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IRRIGATION

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IRRIGATION

India, with a geographical area of 3.3 million square kilometres (Km^2), experiences extremes of climate.

Annual average rainfall in the country is of the order of 1170 mm, which is equivalent to nearly 4000 cubic Km of water. However, the rainfall varies from 100 mm in Western Rajasthan to over 8000 mm at Cherrapunji in Meghalaya, considered wettest spot on earth. So irrigation is essential for the growth of agriculture which in turn can lead to socio-economic development.

Direct positive impacts of irrigation include:

1. Increased agricultural production:
   - Increased crop productivity
   - Expansion in crop areas
   - Increase in cropping intensity
   - Increase in crop diversification
2. Increased commercial fish production (in-land fisheries).
3. Increased benefits of water use in industrial, commercial and residential sectors—from raw water provided through irrigation infrastructure or from groundwater.
4. Increased environmental benefits of water for in-stream flows, disposal of waste, wildlife, flora and fauna; increased farm forestry and vegetation in irrigated areas.
5. Increased health benefits—improved sanitation due to better access to water.
6. Increased benefits from flood control.
7. Increased benefits from water use for rural domestic and livestock purposes.
8. Increased groundwater recharge; reduction in opportunity costs of water uses.
9. Increased recreation from water bodies, sight seeing, fishing.
10. Increased employment in agriculture due to increased cropping intensity, increased crop area and output from irrigation.
11. Increased employment outside agriculture from increased crop output in related industries such as input industry (backward linkages) and output processing industries (forward linkages).
12. Positive impact on poverty reduction through increased productivity and increased employment opportunities.
13. Increased food security at national, regional and local levels.
14. Lower food prices for consumers, due to productivity gains and increased overall food supplies.
15. Improved nutrition, improved calorie intake and improved health.

IRRIGATION TECHNIQUES AND THEIR DEVELOPMENT IN INDIA

Various types of irrigation techniques differ in how the water obtained from the source is distributed within the field. In general, the goal is to supply the entire field uniformly with water, so that each plant has the amount of water it needs, neither too much nor too little.

Basically there are two types of irrigation- "surface and localised". In surface irrigation systems water moves over and across the land by simple gravity flow in order to wet it and to penetrate into the soil. Surface irrigation can be subdivided into furrow, border strip or basin irrigation. It is often called flood irrigation when the irrigation results in flooding or near flooding of the cultivated land.

Localized irrigation is a system where water is distributed under low pressure through a piped network, in a pre-determined pattern, and applied as a small discharge to each plant or adjacent to it. Drip irrigation, spray or micro-sprinkler irrigation and bubbler irrigation belong to this category of irrigation methods. In drip irrigation, water is delivered at or near the zone of plants, drop by drop. This method can be the most water-efficient method of irrigation, if managed properly, since evaporation and runoff are minimized. In sprinkler or overhead irrigation, water is piped to one or more central locations within the field and distributed by overhead high-pressure sprinklers or guns.

Irrigation projects with a Culturable Command Area (CCA) between 2,000 and 10,000 hectares are classified as medium projects and those with CCA of more than 10,000 hectares as major projects.

A) GROUNDWATER IRRIGATION SYSTEM:

Groundwater has rapidly emerged to occupy a dominant place in India's agriculture and food security in recent years. It has become the main source of growth in irrigated area over the past 3 decades, and it now accounts for over 60 percent of the irrigated area in the country. It is estimated that now over 70 percent of India's food grain production comes from irrigated agriculture, in which groundwater plays a major role.

The behaviour of ground water in the Indian sub-continent is highly complicated due to the occurrence of diversified geological formations with considerable lithological and chronological variations, complex tectonic framework, climatological dissimilarities and various hydro-chemical conditions. Studies carried out over the years have revealed that aquifer groups in alluvial / soft rocks even transcend the surface basin boundaries. Broadly two groups of rock formations have been identified depending on characteristically different hydraulics of ground water, viz. Porous formations and Fissured formations.

I. Porous Formations :

Porous formations have been further subdivided into Unconsolidated and Semi – consolidated formations:

a) *Unconsolidated Formations*

The areas covered by alluvial sediments of river basins, coastal and deltaic tracts constitute the unconsolidated formations. These are by far the most significant ground water reservoirs for large scale and extensive development. The hydrogeological environment and ground water regime conditions in the Indo-Ganga-Brahmaputra basin indicate the existence of potential aquifers having enormous fresh ground water resources. Bestowed with high incidence of rainfall and covered by a thick pile of porous sediments, these ground water reservoirs get replenished every year and are being used heavily. In these areas, in addition to the annual replenishable ground water resources available in the zone of Water Level Fluctuation (dynamic ground water resource), there exists a huge ground water reserve in the deeper passive recharge zone below the zone of fluctuation as well as in the deeper confined aquifers which is nearly unexplored. Although the mode of development of ground water is primarily through dug wells, dug cum borewell and cavity wells, thousands of tube wells have been constructed during last few decades.

b) *Semi-Consolidated Formations:*

The semi-consolidated formations normally occur in narrow valleys or structurally faulted basins. The Gondwanas, Lathis, Tipams, Cuddalore sandstones and their equivalents are the most extensive productive aquifers. Under favourable situations, these formations give rise to free flowing wells. In select tracts of northeastern India, these water-bearing formations are quite productive. The Upper Gondwanas, which are generally arenaceous, constitute prolific aquifers.

II. Fissured Formations (Consolidated Formations)

The consolidated formations occupy almost two-third of the country. The consolidated formations, except vesicular volcanic rocks, have negligible primary porosity. From the hydrogeological point of view, fissured rocks are broadly classified into four types viz. Igneous and metamorphic rocks excluding volcanic and carbonate rocks, Volcanic rocks, Consolidated sedimentary rocks and Carbonate rocks.

a) *Igneous and Metamorphic Rocks Excluding Volcanic and Carbonate Rocks*

The most common rock types are granites, gneisses, charnockites, khondalites, quartzites, schists and associated phyllites, slates, etc. These rocks possess negligible primary porosity but develop secondary porosity and permeability due to fracturing and weathering. Ground water yield also depends on rock type and possibly on the grade of metamorphism.

b) *Volcanic Rocks*

The predominant types of the volcanic rocks are the basaltic lava flows of Deccan Plateau. The contrasting water bearing properties of different flow units controls ground water occurrence in Deccan Traps. The Deccan Traps have usually poor to moderate permeabilities depending on the presence of primary and secondary pore spaces.

c) Consolidated Sedimentary Rocks excluding Carbonate rocks:

Consolidated sedimentary rocks occur in Cuddapahs, Vindhyans and their equivalents. The formations consist of conglomerates, sandstones, shales, slates and quartzites. The presence of bedding planes, joints, contact zones and fractures control the ground water occurrence, movement and yield potential.

d) Carbonate Rocks

Limestones in the Cuddapah, Vindhyan and Bijawar group of rocks are the important carbonate rocks other than marbles and dolomites. In carbonate rocks, the circulation of water creates solution cavities, thereby increasing the permeability of the aquifers. The solution activity leads to widely contrasting permeabilities within short distances.

Growth of groundwater irrigation in India:

For the net irigated area of about 29.75 mha between 1970 & 2007 groundwater accounted for 24.02 mha. The share of groundwater irrigation through wells has risen from 28 percent to 62 percent. The main contribution has come from rapid growth in tubewell irrigation.

The green revolution was a major force in this growth. Beginning in the mid-1960s, the green revolution was a major turning point in India's agriculture. The adoption of new seeds and fertilizers provided great benefits and the benefits were the best under irrigation. Large investments had been undertaken in surface water projects to provide irrigation water to larger number of farmers. A number of other significant changes also took place in the late 60's and 70's. Electricity supply expanded in rural areas making pumping of groundwater easy and economical. New modular well and pumping technologies became widely available. In the surface irrigated and flood-prone areas, water-logging and/or salinity were problems, and it was realized that encouragement of groundwater pumping provided an effective mechanism for lowering the groundwater table and reducing the severity of the problems. Farmers realized that groundwater was abundant in many areas, especially in the large alluvial basins. The reach of institutional credit expanded making credit more widely available. Farmers realized they could develop and apply water 'just in time' from groundwater sources, something which was not possible in the institutionally-complex and poorly managed canal systems.

