WATER RESOURCE MANAGEMENT IN INDIA WITH SPECIAL REFERENCE TO MAJOR AND MEDIUM IRRIGATION SYSTEMS

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CERTIFICATE

I, **Indranil De**, certify that the dissertation entitled **"WATER RESOURCE MANAGEMENT IN INDIA WITH SPECIAL REFERENCE TO MAJOR AND MEDIUM IRRIGATION SYSTEMS"** for the degree of **MASTER OF PHILOSOPHY** is my *bonafide* work and may be placed before the examiners for evaluation.

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To

Ma and Babai...

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List of Abbreviations

CADP	Command Area Development Programme
CCA	Cultivable Command Area
DDP	Desert Development Programme
DPAP	Drought Prone Areas Programme
FC	Field Channel
FD	Field Drainage
GR	Gross Recovery
LL	Land Leveling
M&M	Major and Medium
M&R	Maintenance and Repair
NWP	National Water Policy
O&M	Operation and Maintenance
PIM	Participatory Irrigation Management
WB	Warabandi
WE	Working Expenditure
WUA	Water Users Association

Chapter 1

Introduction and Survey of Literature

The concern about water resource allocation, planning and management has gained momentum in recent years due to soaring population of the world and its consequent effect on declining per capita availability of fresh water. Management of water resource in this context means harmonizing the demand and supply of water. When it is the case that India accounts for about 4% of world's fresh water resources but 16% of the world's human population and 15% of the world's animal population then it can well be seen that situation in India is no better. At the time of Independence, India's population was less than 400 million and per capita water availability was over 5000 cubic meters per day (m^3/yr). After fifty years of Independence, the county's population has increased to a staggering 9458 million and per capita water availability has plummeted to hardly more than 2000 m^3/yr. Total annual water demand is expected to increase from 552 billion cubic meters (BCM) in 1997 to 1050 BMC by 2025 (World Bank, 1999). Singh (2001) has examined the current water availability and requirement scenario in India and attempted to identify critical issues in managing water resource and explore various alternatives. His analysis is basically based on the figures provided by National Commission for Integrated Water Resources Development (GOI, 1999). At present with total population of 100 crores and utilizable resource potential of 1086 BCM the average amount of utilizable freshwater available in India is 1086 CM per capita per annum. These figures shades light only about aggregative water constraint but neglects local conditions or seasonal variability. Water resources are plentiful in Eastern and Northeastern India but in other areas rainfall is unreliable and/or short. Six of the twenty major river basins have reported a miserable less than 1000 m^3/yr. By the year 2025, five more basins will become water scarce and by 2050 only the Brahmaputra, Barak, and west flowing rivers from Tadri to Kanyakumari would remain water sufficient. Moreover, with it localized problems of water shortages are prevalent in all the basins. Environmental problems relating to water quality degradation has aggravated the situation (World Bank, 1999). Hufschmidt(2002) has rightly argued that the time has passed when abundant supplies of water were readily available for development at low economic, social and environmental cost. This is because in the arid and semi-arid regions of the developing world, water is extremely scarce while in the sub-humid and humid zones, competition for readily available supplies is strong and rapidly increasing.

All these problems have led scholars to indulge in voluminous of writings on this issue. The last comprehensive study on the water policy for the developing countries was done 14 years ago at the United Nations Water Conference in 1977 (Biswas, 1978). The debate and discussion regarding water management in general and irrigation water management in particular has gained momentum in the nineties. As there are quite a few aspects of water resource management to be considered we will divide our discussion into four sections. We will first look into the water resource and its management as a whole. Then we will look into the aspects of major and medium (M&M) irrigation water resource minutely. Thereafter we will discuss about the financial aspects of M&M irrigation. Lastly, we will discuss the policies and institutions that play an important role in management of water resource, specially regarding M&M irrigation projects.

1.1 Water Resource and it's Management

At this moment India faces a critical situation. Its finite and fragile water resources are stressed and depleting on the one hand and on the other hand various sectoral demands are growing rapidly. Over time with changing significance of various sectors of the economy and due to India's process of development there has been alteration in water requirements and relative claims by he various sectors. Historically plentiful water has been used primarily for irrigation. Though demands in other sectors are insignificant relative to resource availability, but it is increasing rapidly. Population growth combined with major changes in composition of demand resulting from raising incomes, urbanization and rapid industrialization will put a constraint on water use in irrigation. Irrigation accounts for 83% of consumptive water use .Two third of agricultural production depend on irrigation water use and difference between irrigated and unirrigated water use is almost seven times (Saleth, 1997). Drinking water requirement of the rural and urban areas is also a fundamental need. The share of water for consumption of industry and domestic purpose in overall water consumption is expected to increase from 8% to 25% by 2025.

Agriculture absorbs about 67% of India's labour force as compared to 13% by industry. But the share of agriculture in GDP at factor cost has declined from 59.2 % in 1950-51 to 34.9 % in 1990-91 and further to 27.5 % in 1999-2000 (at 1993-94 prices). The industrial sector now exceeds the agricultural sector in rupee value as contribution to India's economy. Notwithstanding the growing importance of industrial sector in the Indian economy, agricultural will still perform a crucial role in the society and economy for providing employment, poverty alleviation and in meeting the growing and increasing diverse food needs. As irrigation has always played a deciding role in increasing agricultural yield, production water need for irrigation purpose will have to be given its due importance. Along with this water demand is substantial for energy, ecological, navigation, fisheries, recreation, ceremonial, religious and other uses. Water demand from all these sectors is creating a serious problem of conflict between sectoral uses. From the point of view of equity water has great importance in minimizing losses due to flood and drought. Irrigation water distribution among head-reach and tail ends farms and among different farm sizes has also equity implications.

The function of irrigation is to bring the seasonal pattern of water availability of plants more closely in line with moisture deficit due to evapotranspiration (ET). Irrigation is one of he important factors of improving agricultural production and productivity in India. It has been the *sine qua non* of Green Revolution in India. Due to irrigation, India has been in a comfortable position with regard to the availability of foodgrains over the last two decades or so. There has been a one-to-one correspondence (i.e. the elasticity is almost one) between foodgrains production and gross irrigated area. Some approximate estimates suggest that across states the gross value of output per hectare of irrigated land is between 50 and 280 percentages higher than that of unirrigated land (Vaidyanathan, 1991). According to another study the average aggregate productivity of irrigated agriculture per unit of land would seem to be seven times that of rainfed agriculture (Saleth, 1997). Productivity of irrigated land also appears to be stable across years. Irrigation makes difference to land use patterns (especially the extent of fallows), cropping intensity, crop patterns, the level of fertilizer use and the efficiency with which nutrients are used. Besides the gain in agricultural sector irrigation has several positive externalities. It is a major source of employment generation in the rural sector, especially in the arid and semi-arid region. It has also grave implications for rural poverty alleviation. According to the government of India estimation the incremental employment generated by the irrigation potential created during the Eighth Plan has been 8.7 million person-years. Moreover employment and income impacts of irrigation have powerful multiplier effects since irrigation development forges inter-sectoral and inter-regional linkages through output growth and income flow. An overall non-farm output multiplier of irrigation stands at 2.19. A 100 rupee worth of irrigation-induces incremental agricultural output to generate Rs. 105 worth of additional output in manufacturing and Rs. 114 in the tertiary service sector (Hazell and Haggblade, 1990). Impact of irrigation on the poverty can be realized by observing the decline of national average prices of rice and wheat by 2.2 % and 3.3% per annum in real terms, respectively between 1964 and 1994 (Kumar et al., 1995). In districts with less than 10% of cropped area under irrigation the incidence of poverty is as high as 69% while the same in districts with irrigation coverage of more than 50% of cropped area is 26% and in Punjab and Haryana where 70% of the cropped area is irrigated it is just 10%. So there exists an inverse relationship between the incidence of poverty and the extent of irrigation development (Rao, et al., 1988; Saleth 1997).

The magnitude of future water scarcity has been estimated by Kumar (2001) by analysing the potential future water supplies against future water requirements determined by population and economic trends. He has also figured out implications of future water scarcity for various sectors of water use and in the end has suggested the institutional changes: changes in policy and the legal framework required to achieve efficiency in the use of water. According to his estimates in 2025 the total water required for producing 180.32 million tones of cereals (wheat and rice) and 536 million tones of sugarcane from irrigated areas is 73.73 M ham. If other agricultural produce is added to it the total water requirement will reach 84.79 M ham. If water requirement of human use, animals and industrial production is added to this then total water requirement will soar up to 104.5 M ham in the year 2025. The distinguishing feature of his estimates is that the domestic water requirement will grow from 4.7% in 1990 to 8.9% in 2025 and industrial water requirement will grow from 2% in 2000 to 8.83% in 2025. The gap between the total water requirement and total utilizable supplies will become 26.2 M ham by the year 2025.

In it's study World Bank (1999) has argued that in states such as Punjab, Haryana, Tamil Nadu and in large localities of the country the issue regarding water resource development has been supplanted by management and distribution of water resource. The per capita availability of water resource in India exceeds that of many other countries but a number of countries like Jordan and Israel have been able to harness their water resources in a proper way fulfilling the demand for agriculture, drinking water facilities for the rural and the urban area, industry etc. It has cited some examples to enunciate the present crisis situation. Disputes relating to riparian rights among states of India, massive and disjoint investment of the riparian states in new construction rather than emphasizing on maintenance and modernization of the existing work is an alarming evidence of the anomaly existing in water resource management in India. In Chennai water is getting transferred from another basin while in an area adjacent to the city farmers are pumping groundwater from large aquifers with electricity provided free of charge. On the other hand in case of Delhi, the city's water need is getting fulfilled by encroaching upon the agricultural consumption. In Kondenahally village in Kolar Taluk, Karnataka the village drinking water wells are successively getting dry due to intensive use of groundwater for agricultural purposes.

Frederiksen (1996) has opined that the most serious aspect of the water crisis is misconception about solutions now proposed. With growing world's water crisis sound database and rational analysis of facts is lacking while emotion has dominated debate and discussions. He has identified four important constrains that has been inadequately considered in today's debate in dealing with water crises: (1) scarce time to act if we are to meet the pending needs; (2) the limited measures available for securing essential water supplies; (3) the competing demand for funds to provide the means; and (4) minimal ability to manage droughts when they strike unannounced. Only a few actions of the magnitude needed can be completed within the next 10 years to accommodate the 1 billion new people to be born. Endless studies, conferences, and workshops; long gestation period for legislation, programme formulation, institutional strengething and financing and implementation may prove fatal in this regard. There are a few misconceptions which generally influence our public policy and society in large. It is generally assumed that a majority of a nation's total runoff, expressed as a per capita value, is utilizable and most of that is committed to agricultural use. It reality a large proportion of runoff is lost. In case of India even after construction of a substantial number of additional reservoirs only about 36% of total runoff would be utilizable. It is generally assumed that all water used by agriculture can be made available for other purpose. Only 30% of agriculture's total usage can be made available for other uses. Another misconception in this area is that minor reduction in countrywide irrigation allocation to meet urban demand would minimally disturb farmers.

But such an action may lead to substantial impact on the production of the affected farmers and can have serious social and economic consequences. It is also assumed that improved agricultural efficiency will yield substantial quantities of new water. But urban users are less efficient than irrigation, except where per capita deliveries are extremely low. Another important point to note is that emphasis on basin efficiency should be given priorities over project efficiency. Sometimes it may be the case that one project's losses and return flows is next project's gain.

Among other misconceptions as argued by Frederiksen (1996) there is one regarding the much talked about demand management of water resource. It is generally argued that demand management will release substantial quantity of water in urban and agricultural sector of developing countries. In reality demand management will be effective in urban centers in developed countries but increased charges for water in the agricultural sector will only reduce net incomes of the farmers and ultimately they will abandon agriculture. The other misconception is that use of wastewater will have the potential for greatly augmenting water supplies. In reality additional wastewater reuse is only beneficial in limited local situation (such as coastal areas) of developing countries. It is also assumed that improved management and operation of river basin facilities will offer significant gains in available water supply. Improved management may have positive impact on the water supply of the urban areas through reduction in overexploitation and loss of capacity, but it will take the government years to introduce water rights system and the necessary regulatory capacity to manage conjunctive use of surface and groundwater efficiently in agricultural sector. Another misconception is that water can be allocated from present uses to meet urban demand. But retrenching the supply to the agricultural sector will shrink production and increase poverty of the nation. Construction of reservoirs will produce new water and associated benefits in terms of additional food production, flood protection and clean energy. It is also assumed that there are still substantial water resources that can be developed by most countries. Groundwater is reaching near their exploitable limits and will reach there faster if artificial recharging through irrigation is reduced. A very little opportunity is remaining in diverting additional surface water from unregulated river. In this situation the only measure, which seems to bring some salvation is construction of reservoirs and storage facility. Another misconception which also prevails is that there exists opportunity for improving the effectiveness of water used consumptively in production and processing. But in reality there exists limited opportunity to free substantial quantities of water from crop production by utilising water in a more effective way.

