our youth, wean them away from divisive forces, build them into a formidable force to pitchfork the economy to be positioned at a higher plane and of course create a WIN-WIN for everyone so that, again like Sant Kabir said "Kala Nala Heen Jal, So Phir Paani Hoye, Jo Paani Moti Bhaya, So Phir Neer Na Hoye", Ice becomes water in the course of time. The water that has become a pearl will never again become water. We need to convert all our youth into those pearls.

Best practices in Education is notional at best though specifics can always be defined. Anything that adds to overall well being and acts as a force multiplier for economy is a best practice be it in education, medicine, economics or any other.

Thank You

Cricket, Chai and Collaboration for Engineering Innovation Successful India-Australia Partnerships for National Prosperity

Dr Marlene Kanga

National President, Engineers Australia

Ladies and Gentleman,

Thank you for inviting me to deliver the 26th Dr AN Khosla Memorial Lecture at the 28th Indian Engineering Congress organised by The Institution of Engineers (India) here in Chennai.

As you know, my talk today is in the memory of Dr A N Khosla, a distinguished engineer and administrator of India. Dr Khosla was the President of The Institution of Engineers (India) between 1948 and 1950. Like all great engineers, Dr Khosla was involved in significant engineering projects that were crucial to the economic development of India. His early work on the Bhakra Dam Project has generated incalculable economic prosperity for India. Dr Khosla was, like most engineers, a great innovator. During his time in Iraq as a Commissioned Officer between 1918 and 1920, he invented the 'Khosla Disc' for precision levelling across rivers and wide valleys. Dr Khosla, as 'the Father of the River Valley Projects in India', no doubt had many more innovations. It is therefore fitting that my address today will be about the importance of innovation in engineering and the contribution that this can make to the well-being and economic development of our nations.

My speech here today also marks a first step of what I hope will be ongoing and fruitful bi-lateral relations between The Institution of Engineers (India) and Engineers Australia. Both our institutions have British heritage and the similarities in our origins are remarkable. Like Dr Khosla, I am a National President of the Institution of Engineers Australia, the first who is born in India. My career has also involved innovations. As one of the first chemical engineers in Australia with formal qualifications in process safety and risk from the Imperial College in London, I wrote the first documents for the Government of New South Wales on methods of hazard analysis and assessment of societal risk for hazardous industries. These were subsequently adopted in other states in Australia and have been in continuous use since 1989, providing benefits to society and contributing to the well-being of Australians.

As a result of the common British heritage for our respective institutions, we have very similar purposes and structure. The Institution of Engineers (India) (IEI) was established in 1920, as the first professional body of engineers of India. It was incorporated by Royal Charter to promote and advance the art, science and practice of engineering and technology. Today, the Institution has over 750,000 members encompassing 15 engineering disciplines, 104 State and Local Centres across India and five Overseas Chapters. The Institution is governed by a National Council with the President as its Head and Secretary & Director General as the Chief Executive Officer.

The Institution of Engineers Australia (also known as Engineers Australia) was established by Royal Charter in 1919, just one year before the IEI, as the first professional body of engineers in Australia. The mission of the Institution in Australia is strikingly similar to that of India - to advance the science and practice of engineering and technology. Today, the Institution has over 100,000 members, eight Colleges of Engineering and 29 technical societies. Our operations include nine state based divisions, approximately 30 regional groups and four overseas chapters. The institution provides accreditation for all engineering qualifications in Australia. Our governance structure is also similar; we have a National Council with the President as its Head and a Chief Executive Officer who is responsible for managing the affairs of the Institution. Like IEI, we also have a Code of Ethics and a recognition of professional formation, similar to IEI's “Professional Engineer”, called “Chartered Engineer”.

We refreshed out Royal Charter in 2011 and in 2013, during my term, a major achievement has been the development and implementation of the first general member regulations. This brings together more than 25 different policies and regulations, recognises many of our groups and practices formally for the first time, and provides a contemporary governance framework for the organisation.

The IEI represents India at several international bodies, such as World Federation of Engineering Organizations (WFEO), Commonwealth Engineers' Council (CEC) and Federation of Engineering Institutions of Asia &

Pacific (FEIAP). IEI is a full member of Engineers Mobility Forum (EMF) facilitating international mobility of Professional Engineers certified by The Institution of Engineers (India). In addition, the Institution is a member of many other engineering institutions and organisations around the world.

Engineers Australia is also a member of the organisations just mentioned. Our College Boards and technical societies are also members of various related engineering institutions and organisations around the world. Engineers Australia is also a signatory to various multi-lateral international accords that provide international recognition of Australian engineering qualifications via the International Engineering Alliance. In fact, members of Engineers Australia are providing mentoring and support to the Indian Accreditation Board to attain full signatory status to these international accords. They visited India in November 2013 to observe accreditation visits at two engineering educational institutions. Full signatory status to the international accords will provide international recognition to engineering qualifications obtained in India and approved by the Indian Accreditation Board. This recognition will support the intellectual infrastructure for engineering, vital for ongoing economic growth and development.

So engineers representing our two institutions are already working together. At WFEO, where I am now a member of the Executive Council, we work with members of IEI. I look forward to further collaboration, especially in the area of joint projects relating to engineering education standards, engineering innovation and disaster risk management and as a leader of the engineering profession, I am committed to growing and fostering this relationship.

The similarities between our institutions of engineering are not surprising, given the influence of the British in colonial times in both Australia and India. Both countries have similar legal and political structures. English is or course the language of business, politics and socialisation. Our common links with the British have led to a number of cultural quirks and niceties including both countries' love of cricket and a propensity for drinking tea. These provide additional opportunities for linkages at several levels that can make our collaborations more effective. In science and technology, English as the language of research and communication is a powerful facilitator as are strong legal systems which protect intellectual property rights.

There is therefore an opportunity that is not yet fully developed, for engineers in India and Australia to collaborate in research and development to produce innovations in engineering and technology. Innovation is the path to prosperity and engineers are a vital part of that innovation. I am convinced that engineers and scientists and the new technologies and innovations that they develop will be the new wealth of India and Australia and the future powerhouse of our economies. With dwindling resources, and with pressures to have sustainable outcomes, the demand for innovation has never been greater. Innovation and new technology are no longer optional. Continued economic growth and development will only be possible by being smarter and more innovative.

Engineering invention and innovation have been driving economic development for centuries, especially in India. The early civil engineers built the early urban settlement in the Indus valley at Mohenjodaro around 2600 BC, with rectangular street grids, grand buildings and public baths. The Mauryan Emperor Ashoka built the city of Pataliputra in the 3rd Century BC, the largest city in the world at the time controlling a large empire that covered most of India. The Mughal Emperor Akbar built the planned city of Fatehpur Sikri around 1569, as a new capital to enable control of his vast empire. Early scientific and technological developments in India were followed by the European Renaissance that eventually led to the Industrial Revolution.

The Industrial Revolution in the 19th century in the UK and Europe was driven by inventions like the steam engine which reshaped the world, yielding massive productivity improvements to those who had the means and the determination to implement them. Steam engines led to rail networks and industrialisation, jet engines led to global travel, and the first computers eventually enabled global connections and access to vast amounts of information. All this has been made possible with science, technology and engineering. The creativity of engineers changed the world, affecting the quality of life of everyone in most parts of the globe.

Engineers, scientists and technologists continue to be at the forefront of shaping our world in the 21st century. In the last 30 years alone we have seen the rapid rise of computers and communication technology, the evolution of the internet and a range of products and software that have had social and political as well as economic impacts. For example, the Arab Spring in the Middle East in 2012 would not have been possible without the extraordinary accessibility of mobile telecommunications and inventions like Facebook and Twitter. Many developing countries around the world are benefitting from the advantages of technology including clean water, which has eradicated many diseases such as cholera and typhoid.

The ingenuity of engineers will be indispensable and the solutions they create will be as revolutionary in the 21st century as in the previous 200 years. According to the World Health organisation, more than 50 percent of the world's population now lives in cities and the proportion will grow to 70% by 2050[1]. Within 20 years, Delhi is expected to exceed 25 million, Mumbai to exceed 33 million, 13 cities will be larger than 4 million and 68

cities will have more than a million people[2]. The problems of urbanisation including transport, air quality, food security, water supply and sanitation, energy and telecommunications will all need engineering solutions. Engineers will develop innovative solutions to using energy and water resources more efficiently, create renewable sources of energy and reduce greenhouse gas emissions. For countries exposed to natural disasters and rising sea levels, engineers will be enable sustainable solutions to mitigate these risks and build resilience. These are just a few examples of the enormous benefits that engineering provides to humanity.

However technology has not reached everywhere. Although electricity, clean water networks and modern sewerage systems have been installed in most parts of developed countries, they are still missing in many remote Aboriginal communities around Australia and in many rural communities in India. It is estimated that approximately 20 per cent of the world's population—1.6 billion people—do not have electricity in their homes[3]. Approximately 1.1 billion do not have access to clean water and 2.6 billion lack access to basic sanitation. Nevertheless the pace of change is increasing, even in these remote areas of the world, and it is engineers who will implement these changes.

Having grown up in India, I know first-hand of the rapid pace of change that is occurring in Asia, not only in its large cities some of which are larger than the entire population of Australia, but also in its villages and rural communities. My father, an electrical and mechanical engineer, brought electricity to the west coast of India in the 1970s. In the same period, my father-in-law, a civil engineer, developed water supplies for Bombay and later developed four new cities including New Bombay (Navi Mumbai) which now has a population greater than that of Sydney. I struggle to find my way around Mumbai, a city I once knew well, because of the phenomenal changes that are apparent each time I visit.