Cheap and un-metered electricity, slow development of surface irrigation, and poor management of canal systems further encouraged groundwater development. Over the last two decades, 84 percent of the total addition to net irrigated area came from groundwater, and only 16 percent from canals. Thus, at present the net area irrigated by private tubewells is about double the area irrigated by canals. In the early phase of groundwater development in the 1950s, after independence, the groundwater extraction was dominated by traditional dug wells with depths generally not exceeding 30 feet. Labour or animal devices such as Persian wheels were often used to lift the water, constituting over 60 percent of the irrigation devices. Frequently, there was conjunctive use and hydrological nexus between well irrigation and tank irrigation. With this and the crop choice, the balance between demand and supply of water could be maintained except during years of very low rainfall, and therefore, water use was generally sustainable.

The second phase starting in the 70s saw considerable growth of dug-cum-bore wells. The depth of the wells increased to about 50 to 100 feet and the use of centrifugal pumps became common. More water could be lifted leading to increase in irrigated area and growing of crops with greater water requirement. With the easy availability of institutional credit for the construction of wells in the mid 1970s , the number of wells increased substantially by late 1970. On the other hand, most of the tanks became unusable for irrigation due to poor maintenance and this resulted in even greater dependence on groundwater.

During the third phase beginning from mid-1980s, the extraction technology started changing towards submersible pumps and the depth of wells increased to beyond 400 feet in many areas. Water extraction increased rapidly, under the influence of subsidies on electricity, lack of metering, credit availability, and the commercialization of agriculture . This led to rapid decline in the water table, decline in the quality of water, increased frequency of well failure and rapidly rising costs of well investment and operation. This expansion of groundwater use has resulted in a speedy decline in the groundwater table in several parts of the country. In arid regions such as Rajasthan and Gujarat, ingress of naturally occurring brackish groundwater has become a matter of great concern. According to IWMI, the withdrawal rate in India is twice the recharge rate. Thus, even though groundwater is a powerful tool for poverty reduction, developing and managing this resource in a sustainable way is tremendous challenge. Attempts to regulate groundwater through restrictions on credit and electric connections has had very little effect.

Advantages of ground irrigation system:

a) Well irrigation leads to higher crop production, higher cropping intensity, higher cash input expenditure and higher gross income per acre.

b) Groundwater offers reliability and control of water in irrigation. Experiments elsewhere indicated that water control alone can bridge the gap between potential and actual yields by about 20 per cent. In Spain, irrigation uses 80 per cent of all water and 20 per cent of that water comes from underground. But the 20 per cent produces more than 40 per cent of the cumulative economic value of Spanish crops.

c) Explosive growth in shallow tube wells and small pumps has democratized Indian irrigation. The booming pump irrigation economy has: [a] offered some irrigation access to an overwhelming majority, rather than concentrating all irrigation benefits on small privileged groups in command areas; [b] thereby, helped soften growing farmer unrest in the region's vast dry-land areas, which would have otherwise destabilized social and political structures; [c] has come to account for over 60 percent of irrigated areas, and 80 per cent of irrigated farm output and resultant incomes; [d] drought-proofed the region's agriculture against at least one monsoon failure and made large-scale famines history; [e] improved farm wages and increased demand for farm labour year-round; [f] demonstrated a strong pro-poor, inclusive bias in irrigated agriculture; [g] supported a new drive towards intensive diversification to high value products such as milk, fruit and vegetables, especially in dry land areas in a scale-neutral format.

Contemporary issues related to it:

Extraction of groundwater in excess of its replenishment is a serious problem and leads to significant decline in the groundwater table. In Punjab, Haryana, and Rajasthan, the incidence of over-exploitation is very high and the situation is becoming critical.

A major problem of water table depletion is the deterioration in quality which has a large impact on the health of large sections of the population which heavily depends on groundwater. In Gujarat, groundwater provides most domestic and more than three-quarter of the irrigation water. Over-extraction has caused the water table to fall by as much as 40 to 60 metres in many places, the yield of wells has decreased, cost of water pumping has increased, and in many cases wells are being abandoned. Groundwater mining in Gujarat and Rajasthan has resulted in fluoride contamination particularly endangering the poor in these areas.

There is a distinction between economic depletion (that is, falling water levels make further extraction uneconomic) and the actual dewatering of the aquifers. Aquifers are depleted in an economic sense long before there is any real threat of their being dewatered. The Gangetic basin may have 20,000 feet of saturated sediment but from an agricultural perspective only the top few hundred feet are economically accessible for irrigation. Particularly, wells owned by small/marginal farmers are often shallow—only a few tens of feet deep. Putting this in the context of poverty and famine, falling water tables will first exclude the poor—those who cannot afford the cost of deepening wells. This may happen long before they affect the availability of water to wealthy farmers and other affluent users.

The impact of this would tend to be particularly pronounced during drought periods when a large number of small/marginal farmers could simultaneously lose access to groundwater when their wells dry up. During non-drought periods, water-level declines would undermine the economic position of small/

marginal farmers forcing them onto already saturated unskilled agricultural and urban labour markets. The food security crisis in both these situations may be through the economic route rather than because of food grain availability perse. A region where one of the most extensive over-extraction of groundwater has taken place in the country is north Gujarat. Tube well depths have often crossed 1,000 feet in this area. Cooperatives and partnerships of farmers exist and these do make an assessment of the quantity of water available and do contribute to more equitable distribution of the water among members. However, no attempt has been made to price the water according to its scarcity value and use. The members are aware that the activity of the institution is depleting groundwater in the village, but no effort is made by the institutions to monitor or control the depletion and environmental harm. Equity is being looked at but scarcity and environmental harm/depletion are not being addressed.

Problems of water quality are emerging even in areas, such as the water-rich Krishna delta in Andhra Pradesh, a highly productive area known for its high crop yields. Due to insufficient supply of canal water, farmers' dependence on groundwater for irrigating crops has increased manifold during the last decade. The existing groundwater salinity problem has worsened as a result of unplanned groundwater development and extraction. An in-depth analysis of the hydro-geologic conditions was done through a two-dimensional cross-sectional model, and the simulations showed that the increase in groundwater salinity in the region (except close to the coast) was not due to saltwater intrusion from the sea but because of saline water intrusion from existing saline zones into freshwater zones, because of groundwater extraction.

Thus there is an urgent need to tackle over exploitation of groundwater in the country. The measures may range in nature from informal to formal, individual to institutional/legal, and voluntary to compulsory.

At an informal level, awareness about groundwater over-exploitation and its consequences needs to be greatly increased through extension and publicity campaigns. Groups or associations of farmers may be formed to monitor and manage groundwater. These may be built over existing water users groups/associations/cooperatives or farmer bodies of other kinds. A government department initiative to measure the groundwater level/situation (already existing in some areas) on a monthly or quarterly basis extensively across blocks/villages is required along with reporting and dissemination of this information through the above mentioned means and bodies. Since electric pumps are extensively used to pump the water, controlling the availability of electricity supply for operating pumps can go a long way in reducing over exploitation. This has been successfully tried in parts of Gujarat. Metering and charging of electricity at the real economic price also needs to be implemented.

Other direct measures would include restricting the number of tube-wells through licensing or through imposing institutional credit restrictions. Pumping of water can also be restricted through installation of water meters on tube-wells as done in many developed countries. Overall, new legislation is required to control groundwater exploitation, and a constitutional amendment separating the right to groundwater from the right to land would help provide the necessary foundation for stronger laws and institutional controls. Since agriculture is the largest user of water, accounting for over 80 per cent of the water use, improvement in the efficiency of water use in agriculture can go a long way in alleviating the supply-demand imbalance and tackling the over exploitation of groundwater. Frequent flooding of fields to irrigate is extremely inefficient especially when no proper assessment of the soil moisture and the crop water need is done, and the fields are poorly levelled. Promotion of alternatives such as irrigation through furrows, drip irrigation, and sprinkler irrigation can greatly improve water use efficiency and even these should be done after assessment of soil moisture and critical stages of crop water needs. Good land levelling can also go a long way in reducing farm water needs. Other conservation measures such as mulching can also help. To signal the scarcity of water, formal and informal controls and proper pricing of water is a must. If water is expensive, farmers will use it more efficiently. Pricing should be done by crop, and high water charges should be there for high water using crops such as sugarcane, rice and banana. Restrictions on the dates of planting for crops such as rice can also help, as has been done in Punjab. Avoiding the extremely hot weather in May-June for planting rice can greatly reduce water need and improve water use efficiency. This would be helped by developing and recommending the appropriate crop varieties. On these lines, the development of varieties which are drought resistant and have better water use efficiency would also help substantially.