Iyer(2001) has identified several problems, weakness and failures regarding drinking water supply, drought-prone areas, floods, irrigation, water resource development projects, groundwater development, water quality, waste of water etc. Within the ambit of "Drinking Water Mission' some 'covered' villages are lapsing back into the uncovered category and also newer villages are added to this category. In case of 'drought-proofing' there is no well thought out strategy to deal with the problem. Attention is only given to long-distance' water transfers rather than rainwater harvesting, groundwater recharge etc. Overriding importance on irrigation and power-generation has led to less importance being given for flood management in case of large dams.

In our study we will review the situation of future water demand in different sectors. We will then analyse the availability of water resource in India and it's management taking into consideration the percapita reservoir capacity at state level. Drinking water need in rural and urban area and response of the government in this regard will also be analysed. As flood and drought conditions play havoc in Indian economy, management of water resource to control them has special significance. Study of all these issues in view of water resource management is scarce in India. So, our study may bring light in forefront the situation of management or mismanagement of water resource in the country.

1.2 Water Resource Management in M&M irrigation

Indian irrigation sector can be put into binary classification in several ways: (1) major and medium or minor (2) surface water or groundwater based (3) gravity-flow or lift irrigation works (4) public or private (5) traditional or modern. The first, second and the fourth classification greatly overlap with each other. The first classification is peculiar to India and so we will concentrate on this only. The distinction between major and medium and the minor irrigation project is based on Ultimate Irrigation Potential (UIP) each project is expected to create. Projects with UIP of less than 2000 hectares are classified as minor, those with UIP between 2000 and 10000 hectares are classified as medium and projects with UIP greater than 10000 hectares are classified as major. Major and medium irrigation are mostly associated with canals originating from big dams and barrages built across rivers and the minor irrigation refers to dugwells, tubewells, tanks, etc. In the Indian context major and medium irrigation is synonymous with canal irrigation, which is mainly developed through public investment. Over the period 1951 to 1995, the publicly-created and managed major and medium schemes increased three-fold while the privately created and managed minor irrigation in the ground water segment increased seven fold (World Bank 1999).

The impact of irrigation on productivity is primarily dependent on the characteristic of the system and on the management of water in terms of assurance and timeliness of supplies according to the need of the crop. There is a great deal of debate among scholars regarding the productivity impact of different type of irrigation. One lobby of scholars pleads for major and medium (surface) irrigation works and the other the minor irrigation works. According to the above mentioned criteria wells appear to be the best option as it is privately owned and operated, command area is small and the decisions regarding the crops to be grown as well as the timing and quantum of water supply are more within the control of the owner (Vaidyanathan, 1991). The opposite view is that the minor irrigation too suffers from serious shortcomings (Dhawan, 1999). Wells and tanks become undependable during the drought season. Large-scale major and medium irrigation projects can be utilised to exploit over three-fourth of our 'utilisable' surface water flows and the remaining under one-fourth irrigation can be exploited through small-scale irrigation schemes. Moreover further exploitation of surface water can be done primarily through large-scale irrigation rather than small-scale irrigation. (Dhawan, 1999). In India surface water irrigation through the minor irrigation work has not expanded. The bulk of the expansion of area irrigated by surface water has been achieved through major and medium irrigation works (Vaidyanathan, 1991). Canal irrigation is argued to yield many indirect benefits. It stabilises year-to–year fluctuations in crop area, crop yield, crop output, farm incomes and farm employment. Canal irrigation, which is mostly public sector, has led to decline in spatial disparities in irrigation. It should also be noted that there is no strong reason to suppose a significant or universal large farmer bias in the case of surface irrigation works which is pronounced in case of utilization of groundwater. Groundwater is biased towards large-scale and different institutional factors also favours the large farmers in exploiting groundwater by wells, energised pump-sets and tubewells through liberal loan assistance.

Vaidyanathan (1991) has analysed the importance of irrigation in Indian economy and has also identified problems associated with it. The gross value of output per hectare of irrigated land is estimated to be between 50 and 280 percent higher than that of unirrigated land. The productivity of irrigated land is also estimated to be more stable across years except in cases where irrigation is largely from small storage works. The productivity differential between irrigated land and unirrigated land is argued to be inversely correlated with the level of rainfall and directly correlated with timing and quality of irrigation supplies. The privately owned and operated wells operating within a small command area is argued to be the best due to its assurance and timeliness of its supplies. On the other hand Dhawan (1999) has produced strong arguments in favour of major and medium works. Setting the example of Gujarat with the reference year 1986-87 he has argued that the availability of water in minor irrigation works other than tubewell fell drastically due to drought in the state. The capacity utilization averaged at 67% in case of shallow tubewells and 72% in case of deep tubewells and below 10% in case of small surface flow works. Tubewell technology has inherent hydrogeological limits, as it is technically not feasible in non-alluvial tracts. Moreover, 70% of Indian land mass are constituted by non-alluvial tracts. Explosive development of tubewell irrigation also leads to irreversible groundwater depletion. Canal-irrigated yield is also argued to be nine-tenth of overall irrigated yield at the all India level during the period 1980-81 to 1992-93. Estimates for individual states are somewhat different. Canal-irrigated yield is lower by 37% in Haryana, by 34% in Tamil Nadu and 58% in Punjab while it is higher by 17% in Madhya Pradesh. The yield differential is not noteworthy in case of Uttar Pradesh, Bihar and Andhra Pradesh. It has been argued that the large production benefit from ground-water use in low rainfed areas of Punjab, Haryana, Western Uttar Pradesh, Tamil Nadu and Maharastra is owing to the seeped-in canal waters. This benefit from canal water is not accounted and duly recognised in India According to his calculations net benefit from canal irrigation exceeds the cost of canal irrigation in India by a margin of 144% in 1980-81 and 57% in 1992-93 at current prices. This decline in percentage is attributable to a rise in unit cost of canal irrigation by 367% against a rise in the farm product prices by 156 %.

Studies about the major inefficiencies in irrigation water management has been carried out by Dhawan (1986). He has argued that biasness of the cropping pattern in favour of the heavily-irrigated crop than actually conceived by the project designers has resulted in underutilization of created potential. For this reason low utilization ratio may give a downward bias. Also, the high ratio of utilization of created potential does not mean near-capacity utilization if the irrigated farmland receives less water than contemplated during potential creation. This leads to an upward bias in utilization ratio. It is difficult to find out the net impact of this upward bias in utilization ratio and the downward bias due to diversion of cropping pattern on the utilization ratio. Design of major and medium irrigation systems are based on information on the volume of water flow at reservoir site, its seasonal pattern and variability and certain assumptions regarding conveyance and application losses, crop water needs and crop patterns. Vaidyanathan (1991) has argued that inadequate regulatory structure, rigid designs, physical constraints and most importantly institutional weakness have impaired proper management of the system. Arrangements are grossly inadequate for collecting data on actual water releases, loss in the conveyance, the kind and extent of crops grown, the condition of crops in different segments. The inefficiency of surface water irrigation can be redressed through the Command Area Development Programmes such as lining, rotational supply, consolidation of holdings etc. Rotational water supply through Warabandi programmes has benefited the tail-end farmers. It is effective in narrowing down the inequity between farmers within the canal command. All these measures greatly facilitate the water management through increase in efficiency. Efficiency also increases through better control structures and conjunctive use of groundwater and surface water. Conjunctive use of surface water and groundwater leads to greater increase in efficiency and flexibility of water resource as surface water in this case acts as a source of recharge of groundwater aquifers through seepage. Any shortfalls in the surface water system will definitely disturb this system.

The Report of the Committee on Pricing Irrigation Water (GOI.1992) under the chairmanship of A Vaidyanathan has recommended a few measures for the efficient water use in irrigation. They are as follows:

1. Supply of water on volumetric basis
2. Upgrading standards of construction such as modernization works, lining works etc.

3. Undertaking command area on-farm infrastructural development works
4. Introducing warabandi system(rotational water supply)
5. Having two separate norms, one for establishment required for irrigation management, operation etc. and the other for M&R proper instead of present adhoc single norm and providing funds for M&R accordingly.

Mitra (1996) has identified that the problems which Indian irrigation faces generally arise at the construction phase and some arise at the operation and maintenance stage. The two major problems faced by the irrigation sector in India are paucity of resource and poor performance of the existing major and medium irrigation system. Dearth of resource not only restricts taking up new projects but also puts restriction on operational and maintenance of the existing surface irrigation systems and completing the ongoing unfinished projects. The second problem is basically the fallout of the first problem. Mitra (1998) in his study about the nature of irrigation development in Maharastra, its changing structure, implications of such change on irrigation crop-mix and the issue of management, financing and pricing of irrigation water has found that little less than half of the ultimate irrigation potential yet remains to be exploited under major, medium and minor irrigation sectors. But only half of the irrigation potential created has been utilized in case of major and medium irrigation schemes. In case of minor irrigation projects the utilization is considerably high at 90 per cent. Organizational and institutional changes have to be done suitably in the management and distribution of water from the irrigation system to bridge the gap between potential created and utilized.

Mitra (1998) has observed that in Maharastra the extent of well irrigation is seen to be at 63 % while the same for canal irrigation is at 19 % in 1990-91. As gross irrigated area has experienced higher growth rate compared to net irrigated area, it is argued that land and water has been used increasingly intensively. The overall rate of growth in irrigated area for non-foodgrains is found to be much greater than that estimated under foodgrains between 1960-61 and 1992-93. It is also found that rice, wheat, jowar and pulses together account for around 95 % of the irrigated area under foodgrains and sugarcane, cotton, oilseeds, spices and condiments, fruits and vegetables together is seen to be accounting for around 90% or more of the irrigated area under non-foodgrains in diffeent periods. Among foodgrains , rice is estimated to be the most water consuming crop and jowar and pulses are the least water using crops. Among non-foodgrains category sugarcane turns out the most water intensive crop and oilseeds turns out to be the least water-consuming crop followed by spices and condiments. It has been identified that among other things, low utilization of irrigation potential from major and medium surface irrigation is largely due to concentration of water use in sugarcane.

Inefficient use of water leads to severe environmental impacts through disturbance in the hydrological balance. In the agricultural sector inefficient use of water lead to excessive drawdown of the underground aquifers, construction of unnecessary storage facilities, adverse impacts on the aquatic environment, overirrigation leading to increased nitrate, phosphate, and pesticide contamination of aquifers and increased soil degradation through compaction and salinization. Injudicious use of canal irrigation and neglect of drainage causes waterlogging and rise in the water table, which eventually lead to salinization. At present an estimated 13 million hectares are affected of which 6 million by waterlogging and 7 million by salinity and alkalinity (Vaidyanathan, 1991). If canal water use is properly managed through proper price and non-price mechanism then these lands could have been used for productive purpose. Careful management of water to avoid overwatering, providing adequate drainage facility ('horizontal' drainage) through canal lining and better adaptation of crops are absolutely necessary. Otherwise the social cost of canal irrigation will be greater than the social benefit. It is argued that a long-term dependence solely on well and tubewell irrigation leads to depletion in the groundwater table. Inefficient regulation of groundwater has resulted in excessive withdrawals in many areas. It has posed a threat for the sustainability of groundwater stocks and water supply. Overexploitation of groundwater and its consequent result of lowering of water table lead to intrusion of saline/brackish waters into pores left empty by groundwater withdrawal. These two problems of ground water and surface water can be handled simultaneously if groundwater and surface water is conjunctively used. This is because the seepage due to canal irrigation will recharge the groundwater loss. On the other hand water logging and salinity dangers can be averted if well irrigation is developed within the canal/tank commands. Apart from the problem relating to hydrological balance, irrigation can lead to various environmental problems also. It ranges from siltation of reservoirs to submergence of forests and displacement of people in the area where large reservoirs are constructed. All these damages cannot be easily quantified.

According to World Bank study environment is getting degraded due to contamination of water by industrial and human wastes. In Udaipur the contaminated water has affected the fish, crocodiles, migratory birds etc. In Maharastra a staggering 0.7 million people are suffering from water-related illness due to inadequate maintenance of water delivery system. Frederiksen (1996) has argued that it has been a misconception that increased pollution control will increase usable water supply. It is true that reduction of pollution will release usable water, which becomes valuable in the period of shortage. But in case of developing countries pollution reduction programmes will take a long time and will become an expensive affair while in developed countries it has taken decades to devise the most effective program.