My ancestral home, some 400 years old, in Goa, is also facing rapid change resulting from technology. It received electricity in the 1960s and our first tap, supplied from the public system, was installed only in 2011. We still do not have a public sanitation system installed. Nevertheless, with smart engineering, this village can become a global player with almost instantaneous communications possible to nearly every part of the world. I have seen our telephone number in our home in Goa grow from just 2 digits in the 1990s to 8 digits. There are now nearly 870 million mobile telephones in India at September 2013, compared to approximately 30 million land line subscribers[4]. Mobile telephone subscriptions have expanded rapidly and importantly, the price is highly affordable, less than 1 percent of the cost in Australia! The ability to communicate has profound implications on the economy and on quality of life, enabling new business opportunities even in remote villages.

At the same time young people in these villages are becoming avid consumers of all things technological. They all have mobile phones and watch “Zee” TV. Large numbers of them recognise that science and technology will give them the edge, they want to become engineers. While the United States and Europe have been world leaders in science and research, Asia is now emerging as a world centre of innovation and technological development. China has overtaken South Korea as a science and research producer and has recently overtaken Japan on a number of measures, such as research and development expenditure and national output of scientific publications[5]. In 2009, Japan in turn overtook Switzerland and the United States to become the highest producer of triadic patent families (a set of patents taken at the European Patent Office, the Japanese Patent Office and the US Patent and Trademark Office). South Korea was sixth in producing triadic patents, also ahead of the US[6].

Economies in Asia, including India, are also becoming knowledge creators. India's large and youthful population and growing expenditure on research and development have lifted its publications of scientific papers from 2.1 per cent of the world total in 2000 to 3.7 per cent in 2010, a share that exceeds that of Australia at 3.4 per cent[7]. With rising wages, India is moving from being the call centre hub of the world to developing innovative technologies for the internet, telecommunications and manufacturing.

At the same time, students in Asia, including India, are increasing their proficiency and even outperforming some of their European counterparts in mathematics and science, the enabling subjects for engineering, according to the latest OECD PISA scores. The pipeline is full and the numbers of engineering students are continuing to grow[8].

Countries in Asia, including India, are already producing the largest numbers of scientists and engineers in the world. The US, UK and Japan produced around 70,000 engineers per year in the 1980s and were leaders in engineering. This situation has now flipped dramatically. While the numbers graduating with engineering degrees has remained constant in these countries, Asian countries are now producing an increasing number of scientists and engineers. China now produces more than 700,000 engineering graduates per year compared with just 6,000 in Australia[9]. This translates to around 530 engineers per million of population in China from less than 200 per million in the year 2000, more than doubling in the last 10 years. This compares with around 284 in Australia, a figure that has remained flat over the past decade. In Korea, the figure is 1600 per million of population, up 25 per cent from 1200 in the year 2000. In Germany, the figure has been flat at 800 per million of population[10]. India also has more than trebled the number of engineering graduates in the past decade and now

graduates an estimated 1 million in engineering and information technology[11]. Several hundred thousand young people take the All India IIT entrance test each year. There are now 15 IITs (Indian Institute of Technology), from the original five, and the demand for engineering education has never been greater.

I am also pleased to say, that the proportion of women in many countries in Asia who are studying and practicing engineering is also increasing and out-stripping the proportions in Australia and other western countries, approaching 50% in some regions in Asia and the Middle East[12].

The large numbers of engineers in India compared to Australia provides an opportunity for collaboration in engineering and technology which can leverage off this difference. India is already rapidly emerging as a hub for global research and development in the areas of pharmaceuticals, the automotive industry, information technology and, communications. Other emerging areas are bio-technology, aerospace industry and the design of semi-conductors. At May 2013, nearly half the Fortune 500 companies reportedly had research operations in India. There are many reasons for this including the use of English as the language of business, robust legal systems that protect intellectual property, a large pool of talented engineers and technologists and a vibrant entrepreneurial culture and eco-system[13].

Australia and India already have strong relationships on many levels. There are strong relationships between the Indian National Academy of Sciences and the Australian Academy of Technological Sciences and Engineering, for example on a project on solar PV[14]. The support from Engineers Australia to the Indian Accreditation Board is also significant.

Indian students are the second largest source of international students in Australia and many Australian universities have research collaborations with their India counterparts. In July 2013, a delegation led by the Indian Education Minister the Hon Dr Pallam Raju, Minister of Human Resource Development, visited Australia to participate in the annual education ministers' dialogue on education cooperation and co-chair the second Australia India Education Council (AIEC) meeting with Senator the Honourable Kim Carr, Minister for Higher Education. The visit provided an opportunity to continue to strengthen collaboration between both countries in the areas of vocational education and training and higher education[15]. The potential liberalisation of the higher education sector in India may result in Australian universities establishing campuses in India and many Australian vocational education providers are interested in such opportunities.

Exchanges of culture between Australia and India have occurred for many years. The Parramasala festival in Sydney[16] is now in its third year and growing strongly and Australia hosted the Ozfest arts festival in India in 2012[17].

In Australia, there is now a realisation of the growing importance of India and other Asian economies to economic prosperity in Australia. Seven out of ten of Australia's top trading partners are based in Asia, the other three are the USA, New Zealand and the U.K., the traditional trading partners which led the list just 30 years ago. China is at the top with a 20% share of all trade to and from Australia, worth 120 billion, Japan is second and the USA is third. India ranks 8thwith trade worth approximately $20 billion or 3% share[18]. So there is a lot of upside for growth in trade with India. India also has signed several agreements in support of trade in various sectors. Importantly, trade is broadening beyond resource projects to manufacturing and services[19].

Over the past 30 years, Australia has also had a growing proportion of migrants from Asia, including India, living mainly in Sydney and Melbourne. According to the 2011 Australian census, Asian born Australians now make up 12% of the nation's population, more than equivalent figures for Canada (11%) and the US (6%)[20]. Australians with Indian heritage comprise 2% of the population and the percentage share is growing. Importantly, as a result of government policy on migration, Asian born migrants tend to be highly educated and skilled and their children have high aspirations and education achievements, especially in engineering and technology. Moreover, migrants from countries like

India are more active as entrepreneurs than Australians. Their businesses are in high technology areas such as computer software, telecommunications and medical technologies. Australians with links to India are a valuable resource in building connections for research and development which result in successful innovations in engineering. The growing importance of Asia and especially India as an economic powerhouse has led the Australian government to recognise the need for greater strategic alignment. It is acknowledged that in the next decades, India will become a leader in the world's economy. India and other countries in the Asian region will become home to most of the world's middle class[21]. The Indian sub-continent will become not only one of the largest producer of goods and services but also the largest consumer of these goods.

India is a giant that is awakening, presenting huge opportunities for Australia but also some challenges. Part of the Australian government's plan is to encourage innovation and investment in new technologies and smart manufacturing that have collaborative networks with research and business organisations in India. There is also a huge demand for investment in infrastructure, for transport, water supply and power. This is where all

engineers have an important role, especially those with connections with India and who have the necessary intellectual capacity and entrepreneurial drive.

Both Australia and India have much to gain in climbing the innovation ladder. According to the 2012 Global Innovation Index, Australia ranks 19 in the world and India ranks 64, although it ranks first in the Central South Asia region[22]. Both countries have recognised the importance of innovation as a priority for nation building, prosperity and competitiveness. The President of India declared 2010 as the 'Decade of Innovation' and established the National Innovation Council[23]. The Innovation Australia Board, of which I am a member administers the Australian Government's innovation and venture capital programs[24]. I am also Chair of the R&D Incentives Committee, the largest government program for industry innovation in Australia.

Australia and India have long recognised the opportunities for collaborative research in engineering and technology. The Australia-India Strategic Research Fund (AISRF) was initiated in 2006 and extended and increased in 2009. $130 million over 10 year will be invested in over 200 projects, the largest bilateral research fund for Australia. Both Australia and India make equal contributions to this Fund for research areas which are of mutual interest and benefit. The priority areas for funding have been[25]:

- The Science and Technology Fund which invested in research projects in agriculture, astronomy, astrophysics, earth systems science, environmental science, marine science, micro-electronic devices, nano-technology and information technology.
- The Bio-Technology Fund which invested in projects involving bio energy and bio fuels, biomedical devices, bioremediation, functional foods, stem cells, transgenic crops, vaccines and medical diagnostics.

The projects have been allocated across Australia and India to 90 leading universities and publicly funded research organisations. In addition, The Targeted Allocations Fund began in 2007 under the AISRF, provides large grants to specific institutions. For example Australia's government-funded research institution, the CSIRO[26] received $3.5 million. $1.5 million was granted to the joint IITB-Monash Research Academy[27]. This funding has supported the development of ongoing partnerships between industry and academia in Australia and India. It involves postgraduate research students spending time working in both countries and receiving degrees badged by both institutions. The first PhD students from this project graduated in 2013. The $10 million facility at IIT Bombay will support the research of up to 350 PhD students by 2015. Large businesses are partners in this project, including BHP Billiton from Australia and Tata Consulting Services from India. The industry-university partnerships are expected to yield a significant dividend in terms of innovation. Areas of research include nanotechnology, bio-technology, water, clean energy, infrastructure engineering, advanced computational engineering simulation and manufacturing. The Targeted Allocations Fund has also funded a range of projects under the Grand Challenge Fund and the Fellowship Fund, totalling $4 million.

The AISRF program has therefore established a successful model for collaboration on innovation in engineering. It is expected that successful commercialisation of the research being undertaken will soon follow. A recent report on collaboration between Australia and India on innovation[28] recommended:

- that funding for the AISRF continue as this has enabled scientific communities in Australia and India to collaborate and establish networks especially among younger researchers in both countries;
- an India-Australia Innovation Forum to be held in both countries, bringing together key stakeholders with a focus on commercialising research;
- a series of scientific missions to raise awareness of the potential benefits of collaboration;
- an award recognising Australia-India innovations, which augments national prizes;
- strengthening of diplomatic presences in science, technology and innovation portfolios;
- consideration of alternative funding models to support various types and levels of collaboration such as “kick start” funds and financial support from large business organisations.