Institutional development such as the setting-up of elected and empowered water user associations is extremely important to improve the efficiency and equity in groundwater management. However, the ability of such institutions to implement control would be substantially enhanced by the separation of water rights from land rights, and putting water rights on a strong, separate and equitable basis. Apart from reducing over-exploitation, increasing the recharge of groundwater through harvesting of rain and surface flows would prevent the dewatering of aquifers, and also greatly improve equity by making water available in the wells affordable to small and marginal farmers. Deteriorating quality of the groundwater is another major problem and is substantially related to over exploitation in many areas—particularly with salinity, fluoride and other chemical toxicity problems which usually increase with water depth. However, other contaminations also need to be addressed. Regular testing of all sources of water which are being used for human consumption is a must in improving awareness, alertness and control. Creating alternative sources of water is a must where quality problems exist. As indicated earlier, different approaches are required in different areas and so state governments and state policies need to play a very important role. In Eastern India, for example, which is in the Gangetic basin, there is a case for development of groundwater resources. Eastern India has the bulk of India's poverty and is largely rural, agricultural, flood-prone, with a high population density, and has had a slow pace of groundwater development. Increased density of wells can increase the welfare of the people through irriggation as well as through the powerful positive externality of working against water-logging and flood-proneness.

Research indicates that pumping out of groundwater for irrigation in the dry season can create substantial capacity in aquifers to store flood and drainage water underground during the wet season, and this can mitigate floods by leading to as much as 50 per cent reduction in the monsoon flow of rivers. Thus, groundwater development can contribute to full realization of the agricultural potential of the eastern region and also be effective in reducing and preventing flood and water-logging conditions which are major threats in eastern India. However, safeguards are a must to foster planned development and prevent over-extraction. Legally, water is a state subject in India and groundwater is under the private regime. The rights to groundwater belong to the landowner. The rights to groundwater are transferred to anyone to whom the land is transferred. There is no limitation on how much groundwater a particular landowner can draw. This leads to a concentration of water ownership with the land and capital owners in India and a lack of control over the extraction of water. Legally separating land and water rights would be a fundamental step in better managing groundwater.

B) TANK IRRIGATION

An irrigation tank is a small reservoir constructed across the slope of a valley to catch and store water during rainy season and use it for irrigation during dry season. Tank irrigation systems also act as an alternative to pump projects, where energy availability, energy cost or ground-water supplies are constraints for pumping. Tanks are often connected in a long chain where surplus water from one tank is led to the next in a large drainage system. The tank system has four different functions in irrigated agriculture: soil and water conservation, flood control, drought mitigation and protection of environment of surrounding areas. Likewise, development of tank irrigation has to undergo the four phases, namely, water acquisition or harvesting, storage, disposal of surplus water, distribution and management of water in the command area by an institution. The tank complex comprises the catchment area, the feeder channel, tank bund, water spread area, sluice outlets, command area, field distributaries (water courses) and surplus weir.

However , despite these advantages the tank–irrigated area in India over the past two decades has tended to stagnate and fall. Siltation, neglect of maintenance, encroachment in tank bed and catchment area, and reliance on ground water are some of the immediate reasons for the rapidly decreasing area irrigated by tanks. Other important factors include an inappropriate division of labour between numerous different government bodies each in charge of a separate part of the tank system, the political indifference with respect to tank irrigation compared to canal and ground water irrigation, changing cropping patterns as a consequence of increasing preferences for cash crops, increasing numbers of absentee land-lords, and possibly the changing social configuration of many rural communities.

Contemporary issues related to it:

Mostly tanks are reported to be functioning only in normal and excess rainfall years and not so in poor and low rainfall years. The consequences are: many farmers have started abandoning tank agriculture due its continuous uncertainties in water supplies and moving to the nearby towns for other jobs and only the older people are staying back in the tank villages. The lands are not maintained properly and the prosopis trees are growing freely in the cultivated lands thus making the lands unsuitable for cultivation during the years when the tank has adequate water. Due to the declining commitment on the maintenance of the tank structures, the upkeep of the structures is a costly affair for the farmers when they really want to use the tank for irrigation during normal supply periods.

Disappearance of the supply channels is very common. House construction works due to population increase and village development activities such as roads, schools, buildings are concentrated in the government poramboke (common) lands which are the main source of inflow to the tanks as well as interlinking the tanks in the chain. This is one of the reasons why tanks are not getting adequate storages even though the rainfall is normal.

The traditional village institutions like needkatti or madayan thotti who looked after the tank catchment and tank structures and facilitated the inflows into the tanks regularly during rainy seasons also disappeared, as they could not be paid by the farmers due to frequent tank failures.

The growing nexus between castes and politics among the younger generation in the village also played their role in making the traditional leaders in the village (who looked after the tank management) inactive. Several regional political parties are coming up and since the voting percentage is higher in the villages, these parties concentrate on the rural villages for their benefits and in the process, the households are divided among the political and caste related groups.

Thus the improvement of tank irrigation efficiency for all tank sizes would require more balanced integration of farmers' involvement., government commitment and participation in activities such as control of water distribution, maintenance and repair, revenue collection and management of the tank and the tank bed as well as of the catchment area.

Since the first five year plan, all the five year plans investments gave much importance for Canal Irrigation and Well Irrigation sectors. But the incidence of poverty in the country is high among the small and marginal farmers who depend on dryland and tankfed agriculture, where there is much scope for the development. Hence there is a strong need for the government to reorient its investment pattern towards them. The solution therefore has to come up with specific area development approach for combining both the tankfed and rainfed agriculture. In south Indian context, Tank based watershed development undertaken on contiguous basis in a sub basin level will be looked as a potential area for investment. This should be combined with grant and long term loan based investment.

The solution package varies with respect to area and context. Even though the country is divided into many agro-climatic regions, the schemes so far implemented by the government were taken up with common approach. For instance, the coastal and tribal context need different solutions compared to conventional rural, semi-urban contexts. Coastal agriculture is the which term never got attraction among the Scientists. India having the longest coastline in South Asia has got great opportunity to invest on promoting coastal agriculture with salt tolerant varieties of crops and also revitalize the mangrove plantation. This in turn would minimize the exploitation of sea based bio-diversity by inland farmers as the wage labourers going for fishing. Tribal areas in the Country are endowed with great amount of natural resources with lesser utilization. This is because of high level of illiteracy and reluctance of government machineries and schemes reaching them. There is a huge exploitation of tribals by the traders in marketing the minor forest produce and purchasing the fertile lands at cheaper prices.

The role of NGOs and Voluntary Organisations have to be integrated as an integral part of facilitating these supporting mechanisms to the farmers with the agencies concerned and working on developing successful models for different contexts.

The agriculture extension services is the most important component for achieving the objective. Yet, the present agricultural extension services of the government remain either inadequate or ineffective. Therefore the government must look into promotion of effective extension services by involving People, NGOs, Agricultural Universities / Research Stations and Media. It is well known that the All India Radio played an important role in the first green revolution. So the following action must be taken:

- Mainstream Farm Field Schools Concept and create a demand system among farmers to pay for the services.
- Operating an exclusive Television Channel for disseminating the agricultural technology and services offered by the government agencies to farmers.
- Establishing Plant Clinics at appropriate places for providing timely advice to the needy farmers.
- Information Technology through Village Resource Centres or Internet Kiosks can play a key role in disseminating the best practices, counselling with agricultural experts, traders and other relevant farmers.

A CASE STUDY

DHAN Foundation has initiated a water thematic programme as a small pilot in Madurai district viz. Vayalagam Tankfed Agriculture Development Programme way back during 1992 with aim of stake building of people over the precious traditional water commons viz. tanks and ponds located in varied ecosystems by promoting social capital and community investments for revitalizing the irrigation assets. In its two decades of evolution, a community governed institutional framework was evolved and ensured sustainable food security interventions based on the community needs under a development branding “ Vayalagam”.

The programme has a number of components that are necessary to ensure that the interventions are sustainable in the long term. The measures that are proposed in rehabilitation / revitalization of tanks comprise improvements not only to the physical works but also the software aspects like operation, maintenance and management of water resources. They comprise the following:

Prioritization of Tanks for Rehabilitation

The tank irrigation systems taken up for rehabilitation are spread over the four states of South India viz. Tamilnadu, Andhra Pradesh, Karnataka and Pondicherry and the two states of East India Orissa and Bihar. The tanks / Ahar-pynes are selected based on the scope for working with the marginal communities whose livelihoods and food security dependent entirely on tankfed agriculture. The villages and tanks are identified in such a way that cascades of tanks are selected and all the tanks in each cascade are improved in a phased manner based on the following criteria:

- Willingness of farmers to invest a part of the project cost through labour and/ or cash; while the landless will contribute labour.
- Willingness of the community to own the assets and execute the works themselves without involving contractors and maintain and manage the system thereafter.
- Building equity by involving both women and men in planning and implementation of the programme.