The rapid development of well irrigation, spurred by the introduction of new cereal varieties and the spread of rural electrification, has led to overexploitation of aquifers (Vaidyanathan, 1991). Now the problem is to regulate the number and location of wells. Overexploitation of groundwater through wells has resulted in progressive lowering of water table, lower yield per hectare, and higher capital and operating cost. Regulation restricting the growth of wells has never been invoked or successful. Dhawan (1986) has argued that this problem can be tackled by developing surface irrigation which will recharge groundwater aquifers through seepage, by abandoning gross underpricing of electricity for groundwater and by strengthening private investment in water-economising devices like sprinkles and drip irrigation. Watelogging arising from inadequate drainage can be solved through development of groundwater. Siltation in dams and reservoirs can be tackled through preventing deforestation and encouraging afforestation. The reason for this type of environmental degradation is that water resource development projects are not undertaken through integrated, holistic, environmentally harmonious and participatory approach (Iyer, 2001). Low irrigation prices will lead to external diseconomies like waterloging, salinisation, soil degradation, contamination etc (Sampath, 1992). Appropiate pricing of water is essential to stop overuse of water. Measures like desalination of water and its use is only feasible in cities located near the ocean and where the users can afford the high cost and need a separate water source to meet emergency (Frederiksen, 1996). It has also been a misconception that increased recycling of process water in industry can reduce both consumptive and non-consumptive use of water as its impacts are location-specific and does not have much impact as compared to country's total need.

In our analysis we would like to review the situation of mismanagement of irrigation water resource at state level, especially the major and medium irrigation, in terms of underutilization of created potential. Moreover, we would try to see how much the shift in strategy of major and medium irrigation from expansionary to system performance is logical. Command Area Development Programme has been devised to improve the system performance in India. We will also look into the efficacy of the programme in reducing mismanagement of water resource. Further, we will look into the aspect of environmental damage due to large-scale irrigation.

1.3 Financial Aspects of M&M irrigation

The development of canal irrigation entails a lumpsum cost financially and environmentally. Capital cost of major and medium scheme development is increasing day by day. At current prices and neglecting gestation lag between the time investment undertaken and the time irrigation potential created, the Working Group on Major and Medium Irrigation Programme for The Eighth Plan (GOI, 1989) has estimated that the investment per irrigated hectare is Rs. 1530 per hectare for the First Plan, Rs. 34924 for the Sixth Plan and Rs. 36240 for the Seventh Plan. Taking into account a gestation lag of twelve years and social rate of discount of 5 per cent, capital cost per hectare of irrigation development at 1988-89 prices declined from a three yearly average of Rs. 30658 during 1966-69 to Rs 18822.36 during 1974-80 at all India level. It further increased to Rs. 55180.56 during 1985-90 (Gulati, Svendsen and Roy Choudhury). These figures vary from region to region and from state to state. The cost of providing (other than cost of construction of major and medium projects) canal irrigation has broadly three components in. These are working expenses, interest on cumulative capita outlay and the depreciation charge. Interest cost is the single largest item (over one half) in the cost structure of canal irrigation. Depreciation cost amounts to a little under one third of the total cost. The rest of the cost is incurred in operation and maintenance (O&M). The total cost of per hectare of irrigation amounts to Rs. 2277 (Dhawan, 1999). Effective O&M of the existing irrigation systems is considered to be an important determining factor behind degree of utilization of created potential and efficiency of the system. At the present situation allotment for O&M expenses are abysmally low and entirely inadequate. Reason for low provision for the O&M expenditure has been lack of funds resulting from low levels of cost recovery due to low water rates that are prevalent almost all over the country. So the low water rates and cost recovery ultimately leads to inefficient and low utilization of created potential. Cost recovery of irrigation projects is also an important issue in the face of mounting national debt burden.

Earlier, the second irrigation commission (1972) has prescribed optimum level of charges for irrigation water to be around 5% to 12% of gross income of food crops and cash crops respectively. But, owing to the critical financial situation in the share of O& M of the system the Planning Commission set up a committee on pricing of water in 1991 under the chairmanship of A Vaidyanathan to study various aspects of pricing of irrigation water (GOI, 1992). The Vaidyanathan Committee has recommended volumetric pricing of canal waters and increases the collection of users charges by raising rates and more effective enforcement of scheduled rate. The first essential objective is to raise water charges so that they cover the cost of O&M and as a longer objective it should also cover depreciation and interest on capital. It has also recommended upgrading the standard of construction and infrastructure works. Two separate norms have been suggested, one for establishment required for irrigation management, operation etc. and the other for maintenance and repairs. It should be mentioned at this point that besides price, the cost recovery of irrigation projects also depends on a host of other factors. While affixing the pitch of canal water charge, inter-farmer variation in the accrual of canal benefits and margin of benefits to be allowed to be retained by the farmers should be borne in mind (Dhawan, 1999). It has been argued that the larger farms have experienced a much larger irrigation ratio especially in the case of canal irrigation than the small farmers (Vaidyanathan, 1999). So the question of equity and efficiency in water distribution should be kept in mind while setting water charges and exploring ways to greater cost recovery. The issue of cost recovery greatly relates to the institutional aspect of irrigation management. Water management in India has had an execution through a top-down approach and has virtually been a government monopoly. A 'supply-side' approach has been adopted in the case of water management. For the proper management of our water resource in general and irrigation water in particular a 'demand side' approach is absolutely needed. It is argued that the institutional mechanisms such as user association, farmers' participation in irrigation management, turning over the irrigation system to farmers' group, are essential for improving the performance of irrigation system in India. Role of the local NGOs is considered to be vital for promoting water users association. Moreover it has been argued that the 'top down' (centralized) and 'bottoms up'(farmers participation) approach has to be integrated.

The World Bank (1999) has mentioned about a vicious circle that leads to inefficient management of the irrigation water for major and medium projects. The circle starts at poor quality of irrigation service where non-participation of the farmers in irrigation decision making eventually leads to no control of farmers over the quality and timing of water they receive or even certainty of getting irrigation water. This along with poor quality of agricultural extension work leads to low yields and so low incomes, which lead to farmer dissatisfaction. This condition along with political pressure not to pay for a service, ultimately leads to low recovery by resisting water rate revision and delaying water payments. Again, low recovery leads to underfunding of the operation and maintenance (O&M) of the conveyance systems. Inadequate O&M leads to poor quality and state of most systems. Along with these inappropriate structures, policies and poor staff skills aggravate the situation. All these things together lead to the closure of the circle at the poor quality of irrigation service. In analyzing the financial performance of surface irrigation system in India Gulati, Svendsen and Roy Choudhury (1995) has observed that the recovery ratio as percentage of working expenses recovered has declined over time for each and every region. The western region has demonstrated the highest fall. Though the southern region has shown a smallest rate of decline but its recovery ratio is the lowest. Excepting northern region all regions have displayed a rising trend in O&M expenses per hectare at constant prices. Inadequate provision for O&M expenses has led to poor cost recovery. Dhawan (1986) has also argued that the situation of under-pricing of canal water leads to improper undertaking of repairs and maintenance works which ultimately lead to poor quality of irrigation. He has suggested that appropriate volumic pricing of canal water can tackle the wastage in water use. Vaidyanathan (1991) has also argued in the same way. In his view the sustainability of the canal irrigation system will very much depend on its financial sustainability. Pricing of canal water plays an important role here. While price of surface irrigation water has been abnormally low, groundwater pricing is only through charges for electricity which is low and below the cost of production. It has been generally argued that canal water charge has to be increased. Barring politicians, resistance against any price rise of water may also come from the farmers. This is because a large segment of farmers within the canal command area do not get water due to bad design, overextended commands, delays, "leakages" in construction etc. for which the farmers are not at all responsible.

Mitra (1998), in his study of nature of irrigation development in Maharastra, has identified that inadequate expenditure on O &M has been the main factor behind the inability of the systems to achieve their expected potentials. Moreover within the amount available for O&M, wages and salaries accounts for more than half of the total amount available for O&M leaving little for actual maintenance work. It has also been noticed that though the O&M cost has increased rapidly but gross receipt has not shown any discernable upward trend. Under this condition, not only more funds have to be allocated for O&M, and existing water rates have to be increased to achieve financial buoyancy in the public irrigation system but also institutional change in terms of financial and functional autonomy is imperative to bring about the much needed accountability. Sampath (1992) has also argued that low cost recovery will lead to inadequate fund for O&M and deterioration of physical structure, which will ultimately require considerable cost for rehabilitation or renovation. The Report of the Committee on Pricing Irrigation Water (GOI.1992) has estimated the annual working expenses for irrigation projects at Rs 2,500 crore for 1989-90 (to include reasonable O&M, 1 per cent interest on cumulative capital and 1 per cent depreciation). The Committee has also proposed a two-part tariff, as the amount of water available and used for irrigation will differ according to climatic and other variations. One part of the canal command area would pay a fixed annual fee and the second part of the fee would be variable and depend on the extent to which the service has been used. Sampath (1992) has also argued in this line.

Financial constraints in terms of getting new funds thwart building new projects and continuing ongoing projects Iyer(2001). Three policies have been generally suggested to ease monetary constraint: (1) increased privatization on; (2) increased service fees and transfer of government responsibilities to the beneficiaries; and (3) removal of subsidies from all water related services. Frederiksen (1996) has argued that increased privatization is not a panacea.

Under condition of prolonged drought the as marginal capacity of the farmers to pay will decline, the private initiative will also come to a halt. So government investment in irrigation, flood control and drought abatement is absolutely imperative. It is even impossible to estimate the level of investment needed by the private investors to rehabilitate and expand them. First, the beneficiary owned entities has to get matured and has to demonstrate financial responsibility. After that increase in service fees and transfer of government responsibilities has to take place. But still government has to warrant by creating the necessary regulatory capacity, establish policies on financing and ownership of facilities and alter conditions that now favour the agencies retaining these responsibilities.

It is commonly argued that removal of urban and irrigation subsidies will greatly decrease demands on government budgets, which always runs in crisis in developing countries. Frederiksen has argued that it is rather urgent to identify all subsidies and open the debate on equitable policies and measures to remove the inappropriate ones. Drought preparation of the developed countries is almost sound but for the developing countries it is inadequate. Emergency plans have to be chalked out properly with utmost importance to all basin and metropolitan water plans and programme. Frederiksen taking the example of Sardar Sarovar Project (SSP) has done a case study considering the above arguments. Progress in construction progress in this project was satisfactory if smaller and simpler achievements are considered. But interruption of international funding scuttled the progress of the project and led to time and cost overrun. Delays in reallocating people displaced by the reservoir and incomplete description of environmental concerns brought severe pressure to the state and prolonged the terrible suffering of the region's poor. Steady and constructive help from international community to the developing countries is absolutely necessary, but along with this, governments of these countries must do away with reports inappropriate to conditions, shallow reviews of its current programmes or arrogant directives. Any proposed solution must consider the constrains of time, water availability, funding and drought management option

Sampath (1992) has also taken a similar view as Frederiksen. He has analyzed the role of government in irrigation development and allocation, economics of irrigation pricing, current status of irrigation water pricing and cost recovery in developing countries and the reasons for marginal cost pricing principles not being followed in developing countries. To develop a free water market private property right for water resource is essential which is hardly available. In case of riparian right where adjacent land or overlying land gets the ownership of water. This system can only be used in humid areas where there is no water shortage. In the riparian right system as there is no allocation priorities frequent court battles will occur and the poor will loose to the rich. So public ownership of water is absolutely necessary and will be operated based on first come first serve system, estimated social worthiness, redistribution of income, or improvement in the economic status of a backward region or less privileged group of people, food self-sufficiency, government dictated cropping pattern. Gaining economics of scale is also considered to be easier in public irrigation due to its large quantities of irrigation water. To deal with externalities, particularly environmental concern, public irrigation is absolutely necessary. Regarding marginal cost pricing he has argued that if perfect competition condition are satisfied and externalities are absent, then market prices (long run marginal cost pricing) will be efficient and will reflect social values. But in a noncompetitive situation, where social inequity is well prevalent, average cost pricing is better than the marginal cost pricing. Dinar and Subramanian (1998) has also found that all developing countries and some industrial countries in their survey have set water charges on the basis of average cost rather than marginal cost.

Dinar and Subramanian (1998) has analysed the commonalities and differences of water pricing experience to improve water use efficiency of 22 countries, selected on the basis of the criteria of the degree of water scarcity and availability of information on past attempts to implement water pricing schemes in more than one sector. They have found that three countries in the Middle East and North Africa have much less and declining water available per capita compared to other countries as in the review. The reasons for charging water varies from recovery of cost, income transfer between sectors through cross-subsidization, achieving food security, improvement of water allocation and conservation etc. There exist regional variation in water availability. This along with the technology used have led to differential cost of supplying water but the charges are not generally adjusted by region. Only a few countries have recovered capital cost from the users though governments of both industrial and developing countries are rethinking about this policy. They have found no relationship between water availability and price reforms and also between budget deficit and price reforms. The reports of the countries have discussed about the need for volumetric pricing, moving away from uniform tariffs and abolishing minimum prices, providing incentives to water suppliers and consumers etc.