There are many areas of strength in the innovations systems of India and Australia that can prove to be of mutual advantage. For example, India has a unique approach to innovation especially in the area of frugal innovation. With a large population and limited resources, Indians must innovate to thrive, and this is evident at all levels of society. Frugal innovation initially developed to address the needs of low income consumers in India. But the resulting products have global applications because they make minimal use of resources and energy, two global imperatives for sustainability, to keep costs down[29]. It is “new-tech” but not “low-tech”. For example the Tata Nano car, which has been designed to be a low cost solution to personal transportation demands for millions of consumers in India, has 34 patents and is one of the lowest cost cars in the world at $2500. The Chotukool refrigerator, weighs just 7.5kg, consumes a small amount of electricity and costs just $75. The Aakash tablet computer, the result of UK-India collaboration costs less than $50. Another aspect of frugal innovation is market improvisation or “Jugaad”. This type of market based problem-solving is becoming exemplary. India could give the world a new form of innovation30. For example General Electric has adapted its ECG machines to cost one tenth of its western counterpart, delivering huge medical benefits to Indian patients.

The "Jaipur foot" and "Jaipur knee" use local materials and deliver low cost, appropriate solutions to thousands each day[31].

In many areas, India has rapidly achieved significant positions in certain areas of innovation such as biotechnology between 1999 and 2009[32]. Using an Index based on numbers of patent applications filed, India has appeared on the Index for the first time in 2010 with an Index of 1.0 while Australia has moved from 1.0 to 1.5 in the past decade. India's growth rate of ICT patent applications between 1995-2003 was seven times that of Australia in 2003[33]. Twenty-three per cent of the patents filed are from the public sector in India, in Australia it is just 8 per cent. There are other structural differences in the innovation landscape. The number of new business enterprises as a percent of total enterprises is 4 per cent in India whereas it is 14 per cent in Australia. It also takes less time to establish a business in Australia than in India.

We can learn from each other in determining the most cost effective and efficient approach to commercialising innovations.

Australia has always been an innovating nation, with innovations unique to its environment and circumstances. It has the boomerang, the Black Box, the Cochlear Implant, the Cervical Vaccine and the invention of Wifi by an Australian engineer. These innovations have transformed the Australian economy by creating new jobs and generating profits for decades. For example, the Australian backyard icon, the Hills hoist (clothesline) was invented more than 50 years ago. The company that was then established is publicly listed on the Australian Stock Exchange and employs more than 3000 people[34]. It has global sales exceeding $1.2 billion – and is a great example of the multiplier effect of a simple innovation that led to the development of a diversified public company in metal building products, electronics and communications.

Similarly, other large innovating companies, like Cochlear (Revenues $752 million, 2700 employees globally)[35] and Resmed (revenues $1.4 billion, 2700 employees globally)[36] which were spin offs from innovations made in the University of Sydney. They are publicly listed companies with billions of dollars in revenues and generating wealth for Australians with operations around the world. Their engineers are world leaders in their fields. More importantly, they are bringing humanitarian benefits to thousands with special problems with hearing and sleeping.

The benefits are boundless.

There are many examples of innovating companies in engineering and technology in India. Tata Consultancy Services is the world's largest IT firm. It added 40,000 employees in 2012 alone. Infosys, another IT firm is ranked 7th in 2012 in the Forbes List of the most innovative companies in Asia. Hindustan Lever is rated at 5th, with its consumer products sold in the cities and rural areas. Larsen and Toubro ranks 3rd, India's largest engineering firm with operations in shipping, railways, roads and bridges and other infrastructure[37]. Other large integrated groups are operating in a wide range of industries from electronics and telecommunications to automotive industries and manufacturing. It is not surprising that these large companies are all involved in engineering. They generate enormous economic benefits for India and have thousands of employees.

I am sure that our nations will have many more companies like these. In the US, we all know that companies like Microsoft, Cisco, Google, Facebook, Yahoo and Apple have generated wealth for thousands of Americans. We need this kind of wealth generation in Australia and India, where we can lead the world with our innovations and inventions.

Collaboration in innovation can also accelerate developmental objectives of India and lead to the development of the nation. One of the biggest success stories is the mobile and ICT revolution which has fostered innovation in other spheres by connecting people throughout the country, providing the means for optimisation of ideas and their realisation. The government, for example, is connecting Indian panchayats (village administrations) through fibre optic cables with the goal of transforming service delivery in areas, such as, health, education, agriculture. This has truly provided an important means by which this Indian innovative spirit can be harnessed38. The delivery of the Unique Identification Number for all citizens of India is also being facilitated by the ICT revolution and the growing pool of Indian engineers with the knowledge and skill to implement technology that will lead the world[39].

Another great complementary advantage that exists between India and Australia is that a high proportion of India's engineers are recent graduates and young while in Australia a very high proportion will retire in the next decade[40]. We all know that the best innovators are young engineers. Young people are unfettered by rules and by considerations of what might not be possible. Young engineers have the ability to change the world through their innovations in engineering. However mature engineers can provide the benefit of experience, assisting to refine and modify the development of innovations so that commercial success can be achieved at a more rapid rate.

At a recent visit to the West Coast of the USA, I was enthralled by the buzz of talk of new technological breakthroughs and the convergence of computer science, computer hardware engineering, nano-technology, biotechnology and other emerging disciplines to produce new technology breakthroughs and products. These discussions were not held in laboratories and offices but in trendy bars and coffee shops. The main protagonists were young people in jeans who are millionaires in their 20s but there were also mature engineers, also jean clad, who were able to pick out the ideas with promise and provide guidance to the younger generation.

I am frequently asked by young Australians about the difficulties they have in landing their first job. My response is "why not create one?" In the US, more than 50% of engineering graduates from the Massachusetts Institute of Technology (MIT) start their own companies. They are in an environment where they have the confidence to try, failure is not seen as catastrophic and where capital is available to back ideas. Astudy in 1997 found that MIT graduates had founded 4000 companies, created 1.1 million jobs and generated $232 billion in sales – 15% of Australia's GDP. By 2006, 25,600 companies had been founded employing 3.3 million people and with revenues of more than $2 trillion[41]. This is by living alumni. This new breed of leader will be transforming their world though technology and entrepreneurship.

This kind of leadership and entrepreneurship in engineering and technology is needed everywhere. Rather than wait to buy the next big thing, we should be creating it. We engineers should be creating our own innovations, establishing our technology companies and creating a new future for our nations.

Some of you may know that my company has taken Australian research and transformed it into a world-class software product comprising patented advanced intelligent video analysis technology. The technology we have developed is truly remarkable and is delivering solutions that even we did not imagine and is recognised as the leader in its field, with several triadic patents, granted only to significant innovations. We are working in Asia, including India, on implementations. For example we are conducting pilot testing in Singapore, developing our technology for smart city applications and installing solutions in every airport in Indonesia and for security and smart city systems around India. It should come as no surprise that I am an alumni of India's leading engineering institutions, IIT Bombay and this background is being leveraged successfully to build wealth for both Australia and India.

Another question is what lies ahead, and where is the next big thing in technology? This is not an easy question to answer but it is clear that each of our countries should exploit the areas where it has a specific technological leadership and understanding, influenced by our unique culture, economies and environment. In Australia, the CSIRO has identified resource exploration, the reduction in bio-diversity, the growth of Asia and demand for technology and resources from the region as key areas for innovation and growth. The ageing population provides opportunities for biomedical engineering and health related technologies. Advances in human genome mapping and reduction in costs will result in medical breakthroughs which are coming about with the use of advanced technologies. Many of these are also priority areas for India. A report by the Australia India Institute[42] suggests areas of complementarity are water management, nano-technology and ICT.

The rise of the internet and all forms of rapid communication will also provide new opportunities as well as reducing the tyranny of distance. Australia will no longer be a long way from India and will be able to communicate instantly with its partners. Rising consumer expectations and appetite for new technology will also be drivers of innovation. The scope for innovation in engineering and technology is unlimited. I firmly believe that effective collaboration between Australia and India, and capable engineers who develop innovations in engineering, will accelerate development and nation building. Let us play some cricket, drink some chai and work together to increase the rate of partnership. This is the way that we can lead the world in developing solutions that will create a better, sustainable future for us all.