Tank Institutions and their Roles:

DHAN Foundation facilitated a three tier system of community participation—

1. **Vayalagams (Tank Farmers Associations (TFAs)**
   - Enrolling the farmers having land and the other interested groups in the village under the command area, as members.
   - Planning and implementing development works like tank rehabilitation, community well construction and on-farm development.
   - Undertaking activities such as pisciculture, tree planting and brick

making as a measure of generating revenue for the tank associations.

- Maintenance of tank systems and their management, including water distribution.
- Building up a corpus or endowment for the tanks for maintaining and managing the tanks through the revenue.

2. Tank Cascade Associations (TCAs)

- Formed with the Tank Farmers Associations as members across the cascade.
- Undertaking the development works such as cleaning and excavation of feeder channels and repairs to diversion weirs/ regulators on feeder channels.
- Resolving conflicts among the Tank Farmers' Associations in water sharing and maintenance.
- Mobilising funds across villages for the betterment of the tank irrigation systems.
- Providing improved services on agriculture and water management.

3. Tank Farmers Federations (TFFs)

- Formed with the Tank Farmers Associations as members.
- Organising the tank farmers federation in the administrative district or block level.
- Mobilising funds for the rehabilitation of tanks from various sources, including the District, State and Central government administrations.
- Organising training programmes on tank related aspects for the TFAs, TCAs.
- Monitoring the operation & maintenance of rehabilitated tank systems and the performance of TFAs and TCAs.

Rehabilitation to Assure Food Security:

Tank rehabilitation includes not only restoring the physical structures to their originally designed standard, but more importantly, facilitating the proper maintenance, efficient water management and improved cropping practices in a sustained manner.

Prioritisation of Works:

The people's felt needs and priorities are given importance in formulating detailed work plans and cost estimates, as the planning itself is done with people's involvement. The works included in the tank rehabilitation follow an order of priority, which the users perceive as most important.

1. Acquisition of water

2. System restoration

3. Improvements to water use efficiency

3. Improvements to water use efficiency

4. Tankfed agriculture development

5. Micro finance activities (MFAs)

6. Endowment for TFAs

DHAN Foundation empowered the Community ownership building and stake by making them to invest around 20-30% cost of rehabilitation and the rest of the share was mobilized primarily from the government through the schemes that were in vogue in different periods of time. The funding partners of DHAN Foundation also at-times supported investments in revitalizing the village water assets to demonstrate as an entry point programme to sensitize the stakeholders to participate.

C) CANAL IRRIGATION:

An irrigation canal is a waterway built for the purpose of carrying water from a source such as a lake, river, or stream, to soil used for farming or landscaping.

One of the difficulties with irrigation canals is providing a reliable flow of water. When the canal is directly connected to a water source like a lake or a river, the water supply is fairly reliable. Whereas, when an irrigation canal traverses a great distance or must navigate changes in elevation, other strategies must be employed. It's common, for example, to build a reservoir to store water for irrigation and to fill irrigation canals with systems of dams and locks. Another method is to dig canals alongside water supply sources and build dams or locks separating the two, opening them when water is needed in the irrigation canal and closing them afterwards.

There are various advantages of canal irrigation. Most of the canal provide perennial irrigation and supply water as and when needed. This becomes important as in India the rainfall is limited in both time and space. Besides this saves the crops from drought conditions and helps in increasing the farm production.

Maintenance cost of canals is relatively lower although the initial cost is high. Moreover canals carry a lot of silts brought down by rivers. This sediments is deposited in the field hence increase the fertility of the land.

Canals though have great advantages but they are not free from limitation as well. Water logging is an important problem associated with canal. This leads to creation of unwanted marshy lands hence reducing the cultivable area. Besides it also raise the chances of various types of water borne diseases. Many canals cause flooding in the nearby areas. Canal irrigation is not of much use for the undulating and sloppy areas. Besides their installation cost is much higher.

Contemporary issues related to canal irrigation:

Canal is an artificial channel for conveying water through lands that was perhaps naturally devoid of sustained water flow. Hence, water seeping from canals down to the soil below may, at times, raise the ground water very close to the ground level. This may result in blocking all the voids in the soil and obstructing the plant roots to breathe.

It has been observed that water logging conditions adversely affects crop production as it is reduced drastically. Apart from seepage water of canals, excessive and unplanned irrigation also caused water logging conditions. This happens because the farmers at the head reaches of canals draw undue share of canal water in the false hope of producing larger agricultural outputs. Apart from ill aeration of plants, other problems created by water logging are as follows:

- Normal cultivation operations, such as tilling, ploughing, etc. cannot be easily carried out in wet soils. In extreme cases, the free water may rise above the ground level making agricultural operations impossible.
- Certain water loving plants like grasses, weeds, etc. grow profusely and luxuriantly in water-logged lands, thus affecting and interfering with the growth of the crops.
- Water logging also leads to a condition called salinity, which is caused when the capillary fringe of the elevated water table rises within the root zone of plants. Since the roots of the plants continuously draw water from this zone, there is a steady upward movement of water which causes rise of salts, especially alkali salts, to come up to the ground surface. This situation is termed as salinity.

In order to avoid water-logging condition to occur for canal irrigation system, certain steps may be taken as follows:

- Canals and water courses may be lined. Also if possible, the full supply level of canal may be reduced.
- Intensity of irrigation may be reduced and farmers advised to apply water judiciously to their fields and not over-irrigate.
- Provide an efficient drainage system to drain away excess irrigation water.
- Introduce more tube-wells for irrigation which shall lower the water table.
- Cropping pattern may be suitably modified such that only low water requiring crops are planted instead of those requiring heavy irrigation.
- Natural drainage of the soil may be improved such that less of excess surface water percolates and mostly drains off through natural drains.

When canal system consist of dams, these large dam projects cause irreversible environmental changes over a wide geographic area and thus have the potential for significant impacts. Criticism of such projects has grown in the last decade. Severe critics claim that because benefits from dams are outweighed by their social, environmental and economic costs, the construction of large dams is unjustifiable. In some cases, environmental and social costs can be avoided or reduced to an acceptable level by carefully assessing potential problems and implementing cost-effective corrective measures.

Damming the river and creating a lake-like environment profoundly changes the hydrology of the river system. Dramatic changes occur in the timing of flow, quality, quantity and use of water, aquatic biota, and sedimentation in the river basin. The area of influence of a dam project extends from the upper limits of the catchment of the reservoir to as far downstream as the estuary, coast and offshore zone. While there are direct environmental impacts associated with the construction of the dam (for example dust, erosion, borrow and disposal problems), the greatest impacts result from the impoundment of water, flooding of land to form the reservoir and alteration of water flow downstream. These effects have direct impacts on soils, vegetation, wildlife and wildlands, fisheries, climate and especially the human populations in the area.

Increased pressure on upland areas above the dam is a common phenomenon caused by the resettlement of people from the inundated areas and by the uncontrolled influx of newcomers into the basin catchment. On-site environmental deterioration as well as a decrease in water quality and increase in sedimentation rates in the reservoir result from clearing of forest land for agriculture, grazing pressures, use of agricultural chemicals, and tree cutting for timber or fuelwood.

The impact of dams on flooding

The function of dams and reservoirs in flood control is to reduce the peak flows entering a flood prone area. Rather than maintaining high water levels for increased head or sustained water supply for irrigation, flood control operation requires that water levels be kept drawn down deliberately prior to and during the flood season in order to maintain the capacity to store any incoming floodwater. However, flood plains may be productive environments because flooding makes them so. Flooding recharges soil moisture and replenishes the rich alluvial soils with flood deposits of silt. In arid areas flooding may be the only source of natural irrigation and soil enrichment. Reduction or elimination of flooding has the potential for impoverishing flood recession cropping, groundwater recharge, natural vegetation, wildlife and livestock population in the flood plain which are adapted to the natural flood cycles.