Dhawan (1999) has argued that as the benefit from canal irrigation exceeds the cost, it develops a strong case against subsidisation of canal irrigation and in favour of stepping up of investment in canal irrigation. To analyse the economic viability of canal irrigation investment, we also have to take into account the cost of loss of forest cover and bio-diversity due to submergence, land degradation due waterlogging and salinity/alkalinity within canal commands etc and the non-farm benefits of canal irrigation. He has argued that farmers ought to pay at least for both operational/variable cost and the depreciation cost. Ignoring then political pressure in favour of low water charges, it should be viewed from economic angle. Dhawan (1997) has also argued that until we establish that the rise in the marginal cost of canal irrigation is due to only genuine causes and not due to corruption in public canal irrigation, upward revision of canal water rates is not possible. Jairath (1998), in contradiction to Dhawan's argument commented that there is no difference between corruption and inefficiencies in expenditure and leakages. It is like selling the third rate irrigation at throwaway price. He has emphasized the need to improve the quality of irrigation services. If without improvement in the quality of irrigation services water charges are improved, then farmers, especially the large farmers may shift to other forms of irrigation. Dinar and Subramanian (1998) also argues that there should be non-price measure to encourage water use efficiency. It is absolutely necessary where rural or urban dwellers may resist paying for water and applies political pressure or even technical and managerial capacity may be inadequate to assess and enforce charges. Patel (1990) in his study on Gujarat argues that additional resource after upward revision of water rates should be invested in repairs and maintenance work of the canal irrigation system.

Gulati, Svendsen and Roy Choudhury (1995) have estimated the cost of development of per hectare of irrigated land. They have revealed a J-shaped pattern of per hectare capital cost over the period 1963-64 to 1994-95.Over this three-decade period the average cost of cumulative irrigation potential created through major and medium schemes is estimated to be about Rs 35000 per hectare at 1988-89 prices and 5 % rate of discount and about 29000 per hectare in project-specific calculation. The regions of India in descending order of cost will be southern, western, eastern and northern. Improving design and appraisal, restructuring management institutions, Increasing and restructuring irrigation fees and farmers participation have been prescribed for better cost recovery of irrigation projects. They did not compare the cost of irrigation development with gain in the yield of irrigation development.

Patel (1990) has made an attempt to find out the criteria for a fair water rate structure, analyse water rates practiced in Gujarat during last two decades, it's comparison with farm harvest prices and prices of some strategic inputs used in crop cultivation, farmers view on water rates, income impact of water use, the present system and its associated problems. He has identified that rates of water has risen more in case of rabi and summer season crops and two season perennial crops. It has risen more in case of non-foodcrop than foodcrop and lower rate has been charged for crops in reclaimed land. The revision in the water rates did not keep pace with the rise in farm prices. Farmers can be persuaded to pay higher canal water charges if water supply becomes adequate and regular. He has also suggested that while fixing the water charge maximum net income per unit of water should be taken into account. Additional resource garnered after upward revision of water rates should be invested in repairs and maintenance work of the canal irrigation system.

Easter (1993) has argued that farmer's decision regarding contribution in O and M is guided by profit motive and internal assurance regarding contribution of others. Regarding ability and willingness to pay water charges the findings of Reddy (1998) is interesting. He has analysed farmer's willingness and ability to pay for irrigation water in diverse conditions in a study based on 181 households residing in three districts of Rajasthan. He has argued that effectiveness of principle of cost recovery depends on willingness of farmers to pay for irrigation water and the existing institutional setup in collecting the water charges. It has been observed that small and medium farmers even with the access to water have low ability to pay for private irrigation system. So public irrigation is absolutely desirable, especially in scarcity conditions (whenever feasible) in order to achieve equitable water distribution. It has been observed in the study that the willingness to pay is linked more to scarcity of water than the ability to pay. Average bid more than covers the operation and maintenance cost in both the regions (endowment & scarcity) and in all classes, except one. Average bids are relatively higher if remunerative crop are cultivated. Free rider attitude of people towards public irrigation is prevalent and more so in villages where water is not so scarce. Poor reliability and lack of trust of public irrigation system leads to low willingness to pay. In the endowment region willingness to pay bids systematically increases as the farm size increases reflecting positive association between willingness to pay and economic status. Proportion of farmers biding to the highest range also increases along with farm size. It has also been observed that willingness to pay is positively associated with percentage of area under irrigation (proxy for ability to pay). Another important finding is that price elasticity of water is low as farmers are willing and able to buy water from these markets at much higher prices.

In our analysis we will look into the pattern of expenditure on major and medium irrigation and will try to relate it with the capital cost of irrigation. We will calculate the cost aspect by using the idea of Gulati, Svendsen and Roy Choudhury (1995). We will like to analyse the problems in the revenue account, specially the O&M expenditure and the problem of cost recovery and pricing. Our study also tries to find out the interrelations between these variables.

1.4 Policies and Institutional Setup in Management of Water Resource

Under India's Constitution, subject to Entry 56 of List I, water is considered a "State Subject". Within the context of boundaries of the state the litigation and administration is to be framed. The National Water Policy (NWP) adopted by the National Water Resource council in 1987 is the most comprehensive water policy statement at the GOI level. The states are supposed to frame their state-level policies folling the structure of NWP. But till date, very few states have been able to translate the national policy into specific state-level policies. Though there are few fallacies in the approach of NWP but it is a holistic and integrated basin-oriented approach to water development. It has discussed about the broad issues of priorities or different uses, various environmental problems, participation of beneficiaries in water management. It has also proposed promotion of conjunctive use of surface and groundwater, water conserving crop patterns, irrigation and production technologies. Under Indian statutory law, all surface water including natural flow in a river, storage behind a dam, natural lake is public property. On the other hand ground water rights are tied to land rights and so it gives groundwater a purely private good character. The legislation has failed to devise a structured system and process for providing secure, defensible and enforceable surface water right because the rights for surface water are unclear. Tying ground water rights to land rights has led to de facto rights at the field level in favour of the large farmers with higher pumping capacity and deeper tubewells. Due to these loose and improper legislative frameworks hardly any water market has developed which will lead to efficient and sustainable use of the scarce resource. Water resource continues to be depleted and misused under condition of stress. Under present structure of pricing of both groundwater and surface water there is hardly any incentive to use the scarce resource efficiently and in a sustainable way. Canal irrigation prices are abnormally low and covers a fraction of cost of water provision. Groundwater prices are only indirect through diesel fuel or electricity prices, which are again substantially low.

Institutional setup plays an important role in efficient management of water resource. It can take care of the environmental and financial aspects. Hufschmidt (2002) has made a framework of water policy for sustainable use and then has focused on how water policy is linked to policies in public finance, agriculture, industry and commerce, health, human settlements, transport and environment. He has identified three systems, natural water resource system (supply of water), human activity system (demand for water) and water resource management system (harmonization of demand and supply of water), which are interrelated to each other. An effective water resource policy preserve integrity of the natural water resource system and provide water and water related services to people in an economically efficient, equitable, environmentally sound and sustainable manner. To provide an effective water resource management system, policies that are to be adopted include establishing a national water code, mixed public-private rights to water use which recognize water as a collective good, integration of activities of different agencies at the planning and implementation stages, spatial integration by river basin, water resource demand region, and division of responsibilities or water resource management among national, provincial, local public and private sectors. He has identified that water policies generally overlap with the policies of agriculture, energy, forestry, environment, transport, human settlements, health etc. So water resource policies have to be developed on a comprehensive and consistent basis. An example in this regard is the government policy for India's sugar sector, which has contributed to a rapid increase in sugar cultivation in Maharastra. Maharastra is extremely water short but sugarcane is a high water consuming crop. This has led to misallocation and mismanagement of irrigation water resource.

In it's report, the World Bank (1999) has the present institutional arrangement regarding the water resource management. Irrigation, which accounts for 84% of water use has got the highest priority over water requirements of other sectors. Irrigation department has strong orientation towards civil works construction and so has given limited attention to water planning and management. In Bihar, Kerala, Rajasthan, Orissa and Uttar Pradesh groundwater is handled by another department and in states like Andhra Pradesh, Bihar, Maharastra and Uttar Pradesh major, medium and minor irrigation is split between different departments. The "institutional gap" among specific institutions and mechanisms for handling inter-sectoral issues have scuttled the effort to create a specialist Water Resource Organisation. To improve intersectoral coordination of water issues Tamil Nadu has created a State Water Resource Council, Orissa has established a State Water Resource Board, Maharastra has created a Water Resource Authority, Punjab is proposing to establish Water Resource Council and Rajasthan is also considering to establish similar organizations. To manage water comprehensively within a river basin no attempt has been made to create river basin organization. Laudable attempts have been taken in this regard by Tamil Nadu by establishing a Vaigai Basin committee. To manage water along hydrological lines, states like Haryana, Tamil Nadu and Orissa have decentralized their water resource department along river basin lines. Grassroots institutions also carry tremendous importance in managing water recourse at the grassroots level and to deal with local level problems. Though such institutions are conspicuously absent but developments like 73rd and 74th Constituional Amendments Acts of 1992 which provide options to establish or revive local government structures and promotion of irrigator's users association, has brought opportunities to develop local water management institutions to fully manage the lower-level irrigation systems and to be federated into management committees for participation in management of the whole command. It could also be extended to participation in river basin management. World Bank has presented a reform agenda to deal with the present situation. It has suggested a combination of mechanisms in improving the policy framework, strengthening the legislation and regulation, establishing central, state-level, basin and grassroots level institution, introducing economic incentive through proper price and non-price factors, and improving technology, data, analysis and public information. It has proposed a public-private partnership, decentralization, stakeholder participation and involvement of grassroots organizations. It has sought for a balanced approach through demand management of water resource rather than traditional supply-side orientation by combined use of technology, incentives, public awareness and other actions.

The growing water scarcity and increased competition among different sectors of water use will lead to greater competition between various sectors for scarce water. In the absence of proper legal and institutional regimes it will become a daunting task to integrate the variety of social, economic, fundamental rights and environmental concerns in intersectoral water allocation (Kumar, 2001). If integration is not done properly then it will lead to conflicts between users and users groups. The institutional change to avoid such kind of disastrous situation is suggested to be establishing tradable private property rights in groundwater and canal water, appropriate pricing of water for canals and urban water supplies, unit pricing of electricity used for groundwater pumping and taxing industrial and urban wastewater. Singh (2001) has also argued that in the present situation of lack of well-defined property rights and appropriate legal system water is bound to be overexploited. He has argued that the present situation of water crisis in India is mainly due to over-exploitation, pollution, lack of property rights, deficiency in design and implementation of water supply projects rather than natural factors such as drought. In this situation water management through water users association will usher in efficiency, sustainability and equity in water management. But in reality water market and trading do not produce any additional resource to the country but only allocate water productively (Frederiksen, 1996). It will appear to be effective only in periods of severe droughts. Moreover, when the primary objective of the county is poverty alleviation, water market and trading will prove to be counterproductive. It will undermine a county's social regional development, security and environmental goals.

Iyer(2001) has also argued that water cannot be left to the invisible hands of market forces as it is not only a economic good but also a social good. Proper pricing is only a part of answer to ensure efficiency and economy in water use and conservation of the resource. General campaigning should be launched to curb profligate and waste of the resource. Economy and efficiency in water use should be encouraged in agriculture, industry and water supply system. Proper flood management policy should be adopted and should not be superseded by other objectives. The local water-harvesting and watershed development based approach does not come into conflict with the idea of basin-based approach. We must shift our attention from only river to the ecological system as a whole. Regional cooperation is also needed not only for big dam projects but also in terms of alleviation of poverty, ensuring equity and social justice, removal of disabilities of women, children and disadvantageous groups etc. The National water policy should also give due importance to these issues. Attention should be given to pollution, degeneration or denudation, improving water quality, rainwater harvesting, and watershed development through inter-country cooperation. Importance should be given to woman participation in water resource planning, resolve inter-state disputes regarding water and review of laws regarding water. Basically he has argued that besides a centralised/'top-down' approach local decentralised/community based approach should be considered as a supply side response against water shortage. Human and the nature should be given the highest priority rather than the projects. Transfer of management responsibilities for operation and maintenance has been successfully done in Madagascar (Dinar and Subramanian, 1998), which is predominantly a low income country. It has been observed that the high-income countries are generally relatively open to reforming pricing policies.