1. http://www.who.int/gho/urban_health/situation_trends/urban_population_growth_text/en/[accessed 11Nov13]
2. http://www.mckinsey.com/insights/urbanization/urban_awakening_in_india [accessed18Nov13]
3. http://www.globalissues.org/article/26/poverty-facts-and-stats [accessed 11Nov13]
4. http://www.trai.gov.in/WriteReadData/PressRealease/Document/PR-TSDSep,%2013.pdf [accessed 11Nov13]
5. http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/sc_usr10_roleknowledge_EN.pdf [accessed 11Nov13]
6. http://www.oecd.org/sti/inno/oecdpatentdatabases.htm#indicators [accessed 11Nov13]
7. http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/publications/2011/4294976134.pdf [accessed 11Nov13]
8. http://www.oecd.org/pisa/46643496.pdf [accessed 11Nov13]
9. https://www.engineersaustralia.org.au/sites/default/files/shado/Representation/Stats/2013_statistical_overview_australia.pdf [accessed 11Nov13]
10. Engineers Australia, unpublished research
11. http://articles.economictimes.indiatimes.com/2013-06-18/news/40049243_1_engineers-iit-bombay-batch-size [accessed 11Nov13]
12. Various research presented at the INWES Asia Pacific Nation Network meetings, 2011-2013.
13. http://www.indianexpress.com/news/the-rise-and-rise-of-mnc-r-d/1114884/[accessed 11Nov13]

14.http://www.atse.org.au/atse/activity/international-collaboration/workshops/australia_india_solar_thermal_ pv_workshop [accessed 11Nov13]
15. http://www.australiaindiaeducation.com/files/130712%20Joint%20Communique.pdf [accessed 11Nov13]
16. http://www.parramasala.com
17. http://www.dfat.gov.au/public-diplomacy/oz-fest.html [accessed 18Nov13]
18. Australian Government, Department of Foreign Affairs and Trade, Trade at a Glance, 2012.
19. http://www.aii.unimelb.edu.au/sites/default/files/Unifinished%20Business_4.pdf [accessed 18Nov13]
20. http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/2071.0main+features902012-2013 [accessed 11Nov13]
21. McKinsey Global Institute, India's Urban Awakening, 2010, www.mckinsey.com
22. http://www.globalinnovationindex.org/userfiles/file/GII-2012-Report.pdf [accessed 11Nov13]
23. http://www.innovationcouncil.gov.in
24. http://www.ausindustry.gov.au/innovationaustralia/pages/innovationaustralia.aspx [accessed 11Nov13]
25. http://www.aii.unimelb.edu.au/science-technology
26. http://www.csiro.au/Portals/About-CSIRO.aspx
27. See http://www.iitbmonash.org
28. Australia India Task Force Report, "Science Technology Innovation: Australia and India", jointly produced with the Australian Academy of Technological Sciences and Engineering (ATSE), May 2013, http://www.aii.unimelb.edu.au/sites/default/files/LOW% 20RES%20INNOV%20REPORT.pdf [accessed 11Nov13]
29. http://www.nesta.org.uk/areas_of_work/economic_growth/assets/features/our_ frugal_future_lessons_from_indias_innovation_system [accessed 11Nov13]
30. N. Radjou, J.Prabhu, S.Ahuja, "Jugaad Innovation: AFrugal and Flexible Approach to Innovation in the 21stCentury, Random House, India 2012
31. http://www.nesta.org.uk/areas_of_work/economic_growth/assets/features/our_frugal_future_lessons_ from_indias_innovation_system [accessed 11Nov13]
32. OECD, Key Biotechnology indicators, Dec 2011, http://www.oecd.org/science/inno/49303992.pdf [accessed 11Nov13]
33. OECD, Working party on the Communications Economy, June 2010, http://www.oecd.org/internet/ieconomy/45576760.pdf [accessed 11Nov13]
34. Hills Holdings Limited Annual Report June 2013
35. Cochlear Limited Annual Report June 2013
36. Resmed Limited Annual Report 2013
37. http://www.forbes.com/pictures/ffgh45gif/3-larsen-toubro-india/ [accessed 11Nov13]
38. C. Banerjee, Director general, Confederation of Indian Industry, Global Innovation Index Report 2012, http://www.globalinnovationindex.org/userfiles/file/GII-2012-Report.pdf [accessed 11Nov13]
39. N. Nilekani, Australia India Institute, October 2013, http://www.aii.unimelb.edu.au/events/australia-india-institute-oration-nandan-nilekaniindia%E2%80%99s-transformation-role-information [accessed 11Nov13]
40. Engineers Australia: The Engineering Profession A Statistical Overview, 2013, www.engineersaustralia.org.au
41. https://entrepreneurship.mit.edu/uploads/Entrepreneurial_Impact_The_Role_of_MIT.pdf [accessed 11Nov13]
42. http://www.aii.unimelb.edu.au/science-technology

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Making Rivers Live and Interlinking Rivers – a New Concept

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United Nations (OPS) Consultant

Ladies and Gentlemen!

At the outset I would like to thanks Er G Prabhakar, FIE, Past President of The Institution of Engineers (India) for requesting me to deliver the 27th Dr A N Khosla Memorial Lecture today at the 29th Indian Engineering Congress.

Dr A N Khosla was an eminent engineer of International reputation who trotted on the Globe during the pre-independence and post independence era. He was the President of the Institution of Engineers between 1948 and 1950. Most of the major irrigation projects constructed immediately after the Independence bear his stamp and authority. He made several original contributions in calculating maximum flood discharge of rivers (Khosla's theory); design of aprons of weirs and barrages on permeable foundations and several others, which are all still being used today. Dr Khosla spent most of his life on innovative aspects related to rivers and it is therefore fitting that my address today is about a new concept developed by me to make Indian rivers perennial and thereafter interlinking them.

1. Introduction: Most of the sub-basin rivers and major rivers do not have any flows during the non rainy season and summer seasons. This article deals with a new concept developed by the author to make all these rivers live (flow with water throughout the year), and also on a feasible and implementable solution for a Ist stage on the interlinking of rivers.

2. Rivers: In India, there are 22 major rivers, out of which 14 are more important. There are 44 medium rivers joining the sea out of which 19 are west flowing and 21 are east flowing. Similarly out of the 170 minor rivers joining the sea, 75 are west flowing and 95 are east flowing. In addition there are about 300 tributary sub basin rivers. Thus there are a total of over 500 major, medium, minor & sub basin tributaries in the country. Most of these do not have any flows in the non rainy season and are bone by in summer. However the major rivers do have non monsoon flows but extremely small and negligible when compared to the monsoon season flows. For example the mighty Ganga has a non monsoon flow varying from 35 to 65 cusecs (1236 to 2296 cusecs), at Kanpur, when compared to the flood flows varying from 30,000 to 60,000 cumecs (10 lakh to 20 lakh cusecs). It would be a great boon to the country, if a technical solution can be evolved to make all these rivers live so as to ensure environmental flows and also meet other essential water requirements during summer.

3. Non-Monsoon Flows Strategy: One method of ensuring sufficient river flows in non – monsoon period is to construct a storage reservoir on the river and ensure release of water downstream of river through the dam sluices such reservoirs are usually built to divert water through canals for irrigation and other purposes. But in recent times it has become increasingly difficult to construct big dams (as explained in para 14). A viable alternative will have to be therefore worked out to store flood water. The concept of the author is to store a part of the flood water within the maximum flood zone of the river itself. This can be done all along the river through silt free gated barrages (explained in para 13). These barrages would not allow any silt to be deposited on the upstream of barrages since any silt getting deposited will got flushed out when the radial gates are operated. The barrages would be spaced at frequent intervals, one below the other, such that the stored water of a downstream barrage reaches up to the immediate upstream barrage. This would render the whole river as a long lake of depth equal to M.F.L (Maximum Flood Level) depth, for a sufficient length of the river. Water storage in each barrage can vary from 1 to 10 TMC. There is no need to acquire any lands to store water, since the entire storage would be within the maximum flood zone of the river, where lands are owned by the Government. Also (unlike a reservoir) no villages, forests wild life would get submerged and these storages through barrages are ecofriendly and also ensure environmental flows. Though the water storage in a simple barrage is much smaller than a reservoir, when 30 to 60 such barrages are constructed in a river, the combined storages of all these barrages is almost equal to that of a big reservoir constructed on the river. A schematic representation of locations of 26 barrages all along Ganga river is given in Fig 1 (with exaggerated vertical scale) to make the concept understood. When the above strategy is adopted, there will be water all along the

length of the river, for a sufficient depth as well as some flow as explained below, throughout non monsoon and summer periods. Some major advantages of making the rivers live in the above manner are explained here.

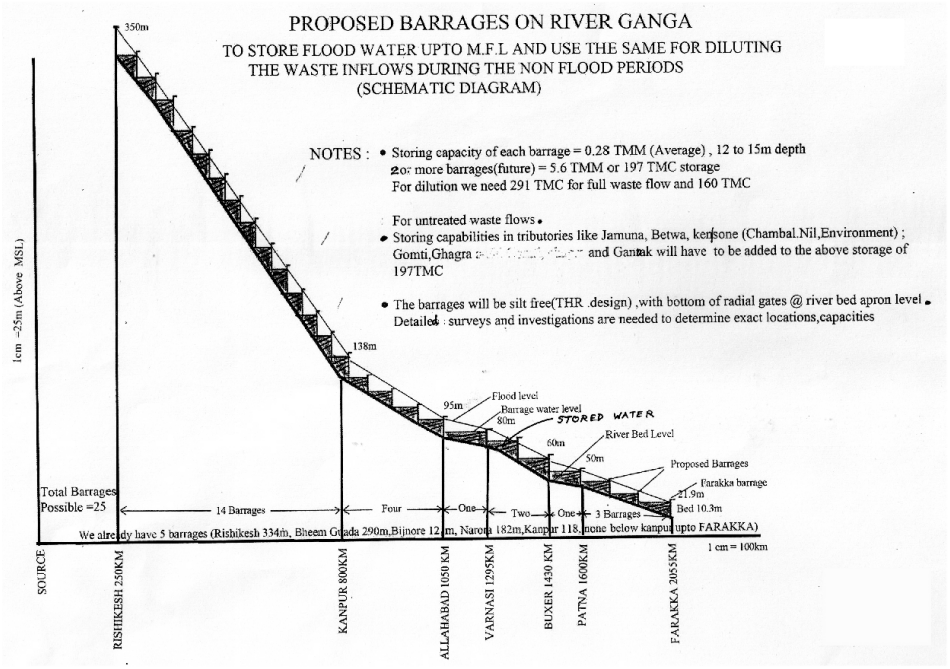


Fig 1

4. Major Advantages of Making Rivers Live: When barrages are constructed to render rivers live, the following major advantages occur:

- Hydro Power generation at each barrage
- Inland water navigation, through the navigation locks at barrages
- Development of inland fisheries with fish ladder provided at each barrage
- Ensuring environmental flows, from start to sea end of the river facilitating growth of wetland mangroves
- Increase in ground water recharge in the entire basin and sub basin and prevention of sea water intrusion into ground water in coastal areas
- Interlinking of the live rivers through inland water navigational canals, which also would supply water for drinking and industrial purposes.
- Development of Industries by the sides of navigational routes in the river and interlinking canals
- Tourism development and aquatic sports Each one of these advantages is now discussed.