To maintain the productivity level of the natural systems, compensatory measures have to be taken, such as fertilization or irrigation of agricultural lands. In addition, when channelization measures reduce the frequency of flooding, the sediments entering the river systems from catchment areas upstream will be passed to the mouth of the river unless overflow areas are present downstream. Channel modification can result in a number of negative environmental impacts. Any measure that increases the velocity of flow increases the erosive capacity of the water. Although channel improvement can alleviate flooding problems in the treatment area, flood peaks are likely to increase downstream, thus simply transferring the problem elsewhere. Dikes built on the flood plain to exclude water from certain areas affect the hydrology of the area, and can have impacts on wildlife and livestock habitat and movement.

The impact of dams on fisheries and wildlife

Fishery alongside the rivers usually declines due to changes in river flow, deterioration of water quality, water temperature changes, loss of spawning grounds and barriers to fish migration. A reservoir fishery, sometimes snore productive than the previous fishery alongside the river, however, is created.

In rivers with biologically productive estuaries, both marine and estuarine fish and shellfish suffer from changes in water flow and quality. Changes in freshwater flows and thus the salinity balance in an estuary will alter species distribution and breeding patterns of fish. Changes in nutrient levels and a decrease in the quality of the river water can also have profound impacts on the productivity of an estuary. These changes can also have major effects on marine species which feed or spend part of their life cycle in the estuary, or are influenced by water quality changes in the coastal areas.

The greatest impact on wildlife will come from loss of habitat resulting from reservoir filling and land use changes in the catchment area. Migratory patterns of wildlife may be disrupted by the reservoir and associated developments. Aquatic fauna, including waterfowl, amphibians and reptiles can increase because of the reservoir.

There is a need for Conjunctive management, for example, when canal irrigation system managers purposely direct surface water deliveries away from water-logged areas to groundwater depleted areas; or when they suspend canal supplies during the rainy period to provide irrigation during dry season; or when they use treated urban waste water to supplement fresh canal or groundwater supplies. In Gujarat state of western India, the Government has constructed a 600 km long spreading canal to use surplus flood waters from Kadana and Sardar Sarovar reservoirs in the south to recharge parched aquifers of North Gujarat to counter groundwater depletion and reduce power subsidies to irrigation. This is a good example of conjunctive management of surface and groundwater.

Conjunctive management is an important opportunity for increasing irrigation efficiency in India and may be the country's best response to runaway groundwater depletion, massive farm-power subsidies, drought and dry spells, and water quality deterioration.

Sustained conjunctive management requires:

- high quality main system management in surface system.
- well-managed and regulated surface water distribution system.
- a profusion of groundwater wells in command areas.
- stringent enforcement of appropriate rules and norms for siting of groundwater structures.
- a main system operational protocol (irrigation scheduling; rules for gate operation, real-time information and communication system, etc) that supports optimal conjunctive use.
- effective network in agricultural extension.

Examples of Conjunctive managements in India:

The Mahi Right Bank Canal System in central Gujarat is one example of conjunctive use by default. Commissioned in the 1970s, the canal irrigation system provided water to 250,000 hectares of land that became waterlogged and faced secondary salinization. Over the years, about 100,000 private tube wells were constructed and became the major source of irrigation water in command areas . These tube wells now serve as vertical drains—excellent substitutes for capital-intensive lateral drainage system. Waterlogged areas shrunk and agriculture boomed in previously unproductive regions. Irrigation efficiency, once defined as cubic meters/hectare of canal supplies was low; but when now measured as cubic meters/canal and groundwater irrigated area together, it is very high.

The vast plains of Punjab offer the same story. Massive waterlogging and secondary salinization in the 1950s and 60s have eased or been eliminated by private tube well development.

Down south in Tamilnadu, many canal irrigation systems have been over-extended so much so that canal water supplies needed to be rotated to different blocks of command areas. In some systems, all canal water is supplied to half a command area for a certain number of months; the other half uses well water while waiting for its turn to canal water privileges. In other systems, the entire canal network is run for a particular season, with canal water deliveries confined to left side in one year and on the right side the next year.

The proliferation of tube wells in command areas has made it possible for irrigation system managers to distribute available surface supplies over a much larger area than was earlier possible. Moreover, farmers value groundwater recharge from canal irrigation as much as—sometimes even more than—direct irrigation benefit.

D) MODERN TECHNIQUES:

- **Drip Irrigation**

It is defined as the precise, slow application of water in the form of discrete or continuous or tiny streams of miniature sprays through mechanical devices called emitters or applicators located at selected points along water delivery lines.

It is also called trickle irrigation. Drip irrigation is adopted extensively in areas of acute water scarcity and especially for crops such as Coconut, Grape, Banana, Ber, Citrus, Sugarcane, Cotton, Maize, Tomato, Brinjal and plantation crops. The advantages of drip irrigation are:

1. Controlled application of water as per the needs of plants at low pressure to limited soil areas (root zones).

2. Water saving to the tune of 50 to 70 per cent by reducing the total evaporative surface, reduction in runoff and controlling deep percolation losses.

3. Soil erosion is minimal, due to no runoff water on surface.

4. Weed growth is minimum.

5. Water loss through transpiration is low.

6. Development of surface crust and determination of surface soil structure is avoided. Soil compaction is less.

7. Limited soil wetting permits undisturbed cultural practices.

8. It is possible to obtain better yield and quality of crops by controlling soil moisture-air -nutrients level.

9. We can save the fertilisers by monitoring the supply of nutrients as per the need of the crop.
10. Improvements in biological fertility can be achieved by avoiding pollution.

The initial expenditure in establishing a long term drip irrigation system usually costs around Rs.32,000/- per hectare. This includes the cost of all the components mentioned earlier except the source of water and pump set on the well or boring. This heavy initial expenditure usually discourages the cultivator to install drip systems in his fields, though subsidies are given on the purchase of these equipment by the central and state governments. On the long term basis, the drip irrigation system is more economical and paying for the farmers.

- **Sprinkler Irrigation**

The main characteristics of sprinkler irrigation system are:

1. Sprinkler irrigation system conveys water from the source through pipes under pressure to the field and distributes over the field in the form of spray of 'rain like' droplets. It is also known as overhead irrigation.
2. Different types of sprinkler systems namely portable, semi-portable, semi-permanent and permanent are in vogue. But due to increased labour costs and energy costs, different types of sprinklers are developed.
3. Center-pivot system is largest sprinkler system with a single machine can irrigate upto 100 ha. A center - pivot sprinkler consists of a series of sprinklers mounted on a lateral pipe, 50 - 800 m long, mounted or carried by a row of five or more mobile towers.
4. One end of the lateral is fixed on a pivot pad. The unit rotates around a center pivot where water is pumped into the pipe, and water is distributed through sprinkler fitted on lateral. The limitations of this system are,
5. 10 - 20 % of area is not irrigated at the corners of square or rectangular plot.
6. High energy requirement and huge cost of the equipment.
7. Now lateral - move systems are developed to overcome the drawbacks in pivot-pivot system for irrigating square or rectangular plots. This irrigation system consists of lateral - move systems, which move up and down the field.

Sprinkler irrigation can be advantageously chosen in the following situations:

1. When the soil is too shallow eliminating the possibility of levelling of lands.
2. When the land is too steep (> 1% slope).
3. When light (<5 cm) and frequent irrigations are to be given.
4. When soils are very sandy (rapidly permeable coarse textured soils) and
5. When supplemental irrigation is to be given to dry land crops during prolonged dry spells, without any land preparation.

Sprinkler irrigation can be a disadvantage in the following situations:

1. High winds (>12 km/hr) cause improper distribution of water.
2. Evaporation losses are high from sprinkler irrigation especially under high temperature and low relative humidity conditions.
3. The initial cost is high.

- **Supplemental irrigation**

Supplemental irrigation (SI) can be defined as the addition of small amounts of water to essentially rainfed crops during times when rainfall fails to provide sufficient moisture for normal plant growth, in order to improve and stabilize yields. SI in areas with limited water resources is based on the following three premises:

1. Water is applied to a rainfed crop which would normally produce some yield without irrigation.
2. Since precipitation is the principal source of moisture for rain-fed crops, SI is only applied when precipitation fails to provide essential moisture for improved and stabilized production.
3. The amount and timing of SI are not scheduled to provide moisture-stress-free conditions throughout the growing season, but to ensure that the minimum amount

of water required for optimal (not maximum) yield is available during the critical stages of crop growth.

Supplemental irrigation is the opposite of full or conventional irrigation (FI). In the latter, the principal source of moisture is fully controlled irrigation water, and highly variable limited precipitation is only supplementary. SI is dependent on the precipitation of a basic source of water for the crop.