In case of irrigation an incentive gap for both service provider and user has been identified for the creation of the above-mentioned vicious circle (World Bank, 1999). As farmers are not involved in the management of the irrigation system and are seldom consulted by the government there is no incentive on their part to improve. Irrigation departments suffers from lack of accountability to the client and find no incentive to be cost efficient in providing services, to be financially self sufficient, to improve the technical quality of services and to link up with other government services, the private sector and the civil society. To break the vicious circle, irrigation management has to be transferred to the farmers, irrigation departments have to be reformed, financial viability has to be achieved, irrigation system has to be upgraded, farmers have to be helped in improving their irrigation services, monitoring of sector performance has to be improved and fully transparent and participatory approach has to be taken. Vaidyanathan (1991) has argued that the paucity of data coupled with absence of user participation and consultation has resulted in frequent inefficient management through mindless operating decisions. As the system managers are unable to enforce restrictions on crop pattern, regulate the tapping of groundwater and prevent unauthorized diversion of canal supplies, the head reach farmers are generally able to appropriate the maximum benefit of canal irrigation and the tail end farmers generally suffer from water shortage. He argues that all these problems can be sorted out if the users of water get actively involved in planning, designing and operating the projects (Mitra, 1996; Jairath, 1998)). Regarding cost recovery this situation can be greatly facilitated by farmer's participation in irrigation management through water users' association (Sampath, 1992). Easter (1993) has attempted to explain the poor performance of irrigation in Philippines, Sri Lanka, Nepal and Maharastra with the help of a model including internal and external assurance, commitment and fairness. Organisational and institutional setup has to impose penalties on farmers and provide incentives to encourage farmers to pay water fees. Improved external assurance through greater farmer participation, good communication, penalties for poor water management, clear responsibility for O&M and water fees, can be used to enhance farmers contribution to O&M. Farmers participation in system planning and management will provide both internal and external assurance. In the debate on irrigation management there exist a dichotomy between 'top down' (centralized) and 'bottoms up' (farmer's participation) approaches. This dichotomy is misconceived and an integrated approach is necessary for the success of pricing and institutional mechanisms in irrigation management (Reddy, 1998).

The advent of HYV seeds in Indian agriculture has spurred the need of irrigation, which in many cases has been taken care of by the groundwater. The development of groundwater has led to increasing disparity between small and large farmers as well irrigation is indivisible investment and also a costly affair (Dhawan, 1986; Vaidyanathan 1991). As most of the holdings in India are small, canal water supply is available according to pre-determined time schedule rather than demand from the individual farmers. Inadequacy in the canal water supply can occur in two conditions. One is when works are designed on scarcity principle and so each farmer gets less than optimum need of water. The other situation is when the inflow is reduced due to periodic water shortages. For the cultivation of HYV crops periodic water shortages are detrimental. That is why it has been argued to abandon scarcity principle in designing distribution network and move towards productive irrigation that will meet the full irrigation need of HYV crops. But Dhawan (1986) has prescribed that rather than distributing water according to the full irrigation need it should be distributed more equitable through scarcity principle. Wells can be established and ground water and surface water should be used conjunctively in this case to fill up the deficit of irrigation need.

Vaidyanathan (1991) has emphasized on the equity aspect of distribution of irrigation benefits. He has argued that a regional disparity in development of irrigation has not narrowed though the irrigation ratio has increased everywhere. This has been due to the spread of well irrigation in recent times, which is mainly privately owned. Public sector canal irrigation has infact shown a narrowing of disparity. One of the reasons behind this is the disparity of different states in outlay for irrigation. He has estimated that productivity can be increased through investments on rainfed land. Only one thirds of the increased irrigation potential are in states where the ratio of irrigated to unirrigated yields is over 3 while two third of the increased irrigation potential are in states where the ratio of irrigated to unirrigated yields is less than 2. As it has been discussed earlier, the upstream farmers generally preempt maximum quantity of water and so the tail end farmers suffer from water shortage. It may also be the case that the upstream farmers may have greater clout with state-level officers, ministers and political parties and thus influence the water allocation decisions at different levels of bureaucracy. On the issue of distribution of canal irrigation benefits among different size of farms, he remains inconclusive. In the debate of intensive versus extensive irrigation for gaining maximum benefit, he has argued that generalized conclusion on this is difficult to get as it is dependent on agroclimatic conditions, seasonal pattern of irrigation needs, crop patterns, state of biochemical technologies etc. In this regard there are two schools of thought. One school of thought argues that through more extensive irrigation larger area and more farmers, especially small farmers will be benefited. If extensive irrigation leads to addition in output as large as the intensive irrigation, then the former is always socially preferable. The other school of thought prefers intensive cultivation on the ground that intensive irrigation leads to higher cropping intensity, higher levels of biochemical inputs. This will enhance the productivity of land. There has been a preference of farmers for intensive use of water by cultivating water intensive crops. This is actually a moot question whether this type of intensive irrigation necessarily gives larger output when land rather than water is the binding constraint.

The distribution of canal irrigation benefit is an important criterion in determining water charges. Two factors that have to be kept in mind in fixing up canal water charge are interfarmer variation in the accrual of canal benefits and the margin of benefits to be allowed to be retained with the farmers (Dhawan, 1994) He has identified that there exists spatial differences in development of irrigation, which leads to interstate and intra-state differences in agricultural growth. Disparities also exist in income benefits from irrigation between dry zone farmers and wet zone farmers and also between tail-end farmers and head reach farmers. Though the allocation policy appears to be neutral in northern states of Punjab, Haryana and Uttar Pradesh through warabandi system of rotational irrigation, in south India where this practice is not performed neutrality in water distribution does not prevail as large farmers forcefully prevent small farmers from utilising their due irrigation turns during times of water stress among crops. According to Dhawan's (1986), analysis taking sample survey data of four states of Maharastra, Tamil Nadu, Punjab and Uttar Pradesh has shown that on farm, benefits from a unit of irrigated area need not rise with the size of a farm holding if equity persists among the farmers in the use of chemical fertilisers. But in the absence of equity in the fertilizer use in Maharastra and Uttar Pradesh each unit of irrigated area is positively related with farm size.

In setting the pitch of canal water charge the magnitude of income gain from small farmers is more relevant than average income gains for all farmers taken together. Considering all these facets, the pitch of the canal tariff cannot be more than four-ninths of the mean value of unit benefits accruing to farmers as a result of use of canal water. Reddy (1998) has also identified that the willing to pay for canal irrigation will depend on the farm size and the relation is positive. Easter (1993) has also argued that farmer's decision regarding contribution in O and M is guided by along other thing the degree of fairness they perceive in the system. A sense of fairness in distribution of canal irrigation benefits increases contribution to O&M. Fairness will prevail more in systems which have homogenous and evenly distributed land resource.

But Sampath (1992) has argued that there are situations when policies to promote equity may lead to efficiency. There is no unique way of management of irrigation projects since the objectives, constrains, conditions, socioeconomic, political and institutional settings vary across country, regions and time. Regarding pricing he has argued that setting of price on the basis of the financial considerations rather than economic consideration may lead to inefficient use of scarce resource. As there are millions of beneficiaries of canal water, it is not justified that farmers will bear the burden of water charge depending on marginal cost. In a non-competitive situation it is not necessary to follow marginal cost pricing. Most of the water pricing systems are neither efficient in maximizing social benefit nor equitable in distributing the benefits of irrigation development or adequate in cost recovery.

In our study we will discuss about the policies taken by the government in the management of water resource in India. We will also discuss about some interrelated policies in this regard. There is not much scope in analysing the institutional aspects of water resource management due to lack of data. But we will go for an analysis in a small scale. We will also analyse the relation between the farm size and cost recovery of M&M irrigation projects.

1.5 The Problem and Scope

Ample studies have been done on mismanagement of water resources in India. But most of these studies lack integration between national and state level picture. So in our study an attempt has been made to look into the problem of mismanagement of water resource at state level and relate with its whole gamut of dimensions, i.e. system efficiency and financial perspective etc. Then we have made an effort to integrate these two aspects. After that we have suggested some policy initiatives for each and every state to manage water resource efficiently.

1.6 Objective of the study

The specific objectives of the present study are: -

(1) To look into the demand and supply side of water resource and its management in India.

(2) To analyse the management of M&M irrigation water resource from system efficiency perspective.

(3) To analyse the management of M&M irrigation water resource from financial perspective.

(4) To suggest policy initiatives for management of M&M irrigation water resource efficiently.

1.7 Hypothesis

(1) System inefficiency in M&M irrigation is not prevalent in all the states.

(2) Capital expenditure in M&M irrigation in many states is insufficient. This has led to inefficient management of M&M irrigation water resource.

(3) Shift from expansionary policy to system efficiency does not hold good for each and every state to manage water resource efficiently.

1.8 Methodology

For different objectives different statistical tool has been used. In many cases simple statistical measures like percentage share and compound growth rate has been used.

Principal Component analysis has been done in constructing 'index of development of core components of Command Area Development (CADP) programmes'. The PCA method of index construction offers a technique, which combines numerous components into one index. PCA reduces a large number of variables or indices into a small number of conceptual variables through the inter correlations.

To construct the "index of development of core components of CADP programmes" following variables were chosen: 1) Cumulative development of Field Channel facilities, 2) Cumulative development of Field Drainage facilities, 3) Cumulative development of Land Levelling facilities, 4) Cumulative development of Warabandi programme

The method of deriving composite indices/principal components is given below:

$$CI = \sum_{i=1} X^s W$$

or $CI = X^S_1 W_1 + X^S_2 W_2 + \ldots\ldots\ldots\ldots + X^S_n W_n$

Where CI = composite indices

where X^S = Standardised[1] values of the original figures of the vector (indicator) of the matrix

[1] Standardisation is done to get scale free figures or to get out of scale bias with the subtraction by mean and division by standard deviation.

W= factor loading (weightage)

This exercise has been done to compute factor scores to get composite indices for states to work out the over all levels of development of CADP programmes.

We have used Ordinary Least Square (OLS) to analyse the impact of water rate and working expenditure on a gross recovery. Here we have taken the following method:

$Y=f(x)=a_0+a_1x_1+a_2x_2+......+a_nx_n$

where y=dependent variable

x_i=independent variable

and a_i=coefficient of independent variable, where i (1) n

In our analysis y = gross recovery/hectare

x_1 = working expenditure/hectare

x_2 = water rate/hectare

We have also examined the goodness of fit of the regression analysis by looking into R^2 (= explained sum of square/total sum of square). We have also looked into the significance of parameters with the help of t-statistics.

In many cases we have calculated the simple correlation coefficient. We have tested the significance of coefficient of variables in the regression and correlation coefficients using the t statistics.

1.9 Database

Paucity of data has impaired the research to a large extent. Data for Financial Results of Irrigation and Multipurpose River Valley Projects, Water charges has been taken from Water and Related Statistics (published by Central Water Commission) for which data after 1995-1996 is not available. The same source has provided with data on Water Resource of Various Types, Irrigation Potential Created and Utilised and Command Area Development Programmes. The Ninth Five Year Plan document has also helped in getting data on these variables. We have obtained information about revenue and capital expenditure of different states from State Finance Accounts. Along with it Statistical Abstract of India and Indian Agricultural Statistics have been extremely helpful in getting data on Net and Gross Irrigated

Area. The farmsize level data on Percentage Distribution of Net Irrigated Area by Sources of Irrigation for Broad Size Class of Operational Holdings has been collected from National Sample Survey (published by CSO, 48^{th} round).

1.10 Structure of the Dissertation

We have divided the study into five chapters. Chapter 1 consists of an introduction and review of literature about our study. In Chapter 2 we discuss the availability and demand for water resource and its management. In Chapter 3 we focus our discussion on the management of water resource with reference to M&M irrigation. In this chapter we only concentrate on the efficiency aspect of M&M irrigation system. In Chapter 4 we discuss the financial aspects of M&M irrigation and analyse the nature and extent of management or mismanagement due to financial problems. Chapter-5 summarises the results of the present study and prescribes few policy implications.

Chapter 2

Water Resource Management in India

The emerging challenge, which the world is facing today and will become prominent in the twenty-first century, is the sustainable management of the water resource in the face of continuing expansion of population and economic activity. The problem has become more acute when we consider the well pervasive problems of poverty and environmental degradation. Though India, as a whole, is well endowed with fresh water resource but there are significant spatial and temporal variations in the availability of water. Local scarcity and surpluses puts a challenge on efficient management of water. Over the years, there has been a continuing growth of population, levels of income, urbanization, industrialization and commercialization of agriculture. As a result demand for water is increasing and has led to conflicts between sectoral uses. This has been the reason that there has been a shift in emphasis from the supply orientation to demand management. Efficiency in water management would be the only logical way out of this precarious situation. To usher in the efficient use of water resource, policies at different level and different sectors has become important. In this regard, a comprehensive and coordinated policy regime is most desirable. India, keeping in view all these constraints, has introduced National Water Policy in 1987. This policy was supposed to be adopted by state governments with relevant changes keeping in mind local needs and constraints. But, till date very few states have been able to adapt and introduce state water policy.