5. Hydro Power: At each barrage 1 to 30 MW hydro power can be developed based on the depth and discharge of flows. For example in the case of Ganga and some other major rivers it could be as high as 30 MW, whereas it would be only 1 MW in some sub basin and minor rivers. The flow discharged from turbines of any upstream barrage is available for generating hydro power in the downstream barrage and like that till the end of river. As one goes downstream the flows in river would get increased due to additional flows entering the river from the increasing catchment areas. Surplus water diversion from the live river is not contemplated in the first stage of development. It is contemplated only in the third stage when reservoirs would be constructed on the rivers. However there would be some loss of flow in the river due to recharge to ground water and allowing a small navigational flow for the interlinked canal, (which also would supply water for domestic and industrial purposes). This reduction occurring in the river would be more than compensated by the natural increase in flow with expansion of catchment area as well as part release of stored water from each of the barrages. Incidentally the flow released from one hydro power station on the river to the down stream side would add to the environmental flow required for the river.

6. Inland Water Navigation in Rivers: A navigational lock is provided on one side of each barrage to facilitate inland water navigation in the river. This is needed to facilitate the vessels (boats, launches and small flat bottom ships) to negotiate drops ranging from 4 to 8 meters at each one of the barrages. Certain quantity of water will be needed to fill the lock each time the vessels negotiate the lock and the same will be emptied into the river. This flow would in turn be available for all the 30 or 40 navigational locks on the down stream side. Incidentally this flow would be available as environmental flow all along the river, upto the sea (or confluence to a main river). Navigational ports will have to be constructed at strategic points on the river and road connections for these ports will have to be established. Infrastructure such as wharfs, ware houses, cranes etc.

will have to be built. The same facilities will have to be provided for the interlinking navigational canal from one river to the other. Since cost of transport through inland water navigation is one tenth of rail transport and one twentieth of road transport, economic growth would occur all along the river and the interlinking canal (due to cheap transport of raw materials and finished goods).

7. Fisheries Developments: When water is stored all along the rivers throughout the year, fish would develop to their natural big size according to their life cycle of growth. In the case of Hilsa (Indian Salmon) fish in rivers joining the sea it can grow 10 times bigger than earlier. This is because the fish would be able to complete its full cycle of life in fresh water and sea water. Thus when the rivers are made live throughout the year, the fish catch could increase 20 times more than that of the earlier catch. Fish ladder will have to be provided at each barrage to enable the fish to travel upstream or to reach their spawning (breeding) water zone. Water released from fish ladder of one barrage would go to the downstream barrage and like this, the same water can reach upto the downstream most barrage in the river. Incidentally this flow also would add to the environmental flow required by the river.

8. Environmental Flows: I would like to coin a new phrase “River's Riparian Rights (RRR)” for setting apart a certain minimum flow in the river during non monsoon season for “ river's own USE”. After satisfying this right, then only the river water can be used for other developmental purposes and general good of the people. The ‘RIVER USE’ relates to supporting all the living species of flora and fauna which depend on the river, as much as human beings depending on it. At the place where the river joining the sea, there will be wetlands and mangroves in the wetlands. The man groves are beneficial to the mankind in several aspects including reducing the damaging effect of storm surges, during cyclonic storms. When there is sufficient environmental flows through out the year, there will be luxurious growth of the mangrove trees and creepers. Such a growth of vegetative species in the swamp is beneficial to the fish and cru stations species for spawning, breeding and growth of aquatic life. There mangroves also support bird species. The ecological balance of Nature and the living species is beneficial to the entire coast land and this can be ensured by maintaining a minimum continuous flow in the river through out the non monsoon period. The water let down from each barrage, through hydro power tail race, navigation lock and fish ladder will form the base discharge of environmental flow. If this is not adequate, required additional flows can also be let down from the stored water in each barrage. The benefits due to ensuring the minimum environmental flows in the river cannot be easily quantified in terms financial gain. But the quality of ecofriendly life for the humanity living in the basin will be very much improved in terms of health apart from the wealth it generates indirectly by way of drastic reduction in losses due to storm surges (during the cyclones). Also environmental clearances for the whole project from Government of India would become easy when such an ecofriendly design is incorporated in the project. Opportunity cost of water available during the summer period would be very high especially in the drought prone areas where such projects are constructed .

9. Ground Water Recharge: Usually the recharge to ground water takes place during the rainy season and when flood waters flow in the rivers. There will be no recharge during the non monsoon period. But when the rivers are made live and when there is environmental flow in the river through out the year, the recharge to ground water takes place through out the year. This would enable the ground water table levels rise up and reach upto 2 meters below ground level when compared to the earlier levels of 10 or 15m. below ground level. This would happen predominantly on both the sides of the river and also to some extent in the entire river basins Increased ground water availability in the weathered zone aquifer would enable extraction of ground water from dug wells where the specific storage in the soils is 50 or 100 times more than that in rock. In such a situation, there will be no necessity to drill bore holes in rock and extract the meagre extent of water stored in the fissures of rock. It is relevant to observe here, that extraction of ground water through bore holes is done by farmers, only when the dug wells go dry. They would always prefer open dug wells to bore wells because, lessor HP pumpsets are required to pump from shallow depths.

The other reasons are:

a) Water is available in plenty in the weathered zone soils, than the hard rock

b) there will be no dissolved salts (e.g. Flourides) unlike in bore holes.

All this is feasible only when there is sufficient recharge to ground water and the live river is one source to recharge through out the year. The increased ground water storage would be able to meet to a large extent the drinking and industrial water requirements of the river basin. When the environmental flow throughout year is ensured the sea water intrusion into the land ground water aquifer is prevented. This is a great boon for the coastal areas all along the sea coast, which are now facing shortage of drinking water during the non-monsoon periods.

10. Inter-linking of Live Rivers: Water can be taken from one live river to another river by a gravity navigational canal as explained in detail in para 17 below. When the main river is made navigable (by creating a

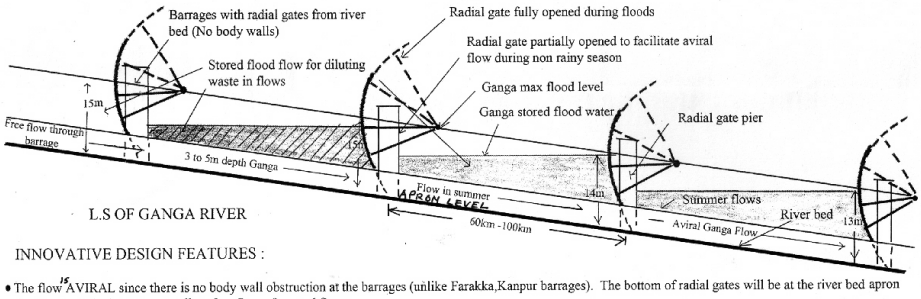
minimum water depth of 3 m required for the draft of vessels), the interlinking canal also should be made navigable by providing a minimum depth of 3 m throughout the length of the canal.

11. Industrial Development: Industrial development would take place quickly when water is provided through the storages created in the barrages. There are financial advantages to industries located on either side of the river and navigational canal. These would be in the shape of cheap transport (1/20 if road transport), when raw materials and finished goods are transported through the navigational route. Also the power required for the industries can be supplied through the hydro power stations located at each barrage. This hydro power would be available through out the year since environmental flows are assured through storages in barrages and water let out from navigational locks and fish ladders. With assured water, power and cheap transport, the industrial growth would be rapid, resulting in over all economic development of river basin.

12. Tourism Development: Ecotourism is possible all along the navigable river and canal, wet lands, mangroves and the development facilities (Hydro Power, fisheries) created. Other attractions would be water sports, boating races, Boat houses for camping etc. This Tourism sector would generate local employment and economical growth in the area.

13. Silt Free Barrages: Conventionally barrages are designed with a body wall of 3 m to 5 m height and gates provided above the body wall. This is to primarily facilitate raising the water levels in the river to command gravity flow in the main canals on either side. In such a design, siltation would eventually take place on the upstream of the barrage for several kilometres length of river after some years of construction. At the barrage site, the siltation would eventually occur up to top of the body wall. Souring sluices are provided at either end of the barrage to keep the upstream side of head sluices free from siltation, thus preventing any silt entering the main canals when the sluices are opened.