Water for supplemental irrigation comes mainly from surface sources, but shallow groundwater aquifers increasingly are being used. Among non-conventional water resources that have potential for the future, such as treated sewage water-harvesting is also important.

CONTEMPORARY ISSUES RELATED TO WATER RESOURCES IN INDIA

A) Water use efficiency:

Water use efficiency is not simply a matter of using less water through restrictions. It is about careful management of water supply sources, use of water saving technologies, reduction of excessive demand and other actions. Water use efficiency is generally defined as: “the socially beneficial reduction of water use or water loss. It simply implies that:

- Water resource use and protection are given equal concern; external social, environmental and economic effects of water use are taken into account;
- Social and economic planning are integral to water use management; and circumstances and context are important factors.

Irrigation sector is the biggest consumer of water as more than 80% of available water resources in India are being presently utilized for irrigation purposes. However, the average water use efficiency of Irrigation Projects is assessed to be only of the order of 30-35%. The productivity of farm land has to be increased for increased production of food to keep pace with the increasing population. This requires that maximum agricultural land is brought under irrigated cultivation and multi crop farming. However, the land and water resources are finite and scare. Thus increasing the water use efficiency of existing irrigation projects, projects under execution and contemplated for execution is of vital importance for maintaining food security and making available water for other developmental needs.

Irrigation projects use extensive open channel conveyance systems to distribute water from source to individual farm plots. The delivery of irrigation water to individual farm plots incur a significant loss of water due to: a)seepage; b) evaporation; c) leakages in structures, gates, shutters; and d) poor water management in the distribution network. While designing any irrigation system, an assessment of these losses is made and taken into account in total requirement of irrigation water so that system meets the crop water requirement of its command.

The loss of water, while it is conveyed from source to individual farm plots, takes place in the following components of irrigation system:

(i) Losses in main & branch canals, distributaries, minors & sub-minors;

(ii) Losses in field channels and water courses during distribution of irrigation water from field outlets to individual farm plots; and

(iii) Losses in field application i.e. during application of irrigation water to individual farm plots.

‘Efficiency’ of water use has to be assessed in at least three ways. ‘Irrigation’ efficiency as conventionally defined by engineers relates to the ratio of consumptive use of irrigation to gross irrigation supplies. ‘Productive’ efficiency, that is the quantum of production per unit of water utilized, can be measured with reference to consumptive use, for irrigated and rain-fed areas separately or in combination, and in physical terms (yields or better crop biomas) for individuals crops or in terms of value for total crop production. ‘Economic’ efficiency is measured by comparing the outcomes of the current allocation and use of available water (and associated inputs) with their ‘optimum’ allocation and use, given the technology, prices of inputs and outputs, and weights attached to different social objectivs. On the basis of currently available data, utilized in this exercise, it is possible to get an idea of the first two measures of efficiency.

Measures recommended for increasing Water Use Efficiency

A. Structural Measures:

- Regular/periodic maintenance of canals by clearing off weed/ vegetation growth etc.;
- Restoration of sections of all channels to their designed sections;
- Repair of damaged lining in canals and regular maintenance of lining so that progressive damage to lining could be avoided;
- Selective lining of canals in reaches passing through permeable soil strata;
- Lining of field channel/water courses having high losses;
- Regular maintenance of gates and shutters so as to eliminate losses on account of leakages.
- Repair / Replacement of damaged gates and shutters;
- Improve control in distribution networks by providing appropriate control structures in canals and distribution system;
- Installation of water meters for ensuring volumetric supply of irrigation water to farmers;
- Rehabilitation & Restoration of Structures.

B. Non-structural Measures:

- Involvement of farmers in the management of Irrigation Systems for ensuring equitable distribution and efficient use of irrigation water;
- Formation of Water Users Associations in the command area and giving them the responsibility of distribution of irrigation water and maintenance of Irrigation system progressively starting from field channels;
- Adopting Participatory Irrigation Management practices.
- Training of farmers so as to educate them on various issues related correct agricultural practices and the advantage of optimal irrigation and harms of over Irrigation.
- Providing agricultural extension facilities in the command of each Project.
- Appropriate pricing policy for irrigation water to avoid wastages and over irrigation.

B) Water Resource Management using indigenous methods:

The indigenous knowledge in India has always developed practical ways for society to live in a sustainable manner with nature, in full respect with the diversity of agro-ecological climatic zones, even those that seems the most difficult and inhospitable.

In Indian tradition, the knowledge was transmitted through practical work under the direction of respected elders and gurus.

Some examples are:

a) Baudi is a deep stoned pit, which is dug where water percolates naturally from the earth surface. It is circular/square in shape, which gently slopes towards the pit in the centre. While constructing baudis, the masons place stones in a particular sequence to have continuous percolation of water from the ground. Baudiis sometimes provided with an outlet and is covered with roof to protect the water. It is smaller in size thus water is used only for drinking purposes. Mostly, the baudis are located at an approachable distance from residential area. One of the characteristic features of baudi is that it narrows down to the bottom.

b) Nawn is a type of water storing structure with a huge capacity to store water. On locating the water source, a tank like structure is constructed by stones. A special channel is segregated from the tank for the users to wash clothes or take bath without polluting the main water source. There is a provision of roof as well as walls on three sides of the tank with sluices on front side to check falling of dust or any other unwanted things into its water.

c) Khatris are rectangular, deep pits made on the hill slopes in hard rocks, where rain water is collected through seepage from rocks. These traditional water storage structures are mostly found in Hamirpur, Kangra and Mandi districts of Himachal Pradesh. The basic purpose of khatri is not to harvest the surface run off but the rainwater that flows through the rocks and soils of hilly regions.

d) Tankas (small tank) are underground tanks, found traditionally in most Bikaner houses. They are built in the main house or in the courtyard. They were circular holes made in the ground, lined with fine polished lime, in which rainwater was collected. *Tankas* were often beautifully decorated with tiles, which helped to keep the water cool. The water was used only for drinking. If in any year there was less than normal rainfall and the *tankas* did not get filled, water from nearby wells and tanks would be obtained to fill the household *tankas*. In this way, the people of Bikaner were able to meet their water requirements. The *tanka* system is also to be found in the pilgrim town of Dwarka where it has been in existence for centuries. It continues to be used in residential areas, temples, *dharamshalas* and hotels.

STEPS TAKEN BY GOVERNMENT FOR WATER RESOURCE MANAGEMENT

In the Indian context, the allocation of functions and powers relating to natural resources between the centre and the states is specified in the Constitution. The development and management of all natural resources except minerals is vested with the states, subject to central government involvement and/or intervention in matters of national importance and in matters involving inter-state matters and international relations. Central legislation often takes place in consultation with states. In addition, the centre also suggests model legislation for adoption by the state governments.

The central government has formulated the National Policy Statement in consultation with states outlining the broad priorities and modalities for extraction and utilization of different natural resources. The concretization of these policies into programmes and the responsibility for their implementation by different agencies are significant, but by no means unfettered, influence on states' programmes because central financial assistance and centrally sponsored schemes account for a significant proposition of the resources for state development plans. Fiscal policies (especially including subsidies explicit and implicit in the pricing of natural resources) have become an important factor influencing the quality of natural resource management.

Deficiencies in the legal framework:

Laws concerning water have grown in a piecemeal and ad hoc manner without a clearly articulated uniform conceptual basis in respect of something so fundamental as the nature and content of water rights. That users entitled to use of water do not have ownership rights but only use rights which is of course well recognized.

Another serious lacuna is the lack of clearly defined criteria for determining the entitlements of different claimants to the common pool of water resources in a river basin. Thus, central legislation does not specify the basis for deciding the entitlements of riparian states.

Lacunae in the legal framework are compounded by organizational deficiencies and weak governance. As noted earlier, all the functions relating to water resources are vested with the government. These processes are neither transparent nor subject to any pubic scrutiny. Those directly affected and civic society organizations do not have any opportunity for participation or even consultation in these matters. Even the limited grievances and criticisms they voice are ineffective for lack of access to relevant information. Another area of glaring failure of governance is in the implementation of water resource programmes for both large scale projects and in local water supply schemes, soil conservation, and watershed development. The use of contractors for construction of local works is the normal practice. They are closely linked to, or proxies for, locally influential people, often party functionaries. The procedures for award of contracts, inspections of implementation, and verification of works reported to be complete are very lax. Mostly they do not even exist. Instances of incomplete works, works of poor quality, and sometimes no work at all are numerous. Several instances have been reported in the press and documented in some evaluation studies. No government has ever considered commissioning independent periodic verification of specific works reported to be completed.