In this chapter we will discuss about the general scenario of water resource management. We will first discuss about the demand for water by different sectors. In this regard we will also discuss about the demand for water by different crops. Next we will discuss about the supply or availability of water in different states of India. We will then discuss about the supply of irrigation water by different sources. A discussion has also been carried out about the area of crops irrigated in different states. As drinking water supply and flood and drought management are important aspects of supply side management of water resource we will make notes on these issues. Watershed development and Participatory Irrigation Management are also discussed as demand management aspects of water resource. As water is also demanded for Hydro Electric Power generation, we have made an effort to look into the statewise scenario of this sector. Lastly we have discussed about the role of different state policies in harmonizing the demand and supply side of water resource sector or water resource management.

2.1 Inter-sectoral water Demand –Present and Future

The present section analyses the national level scenario. Future projection has also been estimated about water demand by various sectors. Irrigation water requirement has always taken the first place at different periods of time. Presently irrigation accounts for 85% of the total water requirement (Table-2.1). But its demand share is expected to decline through time. This drop in the share is sharper between 2025 AD and 2050 AD. It is interesting to note at this point that though the share in total requirement is going to decline but its requirement is going to increase by 2.1% per annum between 2000 AD and 2025 AD and further by 0.66% per annum between 2025 AD and 2050 AD (Table-2.2). As whole the requirement of irrigation water is expected to grow by 1.38% between 2000 AD and 2050 AD. But the concern for this sector is that while the share of water in this sector will decline, the growth rate of requirement will increase.

Within the agricultural sector water intensive crops such as rice and sugarcane together consumed around 63% of the total water in agriculture in 1990 (Table-2.3). The share of water consumed by different crops in different period is expected to remain stable. The most laudable part of agricultural water use is that growth of water requirement in wheat, which has been the moderate water-consuming crop, has increased by 4.4% between 1990 and 2000 (Table-2.4). On the other hand, the growth rate of water requirement of relatively more water consuming crops like rice and sugarcane has been relative less at 1.8% and 3.4%. It has been projected that the growth of requirement of water for rice between 2000 and 2010 is relatively higher at 2.32% as compared to wheat at 1.78%. In case of sugarcane it is expected to be relatively low at 1.32%. So we can argue that more water will be used for relatively less water intensive crops in the coming ten years. Whether distribution is socially optimum will largely depend on yield, the cost and prices of these crops and the social need. Agricultural policy regarding new technology in favour of less water consuming varieties will play a deciding role in this regard.

The domestic requirement of water is exhibiting a more or less stable share of around 6.6% at different time with a slightly upward trend. Its growth rate is also stable at around 1.8% per annum between 2000 AD and 2050 AD.

In case of industry its share is going to increase from 1.26% in 2000 to 4.35% in 2050. Its requirement of water is going to increase at a stable rate of 4% per annum. Among all the uses of water the sector that shows the highest growth of requirement of water is energy. Its growth rate is around 8.4% between 2000 AD and 2025 AD and reaches its peak at 9% between 2025 AD and 2050 AD. Its share in total water requirement is 0.32% in 2000 AD and expected to increase to around 9% in 2050. Other uses of water requirement will exhibit a more or less stable share of 6.5% in total water requirement at 2000 AD and 2025 AD. This share is likely to decline by a small margin in 2050. Its growth rate will be around 2.3% between 2000 AD and 2025 AD but will get reduced drastically between 2025 and 2050. The total water requirement is expected to increase by 2.2% per annum between 2000 AD and 2025 AD. It is expected to decline at 1.13% between 2025 AD and 2050 AD. So the major challenge that India will be facing in the coming 25 to 50 years is to supply more water to different sectors with changing shares and priorities.

This discussion bears the obvious implication that efficient management of irrigation water resource should be given the top most priority in the coming years. The overall management of water resource has to be taken care of, as sectors like industry and energy will be demanding increasing quantity of water. Availability of utilizable water resource also has to be enhanced as the demand for water as a whole is going to increase, more especially within the coming 25 years (Table-2.2). In this regard we should keep in mind that 'perhaps the most important constraint on solving the water resource crisis is time' (Frederiksen, 1996). So we should devise policies that will make available more utilizable water resource along with its efficient utilization.

The tables are in the next page

Table: 2.1 Percentage of Requirement of Water for Different Uses

Different Uses of Water	2000 AD	2025 AD	2050 AD
Irrigation	85.33	83.26	74.08
Domestic	6.62	6.68	7.05
Industry	1.26	2.10	4.35
Energy	0.32	1.37	8.98
Other Uses	6.47	6.59	5.53

Source: Central Water Commission: Report of the standing sub-Committee for Assessment of availability and requirement of water for diverse use in the country, August 2000

Table: 2.2 Growth Rate of Requirement of Water for Different Uses

Different Uses of Water	2000 AD -2025 AD	2025 AD - 2050 AD	2000 AD –2050 AD
Irrigation	2.10	0.66	1.38
Domestic	2.24	1.35	1.79
Industry	4.31	4.11	4.21
Energy	8.39	9.02	8.71
Other Uses	2.28	0.42	1.35
Total	2.20	1.13	1.66

Source as Table 2.1

Table: 2.3 Share of Projected Water Requirement in Agriculture by Different Crops

Year	Rice	Wheat	Sugarcane	Total Food	Oilseeds
1990	44.26	24.19	18.51	86.99	13.04
2000	39.97	28.12	18.86	86.95	13.05
2010	41.51	27.69	17.76	86.94	13.04
2020	42.65	27.21	17.11	86.96	13.04
2025	42.57	27.16	17.23	86.95	13.04

Source: Demand Management in the Face of Growing Water Scarcity and Competitio in India: Future Options, M. Dinesh Kumar, Institute of Rural Management Anand

Table: 2.4 Growth Rate Projected Water Requirement in Agriculture by Different Crops

Year	Rice	Wheat	Sugarcane	Total Food	Oilseeds	Grand Total
1990 and 2000	1.80	4.40	3.04	2.84	2.86	2.85
2000 and 2010	2.32	1.78	1.32	1.93	1.93	1.94
2010 and 2020	1.73	1.28	1.08	1.46	1.46	1.46
2020 and 2025	0.91	0.91	1.09	0.94	0.95	0.95
1990 and 2025	1.80	2.25	1.71	1.91	1.92	1.92

Source: same as Table-2.3

2.2 Availability of Water

India was ranked at 42^{nd} position among 100 countries by per capita water availability in 1990. At that time the per capita water availability was estimated at 2214 cubic meters. The global average in this case was 9231 cubic meters and for countries like Afghanistan, Pakistan and Sudan the figures were 3020 cubic meter, 3962 cubic meters and 4792 cubic meters respectively. The regional water availability varies widely within different regions of India and in some cases it creates stress on water resource as demand for water exceeds the supply of water due to soaring population. We will first discuss water availability in terms of inland water resource and then we will discuss interms of ground water availability.

Population density is highest in West Bengal in 1995-96 (Table-2.5). But it does not seem to be a water stress state in terms of inland water resource as 3% of its geographical area is covered by tanks, lakes and ponds though the length of river and canals is abnormally low at 28.48 Kms per lakh hectare.

In case of Kerala the high population density is supported by 80 Kms/ lakh hectare. Support by other inland water resource is only marginal because 6.25% of the geographical area is under brackish water. Bihar seems to be relatively water stress as length of rivers and canals is 18.4 Kms/ lakh hectare and its population density is also as high as 5.35 persons /hec. Its other inland water resource is only marginal. Bihar is a water stress region in terms of inland water resource as availability of the same is less and population density is markedly high. Uttar Pradesh is relatively water abundant with length of rivers and canals per hectare

are as large as 106 Kms/ lakh hectare. Punjab also appears to be relatively water abundant region than Haryana as rivers and canals per hectare is higher enough in case of the former and population density is almost same in these two states. Barring Arunachal Pradesh and Himachal Pradesh in all hilly states the length of river and canals per hectare is large enough and population density is also relatively less. In case of Assam the population density is relatively high but it has rivers and canals of the length 61.45 Kms/lakh hectare and other inland water resource. Karnataka is endowed with moderate inland water resource and has moderate population density. Andhra Pradesh does not appear to be a water stress region as rivers and canals, reservoir and tanks, lakes and ponds are sufficiently available in the state and the population density in the state is below average. Tamil Nadu is abundant with tanks, lakes and ponds but its population density is high enough and length of rivers and canals is only average. In Madhya Pradesh population density is as below average at 1.67 persons per hectare but available length of river and canals is moderate at 46.6 Kms/ lakh hectare and other inland water resource is only marginal. So, it does not seem to be water abundant region. Maharastra seems to be a moderately water stress region as population density is 2.8 persons per hectare but length of rivers and canals is only 52 Kms/ lakh hectare and inland utilizable water resource is marginal. Karnataka is endowed with enough reservoir facility and tanks,lakes and ponds. Rajasthan seems to be an extremely water stress region as inland water resource is marginal but its population density is moderate at 1.45 persons per hectare.

So, **from our discussion we can argue that inland water stress in India varies from one region to another**. Here a few points are worth mentioning. Generally, hilly states are water abundant in terms of length of rivers. But that does not necessarily mean that these states are being able to utilize this abundant water resource. Proper storage facility is necessary in this regard if there is sufficient need for water and if the topographical and other conditions permit. It will ease the water stress of not only these regions but will also be supportive to water needs of other water stress regions through proper channelising the water resource.

The table in the next page

Table: 2.5 Population Density and Statewise Inland Water Resource of Various Types, 1995

1	2	3	4	5	6	7	8
Andhra Pradesh	41.86	0.85	1.88	0.00	0.23	2.96	2.62
Arunachal Pradesh	23.88	0.00	0.01	0.04	0.00	0.05	0.12
Assam	61.45	0.03	0.29	1.40	0.00	1.72	3.15
Bihar	18.40	0.35	0.55	0.03	0.00	0.92	5.35
Goa	67.57	0.81	0.81	0.00	0.00	1.62	3.76
Gujarat	19.72	1.24	0.36	0.06	1.92	3.58	2.32
Haryana	113.10	0.00	0.23	0.23	0.00	0.45	4.20
Himachal Pradesh	53.89	0.75	0.02	0.00	0.00	0.77	1.07
Jammu & Kashmir	125.00	0.03	0.08	0.03	0.00	0.13	0.40
Karnataka	46.93	1.15	2.16	0.00	0.04	3.35	2.57
Kerala	79.57	0.77	0.77	0.00	6.25	7.80	7.97
Madhya Pradesh	46.59	0.66	0.27	0.00	0.00	0.93	1.67
Maharastra	52.00	0.91	0.16	0.00	0.03	1.10	2.81
Manipur	150.47	0.04	0.22	1.79	0.00	2.06	0.98
Meghalaya	249.67	0.36	0.09	0.00	0.00	0.45	0.94
Mizoram	66.18	0.00	0.09	0.00	0.00	0.09	0.39
Nagaland	96.50	1.03	3.02	0.00	0.00	4.04	0.88
Orissa	28.90	1.64	0.73	1.16	2.68	6.21	2.21
Punjab	303.22	0.00	0.14	0.00	0.00	0.14	4.44
Rajasthan	0.00	0.35	0.53	0.00	0.00	0.88	1.45
Sikkim	126.76	0.00	0.00	0.42	0.00	0.42	0.68
Tamil Nadu	57.05	0.40	5.31	0.00	0.43	6.14	4.57
Tripura	114.39	0.48	1.14	0.00	0.00	1.62	3.13
Uttar Pradesh	105.97	0.51	0.55	0.45	0.00	1.51	5.32
West Bengal	28.48	0.19	3.11	0.47	2.37	6.14	8.41
All India	56.50	0.62	0.87	0.17	0.43	2.09	2.84

Source: Water and Related Statistics, CWC

Legends

1. State

2.Rivers & Canals (Length in Kms./lakh hec)

3. Reservoir as a percentage of geographical area

4. Tanks, Lakes and Ponds as a percentage of geographical area

5. Beels, Oxbow Lakes & Derelict Water percentage of geographical area

6. Brackish Water as a percentage of geographical a

7. Sum of Column (3)+(4)+(5)+(6)

8. Population in density 1996 (population/hec)

The per capita figures of live storage facilities in some cases show sign of shocking mismanagement of water resource. Arunachal Pradesh and Jammu & Kashmir have hardly any live storage facility (Table-2.6). Storage facility is moderate in Meghalaya and Manipur and very high in Himachal Pradesh because of Gobind Sagar and Pong Dam. The abundant canal water resource in Punjab is the blessing of storage facility created in other states. In Andhra Pradesh, Karnataka and Orissa live storage facility is substantial and it is the reason for preponderance of canal irrigation in the state. It may be the case that in a particular state there is potentiality of high storage facility but due to scanty population density or small area under irrigation water demand is low. In that case a better water management policy would be to store the water and channelise it to water stress regions. This may have been the reason that a large storage facility is under consideration in Arunachal Pradesh.