STUCTURAL DESIGN FOR AVIRAL AND NIRMAL GANGA FLOWS
(THEMATIC DIAGRAM)

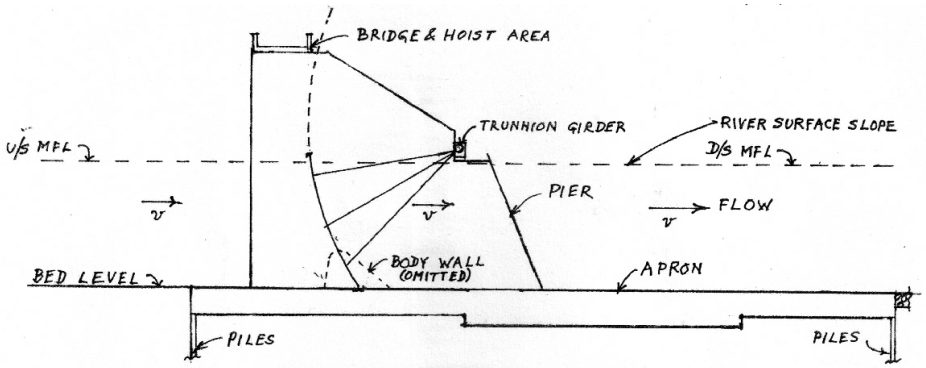


INNOVATIVE DESIGN FEATURES :

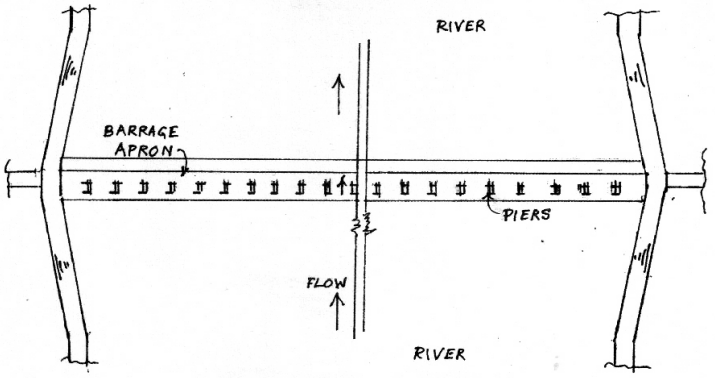
- The flow is AVIRAL since there is no body wall obstruction at the barrages (unlike Farakka,Kanpur barrages). The bottom of radial gates will be at the river bed apron level and will be kept open to allow free flow of normal flows.
- The stored water upstream of each barrage will be released to downstream side to provide enough water for dilution of waste inflows to the extent of atleast 10 times the waste water .Thus Ganga will be rendered NIRMAL.
- There will be no siltation on upstream of barrage as each vent will function as a scouring sluice
- The length of barrage will be more than the width of river to compensate for pier obstruction.The vent will be more than the river cross section flow area.Velocities U/S, through barrage and D/S will be the same and hence there will be no "afflux" due to the barrage.
- The radial gates will never be fully closed -unless for maintainance and repair purposes.

Fig 2

In the silt-free barrage design (patent applied), the body wall is totally omitted (vide Fig 2). The radial gates provided in the barrage will be designed in such a manner that the bottom of the skin plate of the gate touches the apron, located at the bed level of the river. When the radial gate is opened, the silt if any deposited will be flushed out to the downstream side as happens in a scouring sluice. Thus the entire barrage can be considered as a series of scour gates. Fig 2 indicates a schematic L.S of Ganga river having four barrages. The height of radial gate may vary from 5 m to 15 m (river Ganga) depending upon the depth of flow in the river and how large is the discharge. When the radial gate is fully opened the maximum flood of the river passes freely with no obstruction what so ever. However there will be reduction in the width of flow at the place of a barrage due to the construction of piers. This loss in width of natural river flow at the barrage site, is compensated by extending the length of barrage as shown in Fig 3. In this design (since there is no obstruction to flow through a body wall), the velocity upstream of barrage, through the barrage and down stream of barrage will all be the same. Thus there is no afflux (increase in water level) on the upstream of barrage due to construction of the barrage. On account of this, there is no need to acquire any land at any place higher than the Maximum Water Level (MWL) all along the river.



SCHEMATIC CROSS SECTION OF BARRAGE



SCHEMATIC PLAN OF BARRAGE

DESIGN FEATURES:-

1. Body wall is omitted (shown dotted). Radial gates rest on apron.
2. Aprons will be @ Bed Level. All vents of barrage behave like scouring sluices. Vents near flanks also will have aprons @ deep bed level.
3. There is no obstruction to river bed load and other sedimentation transport. Hence there will be no siltation. River 'regime' is not altered.
4. Vent ways of barrage will be equal to river flow cross section area. Where necessary length of barrage can be increased to facilitate this, and smooth transitions provided at sides as well as at bed (near flanks)
5. There will be no 'afflux' as velocity of flow (v) in river and vents will be the same. The river surface profile is not altered. As such there will be no 'Back Water Curve Effect'.

Fig 3

14. Major Reservoirs: As noted in para 3, one well known method for making rivers live is to build major and medium dams on rivers and allow flow in the river throughout the year (along with allowing flows into irrigation canals). Though it was possible to construct such big dams in the post Independence era, it has become virtually impossible to construct them any more after the 1970s, due to enactments of the following Acts and passing of new rules and regulations.

a) Wildlife (Protection) Act 1972 read with Indian Forest Act 1927

b) Water (Prevention and Control of Pollution) Act 197

c) Air (Prevention and Control of Pollution) Act 1981

d) Forest (Conservation) Act 1980

e) Environment (Protection) Act 1986

f) Social welfare and Tribunal welfare Acts of 1990s regarding relief and rehabilitation, land to land compensation in project benefitted areas

g) Consent of project affected persons

h) Acceptance of gram sabhas through open hearings

i) Forest Rights Act 2005.

When the projects were constructed violating any of the above, the affected persons would go on appeal to courts and obtain stay orders. The same bottlenecks would be faced in the case of interlinking of river basins in India, which requires about 80 major and medium reservoirs to be constructed. In view of the above realistic solution the only workable solution is to construct a series of barrages along the river and store the flood water upto the maximum flood levels (patent applied for the new concept).

15. Financial Aspects of Silt Free Barrages: Each barrage will have to be surveyed, designed and estimated separately. Based on the data available appropriate costs can be estimated. It would vary from ` 10 Crore. For barrage (e.g. Bunandi river, Rajasthan) to ` 1,000 Crore in a major river (e.g Narora Barrage, Ganga River). Thus if 20 new barrages are constructed on Ganga river it would cost ` 20,000 Crore In the case of a minor river it would cost ` 300 Crore to construct 30 barrages. The costs would include Civil, Electrical and mechanical works for Hydro Power Station in barrage, navigational lock and fish ladder. If these costs are rightfully apportioned to the respective sectors of Hydro power, Navigation & fisheries respectively no separate budget (except for land acquisition and connecting roads) would be needed to implement this project of making rivers live.

When these three sectors are offered to private partnership the Government participation would be minimum as discussed in para 16 below.

16. Public Private Participation (PPP): With private participation in the project 90 to 95% cost of the project would be met by private party who will be assigned with the project. The private party gets income through selling hydro power, collecting tariffs for navigation vessels and revenue from the fish caught. This annual income would give profits to the private party after meeting the expenses of repayment of capital with interest and also for annual repair, renewal and maintenance costs. The role of Government would be to fix reasonable tariffs for different items such that the private party may not exploit the situation and make only reasonable profits. The Government has a few more roles namely acquiring the land required for navigation canal, providing land for building the infrastructure for navigation (e.g. wharfs, ware houses etc), providing land for infrastructure for fisheries (ie.g. cold storage ware houses) and building connecting roads to the new navigation ports. Thus the Public Participation (by Government) would be about 5 to10% of the cost of the project whereas the balance cost would be borne by he private party. Thus a major programme of building silt free barrages through out India, can be executed with very little Government finances through the PPP mode of execution. Also the entire project can be started straight away through out the country. To facilitate this the Governments should take the first step of survey, design and estimation of each barrage and later call for tenders in the PPP mode to execute the project. Thus this giant project in India can be achieved without any major allocation of grants. This is an important plus point in making all rivers live and deriving all the 8 benefits mentioned in para4.

17. Interlinking of Rivers and Interbasin Transfer of Water: National Water Development Agency (NWDA) had suggested 30 river links (14 in Himalayan grid and 16 in Peninsular grid) and prepared prefeasibility reports for all the river links and feasibility reports for some links. To make these links to work successfully about 80 major and medium dams would be needed. Here lies the crux of the problem. We have noted in para 14, that it would be impossible to construct any new major reservoirs in the future. This proposal has thus become a non starter. The only one link (Ken-Betwa) taken up for execution was stopped in 2011, due to non clearance by the Ministry of environmental and Forests (MoEF), as this project submerges lands in Panna Tier Reserve Forest. Environmentalists cry foul about such big reservoirs and canals for various valid reasons, but I would not like to go through them here though there is sufficient merit in the same. This is because, even before such an environmental review, the whole project will have to answer several practical questions and doubts on the hydrological feasibility , technical analysis and administrative aspects, as detailed below.

a) Himalayan Grid: The reservoirs required for the functioning of this grid will have to be constructed in Nepal, and Bhutan as no reservoir can be constructed in the Gangetic and Brahmaputra plaines. Even if technical issues like building high dams in the most sever seismic zone of 8 to 9 in the Richter scale, environmental clearance etc. are solved, the approval of the neighbouring countries to construct dams in their countries is a great stumbling block. In the present international scenario objections are raised by the neighbouring countries, for constructing a high dam, in a country in its own territory. Famous examples are India objecting to construction of dams on Brahmaputra by China, Pakistan objecting construction of dams by India in the Indus basin within India. The possibility of construction of big Reservoir in one country for the exclusive use of another neighbouring country would therefore be near impossible. This is the reason why consent could not be obtained from Nepal and Bhutan, though Government of India (GOI) is negotiating with them for the past about 2 decades. There is no hope in the near future regarding obtaining their consent , unless these are undertaken as joint projects of both the countries and also with Nepal and Bhutan getting some benefits out of these projects. The feasibility Reports will have to be prepared jointly by both the Governments in order to have acceptance. Unless this is accomplished there is no point in finalizing plans and estimates for the Himalayan link canals. It is similar to completing canals of an irrigation project without the dam coming up (e.g Polavaram Project).