Without addressing the problem of weak and bad governance, it is futile to expect significant progress in improving the quality of water resource management, and averting the over exploitation and degradation of this critical natural resource. Some people (the World Bank, International Food Policy Research Institute and other international aid bureaucracies are the most vocal proponents of this line) argue that the solution lies in privatization and allowing the market mechanism to take care of the problem. This is untenable. Being a common pool natural resource which plays a key role in sustaining a healthy ecosystem, and which has multiple uses and numerous claimants, water resource management involves reconciling and balancing considerations of efficiency, equity, and sustainability. Given its fluidity and the pervasive scope for mutual interference between uses and users, enforceable property rights and trading on any significant scale are nearly impossible. The market mechanism cannot, therefore, be expected to produce an efficient allocation across space and different uses. And it will hardly be concerned with equity or sustainability. Hence, the competing claims have to necessarily be mediated by the society through public institutions and an essentially political process.

Institutional reform must address the following basic issues:

1. We need to correct gaps, weaknesses, and inconsistencies in existing laws and regulations. There is a need for much deeper and systematic study of the scope and content of specific laws, their conceptual basis, clarity, and internal consistency, the interpretation of the laws by courts and tribunals reflected in their judgements, the extent to which they have or have not met the criteria of justice and served the interests of efficient, equitable, and sustainable use of water.

2. The process of arriving at important policy decisions as well as investment decisions must be made more transparent; there must be adequate opportunities for those affected by projects (whether beneficially or adversely) and citizens groups to voice their interests and concerns; and it should be ensured that they are discussed in public forms with the help of independent professionals.

3. Regulatory and dispute settlement mechanisms should be taken away from the government's control and entrusted to bodies comprising independent professionals. Non-confrontational and quasi-judicial methods of resolving disputes should be given greater importance and should be encouraged through appropriate enabling legislation.

4. Giving user representative a sense of stake and opportunity for active participation in making and implementing decisions at all levels and a clearer definition of the rights and obligations of stakeholders is essential. Some recent reform initiatives are welcome attempts in this direction. But they are as yet confined to a few states and even those that have gone farthest (such as AP and Orissa) do not give the elected management committees any power to decide, adapt, and enforce allocation rules and schedules. These powers still vest with the irrigation bureaucracy and are open to influence and direction by the political executive.

5. Measures to improve the quality of information and analyses on resources and their management must be a crucial part of institutional reform in the water sector (as indeed in many other spheres of public interest). Active user participation in resource management will facilitate wider and easier access of information to users. But a number of measures are needed to improve the quality and reliability of information and make them a truly public good. For this purpose, the following specific measures are essential:
   - the apex agencies concerned with water planning and policies (the Planning Commission, CWC, and state water resource agencies) should significantly expand and improve professional competence and increase the funds allocated to collect more and better data from micro watersheds to sub-basins and basins and using specialized professional units;
   - these institutions as well as bodies such as the Indian Council of Social Science Research (ICSSR) should be given funds to specifically encourage and facilitate universities and professional research institutions to conduct sustained and in-

depth studies on issues relating to the water sector in different parts of the country;

- conventional field survey methods for collecting data on the extent of irrigated and rain-fed crop areas (overall) and by major as well as the status of reservoirs, crop conditions, and even yields should be progressively replaced by the use of remote sensing imagery—a fast developing technology and one which has the potential to give far more objective and accurate estimates: and
- it should be made mandatory under the Freedom of Information Law for all such information to be made freely accessible to the public.

Further given that direct monitoring and enforcement of regulations is impossible, strong economic incentives are essential to influence the behaviour of users. This depends essentially on the cost at which water is available and the costs of methods of economizing water relative to the benefits generated by water use. Government policies for pricing of water and electricity for pumping water totally ignore this. Public irrigation is highly subsidized: water rates are only a fraction of supply costs; and assessment and collection of dues at even these low rates is very lax. Electricity is also highly subsidized and subsidies have been increasing over the years to a point where electricity is nearly free in several states.

Individual users' decisions on investing in well irrigation and the way they use water depends crucially on what it costs them to get water relative to the benefits from its use. Irrigated land more than doubles the productivity of land and in some areas increases it by as much as four or five times. The returns to irrigated agriculture have increased with spread of improved agricultural technology and increase in the prices of farm produce. On the other hand, the costs of water (both surface and groundwater) relative to output value have gone down. In such a situation it is hardly surprising that the demand for irrigation has grown much more rapidly than available supplies. The result is an increasing intensity of competition to access the water available in public systems and competitive deepening of wells in the face of declining groundwater levels. The trends cannot be arrested, much less reversed, unless the cost of acquiring water at the user end is substantially increased along with tighter management and stricter enforcement of regulations by the state and the user communities. A radical change in institutional structures and pricing policy for water and electricity are thus crucial for any significant movement towards more efficient and sustainable water use.

Some recent steps are:

- ***GOI is planning to establish National Bureau of Water Use Efficiency***

Centre will establish a National Bureau of Water Use Efficiency as an "authority" for "promotion, regulation and control of efficient use of water in irrigation, municipal and industrial uses under the National Water Mission that was established as part of the National Action Plan on Climate Change. The National Bureau of Water Use Efficiency, will have the responsibility of improving water use efficiency across various sectors namely irrigation, drinking water supply, power generation and industry.

The Bureau will take up five benchmarking irrigation projects in parts of the country to demonstrate water use efficiency through water supply on volumetric basis, empowering Water Users Associations to price water and collect water charges and demonstrating state-of-the-art technologies.

Further to improving "water use efficiency" by 20 per cent, the Mission will review the National and State Water Policies and prepare Sate-specific Action Plans for water sector "through consultation process".

States will have to establish Water Regulatory Authorities for overseeing water pricing and mandatory water audits. Several States have in the past expressed reservations on such a move.

The Mission will issue guidelines to States for basin-wise uses of water for irrigation, drinking and industrial use. At the centre of the plan is the strategy to open up the water sector and incentivise States that reform based on the principle that "incentivising is more effective in bringing out reforms."

Simultaneously, studies will be undertaken on impact of climate change, if any, on water resources.

With funding and technical assistance from the Asian Development Bank, the Ministry will initiate a National Water Use Efficiency

Improvement Support Programme to identify "priority actions". The Central Water Commission has identified 138 major and 73 medium irrigation projects for baseline study of water use efficiency in two years. During 2013-14, water use efficiency is targeted to be raised by five per cent.

- ***First Aquifer Atlas released:***

Central Ground Water Board has released the countries first aquifer atlas.

The atlas provides a country wide overview and summary of the most important information available for each principal and major aquifer systems and depicts aquifer wise ground water scenario. It also deals with major issues and challenges which need immediate attention for sustainable management of ground water resources.

The aquifers of India have been classified in to 14 principal and 42 major aquifer systems. The compilation has been done on 1:250,000 scale by integrating the geological and hydro geological data of CGWB & GSI respectively and various other ground water related thematic data/information from other agencies.

Besides the all-India atlas, the State atlases of Himachal Pradesh, Chhattisgarh, Tamil Nadu-Pudducherry, Kerala, Karnataka and Meghalaya have also been released.

Main findings of the atlas:

1. There has been a sharp decline in groundwater levels in several parts of Delhi, West Uttar Pradesh, Haryana and Rajasthan over the years.
2. Himachal Pradesh has the best groundwater level as water exploited is quickly recharged.
3. Within the national capital, South-West Delhi is the worst affected by depleting groundwater levels. The construction around Aravali Hills has created a situation which has disturbed the groundwater recharge system in the region. Further, overexploitation due to population concentration has led to depletion of levels and the recharge process is slow due to the type of soil in the region.
4. Hard rock areas of South India have also been severely affected. But the recharge process is faster in the rocky areas. Good rains over a five- to seven-year period can bring back water in aquifers.
5. Alluvium, the major aquifer system, covers 31 per cent area in the country and is available in Uttar Pradesh, Bihar, West Bengal, Assam, Odisha and Rajasthan. This is followed by the sandstone aquifer that covers eight per cent area and is found in Chhattisgarh, Andhra Pradesh, Madhya Pradesh, Gujarat, Karnataka and Rajasthan.
6. The rest of the country is covered with other formations of which basalt is in 17 per cent area and is spread over Maharashtra, Madhya Pradesh, Gujarat, Rajasthan, and Karnataka.
7. Shale aquifer accounts for seven per cent area and is available mostly in Chhattisgarh, Andhra Pradesh, Madhya Pradesh, Rajasthan, north-eastern States and in the Himalayas.
8. Limestone aquifer covers only two per cent area especially in Chhattisgarh, Andhra Pradesh, Karnataka, Gujarat and in the Himalayan States.
9. Around 20 per cent area is covered by Banded Gneissic Complex and Gneiss aquifers which are available in almost all peninsular States as well as the Himalayan region.
10. The alluvium aquifer, followed by basalt is most suitable for artificial recharge and development of groundwater.