Table: 2.6 Statewise Storages in India (Live Storage Capacity) (in BCM)

1	2	3	4
Andhra Pradesh	3.28	7.12	1.73
Arunachal Pradesh	0.00		45.5
Assam	0.00	1.05	1.02
Bihar	0.42	4.35	3.58
Goa	0.30	0.67	
Gujarat	2.95	7.25	3.73
Haryana	0.00		0.26
Himachal Pradesh	22.73	0.11	0.36
Jammu & Kashmir	0.00		0.01
Karnataka	4.09	3.01	0.1
Kerala	1.45	1.62	1.95
Madhya Pradesh	2.29	21.63	8.09
Maharastra	2.28	12.92	5.17
Manipur	1.67	0.12	16.32
Meghalaya	3.04		0.51
Mizoram	0.00		
Nagaland	0.00	1.22	
Orissa	3.89	3.3	21.86
Punjab	0.01	2.34	
Rajasthan	1.47	1.59	1.8
Sikkim	0.00		
Tamil Nadu	1.08	0.04	
Tripura	0.97		
Uttar Pradesh	0.94	7.06	20.16
West Bengal	0.18		0.17
Total	1.69	75.4	132.32

Source: Same as Table-2.5

Please refer the next page for the Legends

Legends of the Table 2.6

1. State
2. Storage in Completed Projects per crore population (2000)
3. Projects Under Construction
4. Projects Under Consideration

Ground water is also an important source water resource. Per crore population replenishable ground water resource in India is 431.89 BCM per year (Table-2.7). This figure varies from state to state. Total replenishable groundwater resource per crore population is relatively high in Arunachal Prasesh , Manipur and even in Assam. This figure is moderately high in Punjab, Madhya Pradesh, Orissa, Uttar Pradesh and Andhra Pradesh and relatively low in West Bengal, Kerala, Meghalaya, Rajasthan and Tripura. In Goa and Mizoram the ground water potential is abnormally low. Net draft of ground water per crore populations of 2000 has been extremely high in Punjab, Haryana and Tamil Nadu. The available ground water resource for irrigation per net irrigated area by well is substantially high in Jammu & Kashmir,Tripura, Kerala, West Bengal, Assam, Andhra Pradesh, Orissa, Bihar and Karnataka. This bears the implication that groundwater irrigation development has lot of potential in these states. It is relatively less in case of Uttar Pradesh, Gujarat, Punjab, Haryana and Rajasthan. This issue will be discussed later in large. The less availability of groundwater resource for irrigation may be explained by the high net draft of the same. The high ground water irrigation potential in Kerala and West Bengal can also be explained by low net draft in these areas. Low net draft can also explain the high replenishable groundwater resource in Manipur, Arunachal Pradesh and Jammu & Kashmir. So, **ground water resource in terms of its potential use varies from state to state.**

The table is in the next page.

Table: 2.7 Ground Water Potential in States of India (BCM per year)

State	Total Replenishable Groundwater Resource (per crore population-2000)	Net Draft (per crore population-2000)	Available Groundwater resource for Irrigation (per 10 lakhs hectare of net irrigated by well-1996-97
Andhra Pradesh	4.66	0.94	17.35
Arunachal Pradesh	13.20	0.00	1.22*
Assam	9.28	0.35	21.01*
Bihar	3.05	0.50	15.88
Goa	1.64	0.15	11.88
Gujarat	4.03	1.42	7.26
Haryana	4.05	2.88	5.40
Himachal Pradesh	0.61	0.08	22.31
Jammu & Kashmir	4.40	0.05	1880.00
Karnataka	3.07	0.82	16.52
Kerala	2.48	0.32	79.40
Madhya Pradesh	6.27	0.88	12.47
Maharastra	3.91	0.80	16.21
Manipur	13.19	0.00	2.68*
Meghalaya	2.34	0.09	0.46*
Mizoram	0.00	0.00	
Nagaland	3.62	0.00	0.62*
Orissa	5.45	0.39	20.33
Punjab	7.68	6.49	7.12
Rajasthan	2.25	0.96	2.82
Sikkim	0.00	0.00	
Tamil Nadu	4.25	2.18	16.38
Tripura	2.07	0.60	140.00
Uttar Pradesh	4.80	1.54	8.43
West Bengal	2.88	0.59	27.57
All India	4.21	1.12	11.73

* States that do not have any well irrigation

Source: Same as Table-2.5

2.3 Area Irrigated by Source

Canal irrigation has been the predominant source of irrigation in States like Haryana, Orissa and Andhra Pradesh in 1985-86 with more than 50% of the net irrigated land covered by government canal (Table-A.2.1). In Jammu & Kashmir and Assam private canal irrigation has taken a dominant role. Southern Indian states like Tamil Nadu, Andhra Pradesh etc. has utilized tank irrigation to a large extent with 22.2% of irrigated land in Andhra Pradesh and around 27% of irrigated land in Tamil Nadu was under tank irrigation. Well irrigation has taken a dominant role in Gujarat, Punjab, Uttar Pradesh, Rajasthan, Maharastra etc., with more than 50% of the land irrigated by well. Other sources of irrigation have been mainly popular in North Eastern states. There has been one to one correspondence between irrigation intensity and cropping intensity in states like Punjab, Haryana, Himachal Pradesh and Tripura. Cropping intensity in high in irrigated land in these states. Percentage of gross cropped area irrigated is higher than percentage of net cropped area irrigated in case of Punjab and Haryana. Net cropped area irrigated is 88% in Punjab and 62% in Haryana. In case of other states where the irrigation intensity is relatively low one to one relationship between these two variables cannot be established. States like Madhya Pradesh, Uttar Pradesh, West Bengal, Orissa and Assam has shown an opposite pattern with high cropping intensity but low irrigation intensity. Percentage of gross cropped area irrigated is also less than the percentage of net cropped area irrigated. Cropping intensity should be more than one in rainfed land in these states. It may be argued that this relationship basically depends on the agro-climatic conditions of the states. Water stress regions have to be complemented with irrigation to realize higher cropping intensity. In water abundant region this need is much less. Maharastra, Karnataka and Kerala exhibit a peculiar scenario in this regard. The irrigation intensity is higher than the cropping intensity and net cropped area irrigated is equal to or less than the gross cropped area irrigated. Net cropped area irrigated is low in these states. This means that a small percentage of cropped area is irrigated in these states and irrigation intensity is high in these areas. The rainfed areas in these states must be having no less cropping intensity than other irrigated areas. This means irrigation has not been introduced in rainfed areas where water stress is less. **Overall well irrigation has appeared to be the dominant source of irrigation in 1985-86 followed by canal irrigation.**

The proportion of canal irrigated area has declined in most of the states in 1990-91 as compared to 1985-86 (Table-A.2.2). In Punjab, West Bengal and Assam the situation has remained unchanged. There has been an increase in percentage irrigated by canal in Maharastra and Tamil Nadu. Well irrigation in most of the states has exhibited an increasing proportion of irrigated area, except Punjab. West Bengal has shown almost same percentage of area irrigated by well. The percentage of area irrigated by tank has either declined or remained same in 1990-91 as compared to 1985-86. The growth rate of canal irrigated area between 1985-86 and 1990-91 has been highest in Maharastra at 20% (Table-A.2.4). Increase in well irrigated area has been 9% in this state. Both these factor has probably led to increase in net irrigated area. In Tamil Nadu where the proportion of canal irrigated area has increased but the area under canal irrigation has actually declined. This may be interpreted in terms of decline in area irrigated and area cropped. Jammu & Kashmir, Gujarat and Uttar Pradesh have also experienced a decline in area irrigated by canal. In case of Uttar Pradesh and Gujarat the declining canal irrigated area has been substituted by well irrigation. In case of West Bengal the area irrigated by well had declined along with decline in net irrigated area and cropped area. As the percentage of well irrigation in West Bengal has not declined in 1990-91 as compared to 1985-86, we can argue that the decline in well irrigation has resulted in net cropped area going out of cultivation. Kerala, Madhya Pradesh, Maharastra, Andhra Pradesh and Karnataka have shown a sharp increase in area under well irrigation. Here it should be noted that the Net irrigated area has also increased between these time periods in Madhya Pradeah , Maharastra and Karnataka. In case of Rajasthan tank irrigation seems to be most effective in terms of increase in net irrigated area and net area sown. There has been a phenomenal increase in area irrigated by other sources in Punjab while the increase is moderate in case of Nagaland, Haryana and Madhya Pradesh. Net irrigated area, gross irrigated, net cropped area and gross cropped area has increased in most of the states. From this discussion we can argue that canal, well and tank irrigation has led to increase in net irrigated area in most of the states. **In some cases there has been a substitution of canal irrigation by well irrigation.** The impact of source of irrigation on gross irrigated area cannot be assessed at this level due to non-availability of data of gross irrigated by different sources of irrigation. Notwithstanding, different types of irrigation have played an important role in bringing more land under irrigation within this period. **Overall well irrigation has appeared to be the dominant source of irrigation in 1990-91followed by canal irrigation.** The area irrigated by well has increased in 1990-91compared to 1985-86 by a larger percentage than area irrigated by canal.

In 1995-96 the percentage of canal irrigated area has declined in most of the states as compared to 1990-91(Table-A.2.3). In case of Karnataka it has marginally increased and in case of Assam, Gujarat and West Bengal it has remained same. Percentage of well irrigated area has increased in almost all the states expect Tripura. In case of Gujarat and West Bengal it has not changed at all. Net area irrigated as a percentage of net cropped area has generally increased or remained same in all the states with some exceptions. It has declined in states like Andhra Pradesh, Arunachal Pradesh, North Eastern States and West Bengal. Barring Assam, Maharastra, Meghalaya, Mizoram and West Bengal in all the states the percentage of gross cropped area irrigated has increased. There has been phenomenal increase in private canal irrigated area in Tamil Nadu (Table-A.2.5). In case of Kerala and Assam the increase is moderate or marginal. It should be noted that in case of these two states the government canal irrigated area has infact marginally declined. The increase in net irrigated area in Rajasthan by 6% can be explained by increase in well irrigated area by 8%. In case of Uttar Pradesh though the net irrigated area by canal has declined the increase in well irrigared area has led to increase in net irrigated area. In case of Punjab where the other sources of irrigation has increased phenomenally between 1985-86 and 1990-91,it has surprisingly declined between 1990-91 and 1995-96. This along with decline in canal irrigated area has led to decline in net irrigated area in Punjab. Tank irrigation has increased by a considerable margin in Haryana between 1990-91 and 1995-96. **The growth of canal irrigated area is marginal or nil in most of the states with few states having negative growth also. The growth rate in case of well and others irrigation has been substantial. Net irrigated area along with net and gross cropped area has increased in all the states except a few like Punjab, Maharastra etc.** In Punjab and Maharastra net sown area has also declined along with net irrigated area. In case of Haryana canal and well accounts equal percentage of irrigated area in 1995-96 while earlier it was canal, which used to dominate. It is worth noting here that the potential of groundwater irrigation for states like Rajasthan, Punjab, Haryana, Gujarat and even in case of Uttar Pradesh is very pretty low (Table-2.7). For future development of irrigation, surface irrigation should assume paramount importance in these states. Groundwater exploitation should be regulated in these states. High net draft of groundwater in Punjab, Haryana, Uttar Pradesh, Gujarat and Rajasthan has resulted in such a stress. Groundwater irrigation potential is moderately high in Bihar, Maharastra, Madhya Pradesh and Tamil Nadu. In case of West Bengal percentage of area irrigated by well has remained same for the whole period, while ground water irrigation potential is also high. Well irrigation has become the dominant source of irrigation in Andhra Pradesh in 1995-96.

Potential for groundwater irrigation is also high in this state. Overall well irrigation has appeared to be the main source of irrigation followed by canal irrigation in 1995-96.

Between 1985-86 and 1995-96 the net irrigated area by canal has increased in states like Madhya Pradesh, Maharastra, Rajasthan, Karnataka, Gujarat and Haryana by around 4%, 3%, 3%, 3%, 2%, 2%, 1%, respectively, which has corresponding impact on the net irrigated area (Table-A.2.6). **The growth rate of area irrigated by well has been generally greater than that of canal irrigated area in all the states.** The growth of area irrigated by other sources has been markedly high in case of Punjab and Haryana between these two periods. **During the whole period of analysis well irrigation has been the main source of irrigation in Bihar, Gujarat, Maharastra, Punjab, Rajasthan, Madhya Pradesh, Tamil Nadu and Uttar Pradesh.** Growth of well irrigation between 1985-86 and 1990-91 has been at 4% while the same for canal irrigation is at 2%. Between 1990-91 and 1995-96 the growth of canal irrigated land has been negative while the growth of well-irrigated land is positive at around 4%. Comparing the area irrigated by canal and well between 1985-86 and 1995-96 the growth rate is positive in both cases but growth rate for well-irrigated land is high at 4% while the same for canal-irrigated land is around 1%. **So the inclination for well irrigation has been more during the 90's as compared to late 80's.** Notwithstanding the inclination towards well and also others irrigation in India, the importance of canal irrigation in Indian agriculture is imperative.