b) Brahmaputra Grid: It has to be realized that Brahmaputra river is the only river out of the Himalayan gird that is having surplus water to spare to the Southern Peninsular Grid. The link proposed from this river is the most wrongly understood by the public. Peoples leaders and administrators tend to think this task can be easily accomplished with the cooperation of the Bangladesh Government. A brief review of the past history on sharing of water resources of Ganga and Tiesta rivers between India and Bangladesh, would enlighten anybody, as to

how formidable and near impossible it is to make Bangladesh agree to this link canal. A 30 year water sharing agreement between the two countries came into effect from December 12, 1996. Bangladesh was repeatedly agitating that water is not being released to Bangladesh at Farakka Barrage by India as stipulated in the Agreement especially when the flow available at Farakka (to share between both countries) falls below 70,000 cusecs. They also strongly protest that when the available flow falls below 50,000 cusecs, they are not getting the 50% flows they should get as per the Agreement. River Tiesta flowing from India into Brahmaputra in Bangladesh is causing another worry to Bangladesh since any such treaty, is being opposed by Chief Minister of West Bengal. In this type of a conflicting scenario where Bangladesh feels that they are let down by India, it is near impossible to obtain their consent to take a link canal from Brahmaputra to India through their country. (for sufficiently a long distance). Unless this link canal is constructed, there is no scope of transferring surplus waters of the Northern Himalayan grid to the Southern Peninsular grid. All the sacred philosophy of transferring waters from the surplus basins to deficit basins would be a tall talk limited to papers only. Realising these difficulties with Nepal, Bhutan & Bangladesh the NWDA & GOI decided to concentrate on the Southern Peninsular grid independent of the northern Himalayan grid. Let us now examine the feasibility of the peninsular grid in a rational and logical manner.

c) Southern Peninsular Grid: There are 16 links in this grid. The NWDA found it feasible to transfer primarily from the surplus basins of Mahanadi and Godavary rivers to the other deficit rivers through 9 link canals (the other 7 links are in the small rivers and western ghats rivers). According to their calculations there is a surplus of 230 TMC in Mahanadi basin and another surplus of 530 TMC in Godavary basin and that this 760 TMC water can be transferred to all the deficit river basins in the south. There are some assumptions in this bordering on fallacy as they are unrealistic in the present day conditions. One proposal is to transfer Mahanadi water, through a barrage and link canal connecting Godavary near Dowlaiswaram, almost at the fag end of the river. It is intended to transfer all the 230 TMC water during the monsoon and there will be no supply during the non monsoon period. Floods occur in both Mahanadi and Godavary at the same time during the monsoon season and there is no point in supplying water to Godavary when it is actually realing under heavy floods. Realising this and in order to transfer the required water during the non monsoon period, another proposal was made to build a reservoir at Manibhadra on Mahanadi, to store the flood water and supply the same when required in the Godavary basin. Orissa Government opposed the construction of a reservoir and maintained that if a reservoir is to be constructed, they would themselves need the water to irrigate the vast drought prone areas in their state like KBK area which is already getting huge grants to develop that area. There is also an opinion expressed that when Godavary water is already being diverted by Orissa Government to the Mahanadi basin, through a project recently completed. Water from Indravathi (an important tributary of river Godavary) is now being diverted to river TEL, an important tributary of Mahanadi. This was achieved by constructing a dam on Indravathi and diverting water through a Tunnel (negotiating the ridge) to the Tel river. There is no need for Mahanadi water to supply to Godavary basin. They maintain that there is no surplus at all in the Mahanadi basin and that the basin itself is a deficit basin. In this scenario it is almost impossible to divert any water from Mahanadi, for the simple reason that they need all the water in the river to meet the requirements within the state itself. Let us now examine the case of diversion from river Godavary.

According to the hydrological computations made by Andhra Pradesh and Telangana State, there is no surplus water in Godavary after diverting 80 TMC water to Krishna basin (through Polavaram Project). All the allocated 1480 TMC water would be utilized under the existing projects and projects now under construction. In fact, both the states are actually planning to utilize surplus waters of Godavary (available with a lesser dependability of say 66%), through projects like Dummagudem in Telengana, North Coastal Andhra irrigation project etc. Thus there is now no surplus of 530 TMC water in Godavary in the new scenario. With no water available from Mahanadi & Godavary the proposed 9 southern links would not be feasible unless a portion water from the Brahmaputra river is transferred to the peninsular grid.

In the case of the balance 7 links in the small western ghats rivers. Kerala State rejected the diversion of Pamba to Tamilnadu maintaining that they need all the water of the river to be used within the State itself and that there is no surplus in the river to be spared. On similar grounds Karnataka State rejected the Netravati-Hemavati-Link. The other 5 links (ken- Betwa; Parbati-Kalisindh- Chambal: Par – Tape Narmada; Damanganga – pinjal; and Bedti - Wardha) can be executed as they are hydrologically feasible. However the nine clearances stipulated (as indicated in para 14 above) will have to be obtained to facilitate construction of the same. The history of stopping the construction of ken-Betwa link (for want of environmental forest and wild life clearances) should not get repeated. Thus out of 30 links, most of them are bogged down in unsurmountable problems and only 5 small links can be taken up for execution.

I would like to suggest a viable alternative for the 25 major links, which can be executed straight away. This alternative is eco-friendly much lesser in cost and would give multiple benefits apart from the facility to execute under PPP mode. Another major advantage is that this alternative design can later be expanded in scope so as to

transfer surplus water to deficit basins as originally intended in the main interlinking project. Let us discuss this proposal.

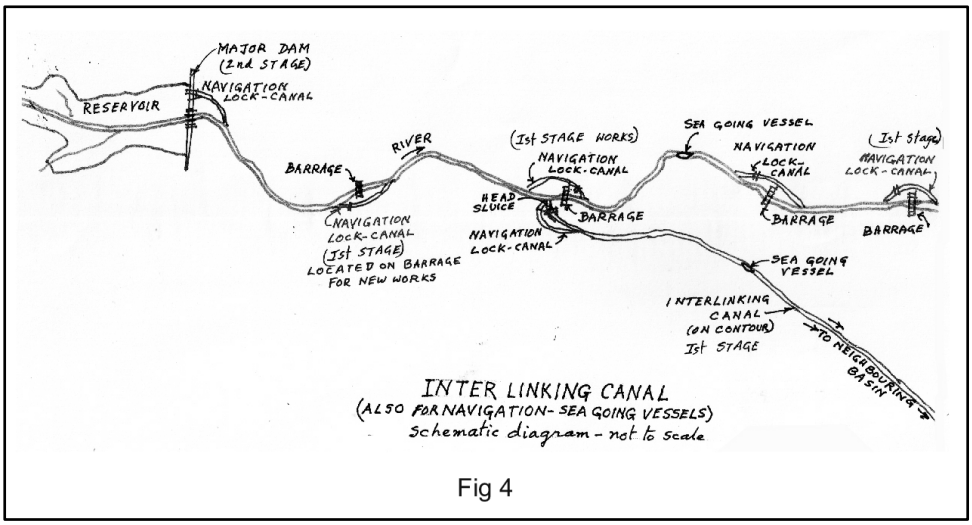


Fig 4

18. Alternative Interlinking Proposal: A schematic representation of this proposal is indicated in Fig 4. In this project, a series of barrages as indicated in para 13 above will have to be constructed as a first step of stage I, on all the rivers where the 30 links are proposed. After a certain designed number of barrages, when sufficient water is stored within the flood zone of the river a contour canal would take off from the river up to the neighbouring basin. This canal would function as navigational canal and will have no drops and hence no navigational locks are needed on this canal. Initially in the first stage, the canal may be 30 m wide and 4 m depth, to facilitate ordinary cargo boats and mechanized launches to ply. When the main river is improved (in the second stage), for sea going vessels upto 3000 T to ply, the navigational canal also would be improved accordingly in the second stage. In the ultimate third stage the canal would be further increased to carry the interbasin transfer of water wherever it is required to transfer water from one basin to the other. This would be done only when a reservoir is constructed in the main river to store the flood water. Thus the navigational canal and main river would be developed in three stages. Details of this are as explained in para 3 above dealing with making the rivers live. All the 8 benefits as mentioned in para 4 above would also occur in this concept. Out of this direct income generating activities such as 1) Hydro power on the main river 2) inland water transport, Fisheries and Industrial development in the main river and the navigational canal would attract PPP mode of execution (vide para 14 above). This would reduce the financial commitment for the Government considerably and the first stage of the interlinking of rivers project can be built by private parties. After studying the first stage of the project, Government can decide regarding the second and third stages of the project. It is evident that in these latest two stages the financial participation of Government would be substantial and the private contribution would be very minor. The main advantage of taking up first stage of the alternative proposal of the project through PPP mode (or otherwise) is that it can be taken up and executed immediately without much loss of time in preparation of the Detailed project Report (DPR). The other advantages are:

a) All State Governments would agree to this proposal since there is no transfer of water as such from one river basin to the other during the first and second stages of the project. Construction of stage three would be taken up only when the States agree to it.

b) In the first two stages, the project concentrates on area development & economic growth through ensuring availability of water in an eco friendly manner.

c) It is easy to obtain all the required eight clearances as the entire project is eco friendly and it also ensures minimum ecological flows throughout rivers on all the days of the year.

19. Conclusions: In all this exercise of the alternative proposal, I am not suggesting that the proposals of NWDA should be kept on the back burner. Instead of waiting endlessly for years together (even decades), - which happens as there are several things which are not under India's control - an alternative solution (patent applied) is suggested to immediately start the interlinking of rivers project. At the same time GOI may continue the efforts to obtain consent of neighbouring countries as well as the State Governments, for interlinking rivers as envisaged by the NWDA.