- ***Centre unveils River Basin Draft Bill:***

The Centre has released a Draft River Basin Management Bill which aims to set up 12 river basin authorities in the country to settle inter-state water disputes, prevent floods and pollution.

The Draft River Basin Management Bill, which seeks to amend the River Boards Act, 1956, propose to create a mechanism for integrated planning, development and management of water resources of a river basin. The current river boards do not have the provision.

The Bill proposes a two-tier structure for each of the 12 river basin authorities-Brahamani-Baitarini basin, Cauvery basin, Ganga basin, Godavari basin, Indus basin, Krishna basin, Mahanadi basin, Mahi basin, Narmada basin, Pennar basin, Subarnreakha basin and Tapi basin.

The governing council will be entrusted with the job of approving the river basin master plan to ensure sustainable river basin development, management and regulation.

While taking steps to enable the basin states to agree on implementing the river basin master plan, the authorities will also settle inter-state water disputes.

The executive board on the other hand will prepare schemes for irrigation, water supply, hydropower, flood control, pollution control and soil erosion.

The Bill mentions that the governing council of the concerned river will use conciliation and mediation to solve disputes between two or more states over recommendations of the authority or refusal of the states to undertake steps in pursuing the river basin master plan. If the matter is not to be settled, the dispute will then be referred to the Inter State River Water Disputes Act, 1956 for adjudication.

- ***National Water Framework Act drafted***

The Ministry of Water Resources had initiated the process of reviewing the National Water Policy, 2002.The Salient Features of Draft National Water Policy (NWP, 2012) are:

a) Constitutionally the States have the right to frame suitable policies, laws and regulations on water, the draft NWP, 2012 lays emphasis on the need for a national water framework law, comprehensive legislation for optimum development of inter-State rivers and river valleys, public trust doctrine, amendment of the Indian Easements Act, 1882, etc.

b) The Draft NWP, 2012 presents a holistic picture of ecological need of the river rather than restricting it to only minimum flow requirement. It states that the ecological needs of the river should be determined recognizing that river flows are characterized by low or no flows, small floods (freshets), large floods and flow variability and should accommodate development needs. A portion of river flows should be kept aside to meet ecological needs ensuring that the proportional low and high flow releases correspond in time closely to the natural flow regime.

c) It recognizes the need to adapt to climate change scenario in planning and implementation of water resources projects. Coping strategies for designing and management of water resources structures and review of acceptability criteria has been emphasized.

d) Need and approaches towards enhancing water availability have been stipulated. Direct use of rainfall and avoidance of inadvertent evapo-transpiration have been proposed as the new additional strategies for augmenting utilizable water resources.

e) Draft proposes the mapping of the aquifers to know the quantum and quality of ground water resources in the country has been proposed with the provision of periodic updation.

f) A system to evolve benchmarks for water uses for different purposes, i.e., water footprints, and water auditing should be developed to ensure efficient use of water.

g) Water Users Associations should be given statutory powers to collect and retain a portion of water charges, manage the volumetric quantum of water allotted to them and maintain the distribution system in their jurisdiction.

h) All water resources projects, including hydro power projects, should be planned to the extent feasible as multi-purpose projects with provision of storage to derive maximum benefit from available topology and water resources.

i) The Draft NWP, 2012 lays emphasis on preparedness for floods / drought with coping up mechanisms as an option. Frequency based flood inundation maps should be prepared to evolve coping strategies.

j) Appropriate institutional arrangements for each river basin should be developed to collect and collate all data on regular basis with regard to rainfall, river flows, area irrigated by crops and by source, utilizations for various uses by both surface and ground water and to publish water accounts on ten daily basis every year for each river basin with appropriate water budgets and water accounts based on the hydrologic balances.

WATER PRIVATIZATION: IS IT A SOLUTION FOR WATER RESOURCE MANAGEMENT

A United Nations (UN) study says that by the year 2025 two-thirds of the world may be water-poor therefore, water has come to be known as "the oil of the 21st century." Around the world, multinational corporations are taking profit from the "water-starved" regions by taking control of water as a commodity. Water privatization issue rose out of the growing problem of water scarcity in the world. Treating water as an economic good, and privatizing water systems are not new ideas. As a measure of the new importance of privatization, the World Bank, other international aid agencies and some water organizations like the World Water Council are increasingly pushing privatization in their efforts.

Privatization of water utilities is being common in much of the world;

- In France, water utilities are private; some are quite large and have worldwide operations such as Veolia and Suez Lyonnaise des Eaux.
- Britain's government water monopoly was broken into eight large private water utilities by Margaret Thatcher (e.g. Thames Water).
- In US, water delivery is more public than in France; 86 % of people get their household water services from a public utility. But some members of Congress and local politicians want to see private companies take over more water systems.

Countries that have experimented privatization have not found that it solves their water woes. In fact, many private companies are providing worse service at a higher cost than most public utilities.

On the other hand, privatization of water services is only the first step towards the privatization of all aspects of water. Through the privatization of water resources in the developing world, collective ownership of water resources is being replaced with corporate control.

There are two main types of private sector participation in water supply and sanitation: the British and the French Model.

The **British Model** consists of privatising the water resources as well as water services and operations. While in the **French Model**, water resources remain publicly owned but the operation and services are privatized. The French model is more common worldwide.

CASE STUDY OF ENGLAND

England and Wales is a typical example of private participation in infrastructure. Privatization in the water sector started in 1989. The reasons behind this included the efficiency of the private sector and the financial ability of private companies to finance the large investments needed to repair the water systems in addition to increased competition. These private companies were responsible to provide the entire cycle of services from extraction of raw water, delivery of processed water and collection, treatment and discharge of wastewater.This privatization 'entailed a change in the ownership, financing and regulation of the water industry'. To this end, England developed extensive regulatory frameworks for the water sector to protect consumers and public health: "Companies were forbidden from disconnecting domestic consumers (even for non-payment of bills), and were required to create special, low tariffs for vulnerable consumers. They were also required to submit strategic financial plans as well as resource development and water supply management plans to an economic regulator and an environmental regulator for review". As such, an environmental regulator, an economic regulator and a drinking water quality regulator were created where the economic regulator relied on price caps and yardsticks to improve competition.Today, in England and Wales, nine of the ten water companies that were privatized by public flotation in 1989 continue to operate as private companies. In general, it is reported that privatization in England and Wales has led to water quality and environmental improvements but at higher water prices .

The reasons for the privatization of water are:

- Need for investment & financing for this investment
- Need for technical expertise
- Increase efficiency
- Improve service quality

But whether water privatization is a boon or bane is a topic of debate in international scenario.

Supporters argue that privatization:

- improve efficiency,
- creates competition,
- enable the extension of water services with good water quality.
- water sector obtains the necessary investment finance and therefore it reduces public debts and government subsidies.

On the other hand, the opponents to privatization of water argue that-

- privatization increases the price of water in developing countries, where the majority of the population cannot afford it and thus it reduces access to clean water; so public health is undermined.
- This process leads to monopolies.

Although privatisation has brought discernible improvements in water and environmental quality, there are still numerous issues in need of attention. Technical efficiency and waste minimization has been increasingly scrutinized by regulators since privatization. There have been numerous pollution incidences such as heavy metal poisoning and eutrophication.

The issue of privatisation is very complex and the extent and nature to which common man benefit from water being privately or publicly owned, depends on which category he belongs whether he is a consumer, business or government. The water companies enjoy large profits and a large degree of control, whilst the governments have been able to pass the investment buck and yet still maintain some regulation of the industry. The 'privatized regime is in many respects better for consumers than its nationalized predecessor'. Although there have been increases in water charges, they are justified because they are due to increased investment in the industry which has led to improved water and environmental quality and sustainability.

However, there has been some concern over whether consumers are receiving value for money or whether the increased financial and political aspect outweigh any improvement to their water supply.