The Thirty-first Dr Ajudhia Nath Khosla Memorial Lecture was delivered during the Thirty-third Indian Engineering Congress, Udaipur, December 21-23, 2018

Inclusive Growth for Technological Development of Future India

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Changing Nature of Engineering and Technology with Progress of Human Civilization

The innovative spirit of human civilization has played a significant role in its history of survival and progress. This is reflected in the way industries have responded to the changing needs of civilization. During the Stone Age (105 BCE), the role of industry was for survival – making crude weapons and simple tools; basic shelter and clothing to protect humans from the vagaries of the environment and nature. The dawn of civilization witnessed industry gradually responding to mankind's emerging needs through the creation of social well being with the development/manufacturing of dwellings & habitats, weapons & armaments, transport & communication, social welfare building, clothing, etc. The industrial revolution ushered in newer and diverse types of industry for manufacturing of various advanced machinery and equipment, development of newer processes and technologies and intensive exploitation of natural resources. With the advent of the silicon age, computer age, nano and bio technology age, the industry has focused on improved resource utilization, digitization and state-of-the-art technology driven growth leading to sustainable development. Currently we are entering the stage of Industry 4.0 dealing with big data analytics.

Technological Development

The 4th Industrial Revolution (Industry 4.0) is evolving on cyber-physical systems covering internet technology which is classified as:

i) Internet of Things (IoT)
ii) Internet of Services (IoS) and
iii) Internet of Data (IoD)

The Internet of Things (IoT) is the most powerful driver for technological growth in recent times. It allows objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, resulting in improved efficiency, accuracy and enhanced economic benefit, in addition to reduced human intervention.

Traditional manufacturing methods involve a material being carved or shaped into the desired product by parts of it being removed in a variety of ways. Additive manufacturing is the opposite – structures are made by the addition of thousands of miniscule layers which combine to create the product. There are, in fact, a number of different sub-types of additive manufacturing, including not only 3D printing but also rapid prototyping and direct digital manufacturing. Recent technological advances have resulted in its use becoming far more widespread. The future holds exciting possibilities. Long back, since development of engineering drawing as a subject, engineers across globe has set a common framework and norms for Two Dimensional (2D) drawing preparation for collaborative engineering. A 2D engineering drawing can explain matters to engineers in a specific and crisp manner, but the understanding is limited by the individual capability to visualize things in Three Dimensional (3D) way. 2D is non-existent in real world; 3D visualization is essential for construction or developments of real things, as in reality physical existence of all tangible matters are three dimensional. Hence the 3D modelling for engineering collaboration evolved, initially for manufacturing industry and latter for building and plant construction. Usually constructions are taken as a part of a project and that demands involvement of cost engineers and schedulers in a team, which calls for additional two dimensions in engineering collaboration i.e. Time & schedule (4D) and project cost (5D). After the project completion when a plant goes into operation, essentially through a protocol, project team handover the engineering design translated in the form of constructed and erected plant, to a team of operational engineer. Now-a-days for this hand-over, two more dimensions are being added, like the designed energy consumption/dissipation data (6D) and the designed maintenance & lifecycle information (7D). It has become an especially important technology within the scope of computer-aided technologies, with benefits such as lower product development costs and a greatly shortened design cycle.

Top twelve technologies that will transform the world in 2018 and beyond are classified as:

- Artificial Intelligence
- Machine Learning
- Block chain
- Augmented Reality and Virtual Reality
- Cloud Computing
- Angular and React
- DevOps
- Internet of Things (IoT)
- Intelligent Apps (I – Apps)
- Big Data
- RPA (Robotic Process Automation)
- Digital Marketing

According to World Bank, Indian economy is likely to grow around 7.8 per cent in FY 2018-19. India has a strong domestic market and thus 'Make-in-India' policy can enable the country to effectively confront global competition and face the challenges for developing products at competitive cost, within reduced time and with enhanced quality to exacting global standards. Such development should happen keeping due importance to sustainable growth by achieving the following:

- Adoption of energy saving measures.
- Reduction in carbon foot print.
- Use of alternative energy.
- Achieving zero liquid discharge.
- Improvement in operational efficiency.
- Optimization of consumption of power, water, utility gases and fuels.
- Flexibility in engineering, manufacturing, operation and marketing
- Exploiting alternative resources and developing newer materials.

National Academy of Engineering (NAE) has identified following fourteen grand challenges for engineering in the 21st century:

- Advanced personalized learning.
- Make solar energy economical.
- Enhance virtual reality.
- Reverse-engineer the brain.
- Engineer better medicines.
- Advanced health informatics.
- Restore and improve urban infrastructure.
- Secure cyberspace.
- Provide access to clean water.
- Provide energy from fusion.
- Prevent nuclear terror.
- Manage the nitrogen cycle.
- Develop carbon sequestration methods.
- Engineer the tools for scientific discovery.

Challenges for Skill Development

Skill shortage in India is predominantly high. It is observed that skill shortage as a percentage of firms with ten (10) or more employees in India is as high as 64% as compared to China's only 24% having similar human resource pattern.

It is also noticed that around 31% of youth (age 15-29 years) in India who are neither employed nor in education and training (NEET) and is almost three times of youth in NEET in China.

To combat the situation, following sectors are to be primarily addressed for development of skilled workforce

Inclusive Growth

The burning issues in the dawn of knowledge era confronting the world today relates to:

- Environment, energy, health
- Natural hazards, extinctions, unsustainable consumption
- Growing inequalities and knowledge divide

Sectors	Requirement
Education:	Graduates with the right skill-set
	STEM (Science, Technology, Engineering and Mathematics) subjects are of prime importance
	Systematic thinking
	Ability to deal with self-learning system
Business:	Reskilling & lifelong learning
Policymakers:	Structural transformation as well as Social & organizational challenges
Social system:	Division of labour (automation & human)
Legal: claim	Legal obligations in liabilities & insurance

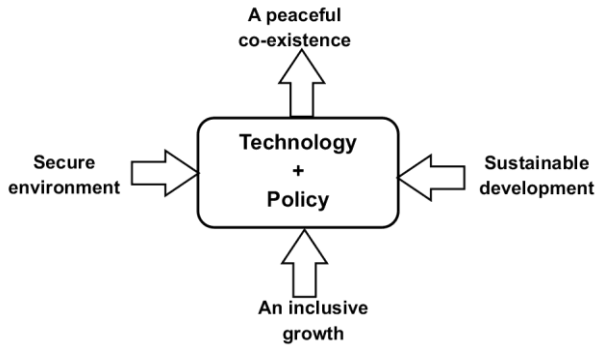
The focus in the new age technology beyond excellence encompasses:

- Addressing human needs and concerns beyond excellence in technology
- Connecting to 'Millennium Development Goals' eg. hunger, health, education, environment
- Linkages with Global Change Research Programs eg. Climate change, energy issues

India's manufacturing sector contributes only 17% to the country's total GDP, as against 30% or more for advanced industrial economies. It is likely that India will have around 900 million working population by 2020, of which around 600 million will be accounted by the country's youth, which is a strong force for the progress and development of any nation. Reduction of manpower requirement in the agricultural sector due to multiple reasons, including greater farm mechanization, has led to creation of surplus workforce that cannot be directly absorbed by the fast growing service industry, mainly due to the significantly different requirements of skill sets by the service sector and limitation of service industry to absorb such large surplus workforce. On the other hand, it would be relatively more feasible to create greater employment in the manufacturing sector through re-training. A strong and vibrant manufacturing sector would be in the greater interest of India, and would ensure the long term growth and sustenance of the country's economy. In fact, high-end technological development, proper utilization of rich natural resources, together with the skilled work force available through re-training, in the country could help in creating a strong platform for building a modern India. Training and development of national human resources, for enhancing their skills to cope with the demands of a resurgent Indian manufacturing sector will be the key areas to focus on.

In order to accelerate economic growth, India will have to shed its feudal legacy. A SWOT analysis along with unflinching commitment for rebuilding India is of prime importance. A competitive environment needs to be created in manufacturing and engineering sector to face the global challenges. The challenge is two-fold, one of creating alternative technologies and two of redefining the economic growth paradigm.

Societal and technological developments co-evolve and influence each other deeply. New technological developments can support the creation of socio technical systems that would possibly be more sustainable from ecological considerations. The pursuance of technological alternative calls for the creation of alternative social carriers of innovation and development. It is quite important that the processes of radical transformation are developed around alternatives in respect of the development of future form of social practices, economy and technology.

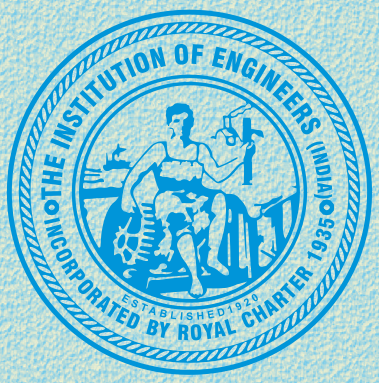


Inclusive growth is extremely important in India today. At the most basic level, economic growth results from labour force growth and productivity growth of workers. With 80% of the labour force stuck in low-productivity activities in informal employment, it is not surprising that the Indian economy is performing far below its true potential. For the Indian economy to reach the growth potentials, ways and means must be found to train the labour force towards skill development and more than from informal to formal employment. Ultimately, the economy can reach its full potential only when the hundreds of millions of Indian workers can have the access to newer technology and can escape the trap of low productivity.

Eventually adoption of a newer technology with improved mindset for innovation and effective use of the vast pool of human resources duly trained and skilled are the key 'mantras' for rebuilding India.

Concluding Remarks

- Enormous change for the industry & society and the people require to be at the heart of the change.
- Change towards state-of-the-art jobs requires multidisciplinary skills.
- Technological advances are largely predictable and social impacts are less, leading to need of reviewing the social welfare system to tackle inequality.
- Major efforts are required to train and for re-skilling of people.
- Ignoring the change or wanting to be a follower, we would likely miss the opportunity for sustainable growth of future India and may never catch up.



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