Another important point we will like to make note of is that the balance between groundwater and surface water exploitation is not maintained in almost all the states. From our above discussion it has been made clear that there has been a general inclination towards the groundwater by means of well irrigation, more so in the nineties than in the eighties. Groundwater exploitation has been much larger than the surface water exploitation in Gujarat, Uttar Pradesh, Rajasthan, Punjab and Maharastra in all the three time points under condition (Table-2.8). In Rajasthan and Uttar Pradesh the percentage of area irrigated by groundwater has also increased from one time period to another. In all these states, especially in Rajasthan, available groundwater resource for irrigation is also meager (Table-2.7). In Jammu & Kashmir, Assam and Tripura surface water use is much more than the ground water use. But all these three states have enough groundwater resource for irrigation. Though this is the scenario at the state level but at the local level the situation may somewhat differ.

Bias in exploitation in groundwater or surface water is a sign of mismanagement of water resource. This is because conjunctive use of groundwater and surface water increases the efficiency of surface water system, which serves a source of water for the groundwater through seepage. The problem of water logging can also be solved by vertical drainage through well irrigation. Policies should be initiated so that **overexploitation of groundwater is resisted and conjunctive use of ground and surface water is encouraged.**

Table: 2.8 Difference Between Percentage Irrigated by Groundwater (Well) and Surface water (Canal + Tank)

State	1985-86	1990-91	1995-96
Andhra Pradesh	-48.42	-35.60	-15.28
Arunachal Pradesh	0.00	0.00	0.00
Assam	-63.29	-63.37	-63.29
Bihar	-1.71	9.38	15.90
Gujarat	53.15	58.48	58.05
Haryana	-6.04	-3.45	-0.83
Himachal Pradesh	-3.13	-21.01	6.93
Jammu &Kashmir	-92.90	-93.69	-94.30
Karnataka	-29.61	-18.37	-16.51
Kerala	-35.81	-27.35	-24.27
Madhya Pradesh	-3.86	10.49	19.69
Maharastra	19.78	25.19	25.87
Manipur	0.00	0.00	0.00
Meghalaya	0.00	0.00	0.00
Mizoram	0.00	0.00	-100.00
Nagaland	0.00	0.00	0.00
Orissa	-29.95	-23.35	-20.00
Punjab	23.36	18.06	26.02
Rajasthan	19.72	20.57	34.67
Sikkim	0.00	0.00	0.00
Tamil Nadu	-16.63	-10.19	1.68
Tripura	0.00	-65.60	-62.86
Uttar Pradesh	26.31	34.49	43.07
West Bengal	-14.02	-14.05	-14.02
Total	2.89	8.87	17.77

Source: Statistical Abstract of India

2.4 Crops Gross Irrigated

In many North Eastern States Rice is the only irrigated crop in 1985-86 (Table A.1.7). Rice accounts for more than 50% of the gross irrigated area in states like Andhra Pradesh, Orissa, West Bengal, Tamil Nadu, Kerala and Jammu and Kashmir. Wheat accounts for more than 40% of the gross irrigated area in Uttar Pradesh, Punjab, Haryana and Madhya Pradesh. Percentage of gross area irrigated under sugarcane is relatively high in Maharastra, Uttar Pradesh, Karnataka and Tamil Nadu. In case of Jowar the percentage is relatively high in Maharastra and Karnataka. The share of gross irrigated area under rice has generally declined or remained more or less stable in most of the states in 1991-92 as compared to 1985-86 (Table-A.1.8). It has increased in states like Gujarat, Kerala, Nagaland, Orissa, Punjab, Tripura and Uttar Pradesh. The variations in share of gross irrigated area under rice carries significance as it is one of the most water consuming crops. Share of rice in gross irrigated area has declined at all India level but the area irrigated by rice has increased between 1985-86 and 1991-92 (Table-A.2.10). In case of another high water consuming crop, i.e. sugarcane, the share and area gross irrigated has increased in Andhra Pradesh, Gujarat, Haryana, Karnataka, Maharastra and Tamil Nadu, while the share has declined in states like Bihar and Madhya Pradesh. In case of other states it has remained more or less constant. Area irrigated under sugarcane has substantially increased in West Bengal, moderately in Punjab and even in Rajasthan between 1985-86 and 1991-92. In many major states the share of gross irrigated area under wheat has declined which is one of the moderate or relatively less water consuming crop. But it may be noted that gross area irrigated for wheat has generally increased barring states like Andhra Pradesh, Nagaland, Orissa and Tripura where the area has in fact declined. In case of Jowar that is one of the least water consuming crop the share of gross irrigated area has either declined or remain stable within the same time period. There has been substantial increase in gross area irrigated under Jowar in Punjab, Haryana, Uttar Pradesh and Maharastra while it has substantially declined in Gujarat, Rajasthan and Madhya Pradesh. Decline in the share and gross irrigated area under less water consuming crops in water stress states is not a sign of better water management.

The proportion of gross irrigated area under rice has increased in major states like Punjab, Haryana, Uttar Pradesh, Karnataka, Maharastra, Orissa, Assam and Bihar in 1996-97 as compared to 1991-92 (Table-A.2.9). In Kerala and Madhya Pradesh the percentage of rice irrigated area has declined but the area irrigated has increased (Table-A.2.11). In Orissa the percentage of gross irrigated area under rice has increased but irrigated area under rice has declined. So, between 1991-92 to 1996-97 there has been overall increase of irrigation for rice at all India level. It is also important to observe that in Madhya Pradesh, Maharastra and Rajasthan share of sugarcane irrigated area and its share in gross area irrigated has declined 1996-97 as compared to 1991-92. It seems to be a welcome sign as irrigation is getting diverted from one of the most water intensive crop to other crops in a water stress region (Table-2.5). In most of the other states the share has remained more or less constant but area has increased. The share has increased in West Bengal and Andhra Pradesh. In Andhra Pradesh the gross irrigated area under sugarcane has increased by 7.23%. Both these states are not water stress. So, **diversion of gross irrigated area under extremely water consuming crop from water stress region to relatively water abundant region is always laudable in terms of efficient water management.** Overall rice and wheat each accounts for around 30% of gross irrigated land in all three period with slightly high percentage in 1985-86. The growth rate of area irrigated under rice and wheat has been almost same between 1985-86 and 1991-92 but between 1991-92 and 1996-97 the growth rate of area under wheat has been greater than that of rice. It is in fact a **welcome sign as less water consuming food crops are getting increasingly irrigated.**

It has been observed that gross area irrigated for food grains and non food grains has increased for almost all the states during 1985-86 to 1996-97, while the rate of growth is generally more in case of non-food grains (Table-A.2.12). In Mizoram the share and area of gross irrigated under rice has declined substantially in 1996-97 as compared to 1991-92. Share of irrigated area under wheat has declined in Bihar, Punjab, Orissa and Uttar Pradesh in 1996-97 as compared to 1991-92. In case of Orissa the rice irrigated area has also declined. In case of pulses the share of gross irrigated area and area under pulses has increased at all India level. In Andhra Pradesh, Haryana and Orissa the share and area irrigated under pulses has declined in 1996-97 as compared to 1991-92. The percentage irrigated for food grains has always been much high as compared to non-food grain but the difference has slightly declined from in the 90s. Food grains irrigated area accounts for 84% of the gross irrigated land while the same for non-food crops is low at 14% in 1985-86 at all

India level. But the difference has narrowed down in 1996-97 as the share of food crops in gross irrigated area has declined to 81.2% while the same for non-food crops has increased to 18.8%. Among food crops and non-food crops area irrigated for non-food crop has increased by a much larger margin than food crop between 1985-86 and 1991-92 though the difference narrowed down between 1991-92 and 1996-97. **It should be considered whether the relatively high growth in irrigated area for non-food crops puts stress on the food security of the country**. From this discussion it seems that share of irrigation has been diverted to less water consuming crop but one can not argue whether it is a welcome sign so far as water management is concerned, unless we consider its effect on food security and overall socio-economic well being. In this regard, we should mention that **new agricultural technology should be innovated in such a manner, that at least food crops like rice consumes less water and become drought resistant.**

2.5 Rural and Urban Drinking Water Supply

Rural and urban drinking water supply always carried foremost importance in water resource planning. In the National Water Policy 1987 drinking water supply has been given top priority as a supply side response to water management. Drinking water supply in rural areas has always been the responsibility of the State. Government of India (GOI) introduced Accelerated Rural Water Supply Programme in 1972-73 to accelerate the pace of coverage of drinking water supply. In 1986 Technology Mission on Drinking Water and Related Water Mission was introduced by Government of India, which was later renamed as Rajiv Gandhi National Drinking Water Mission. As a result of these initiatives the rural water supply schemes has been able to cover each and every rural person in Haryana, Maharastra, Karnataka, Madhya Pradesh, Tripura and Bihar (Table-2.9). In case of different Union Territories these schemes have also been overwhelmingly successful. In case of Punjab, Nagland and especially in Kerala these schemes did not perform well. In case of Nagaland, Punjab and Kerala inland water resource in the form of rivers and canals is high but these resources could hardly been utilized to meet the growing drinking water need (Table-2.5). Storage facility is also inadequate in case of Punjab and Nagaland (Table-2.6). Prospects of ground water exploitation are low in Kerala and a substantial portion of its geographical area is covered by brackish water.

Urban water supply scheme has been extremely successful in covering the entire urban population in Haryana, Himachal Pradesh, Jammu & Kashmir, Nagaland, Rajasthan, Pondicherry and Chandigarh but barring Pondicherry and Chandigarh rural water supply schemes in these states have not been able to bring the benefits to the entire rural population. Available replenishable groundwater resource is Haryana is slightly below average but no reservoir facility is available in the state. In case of Assam and Orissa the achievement of urban water supply schemes is poor and more so as compared to the rural water supply schemes. These states are not at all scarce in terms of inland and ground water resource. Scarcity of drinking water in these regions may have been due to inefficient water management.

Table: 2.9 Percentage of Population Covered by Rural/Urban Water Supply Programme

State	Rural up to 1997-98	Urban as on 31.3.97
Andhra Pradesh	99.7	87
Arunachal Pradesh	98.2	96
Assam	72.6	47
Bihar	102.3	80
Goa	97.1	83
Gujarat	95.4	98
Haryana	127.8	100
Himachal Pradesh	86	100
Jammu & Kashmir	81.3	100
Karnataka	111.1	93
Kerala	48.3	75
Madhya Pradesh	104.3	90
Maharastra	114.2	99
Manipur	86.3	84
Meghalaya	91.9	93
Mizoram	75.4	47
Nagaland	60.3	100
Orissa	80.6	65
Punjab	67.3	78
Rajasthan	82.7	100
Sikkim	85.3	62
Tamil Nadu	79.4	90
Tripura	103.3	82
Uttar Pradesh	90.1	98

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State	Rural up to 1997-98	Urban as on 31.3.97
West Bengal	82.9	85
A & N Island	106.4	86
Daman & Diu	111.3	83
Lakshadweep	206.6	78
Pondicherry	152	100
Delhi	86.9	90
Chandigarh	100	100
D & N Haveli	105.9	19
India	92.7	91

Source: Same as Table-2.5

Orissa has also the advantage of storage facility, which it can use to ease drinking water scarcity. Mizoram and Sikkim are abundant in rivers but non-availability of storage facility might have created a scarce drinking water situation in these two states. Replenishable groundwater is also not available in these two states. So from the above discussion it is clear that though over 90% of rural and urban population of India has been covered by the water supply schemes, in many states benefits of drinking water supply schemes has not been reached properly. **Scarcity condition in many cases has been the result of inefficient water management rather than non-availability of it. Policies should be devised to tap the ground as well as surface water resources in these states.** The National Water Policy (1987) has also acknowledged the need to build up sufficient reservoir to meet the demand for drinking water, especially in the hilly regions.

2.6 Flood & Drought Management

One-eighth of the country's geographical area, as estimated by Rashtriya Barh Ayog, is under flood prone area. Out of this total floods prone area 80% of the area has been protected with the construction of new embarkments, drainage channels, protection to towns or villages etc. At 1980-81 prices the planwise expenditure

Table: 2.10 Planwise Expenditure and Cumulative Benefits (Area Protected) Under Flood Management Programme at 1980-81 Prices (Rs. Crores)

Period	States & U.Ts	Centre	Total	Cumulative Benefits (Area-protected in million ha. at the end of the period)
First Plan(1954-56)	81.29		81.29	1
Second Plan(1956-61)	249.02		249.02	3.24
Third Plan(1961-66)	347.84		347.84	5.43
Annual Plans(1966-69)	117.21		117.21	5.83
Fourth Plan(1969-74)	383.83	11.39	395.22	8.04
Fifth Plan(1974-78)	351.38	81.37	432.75	9.98
Annual Plans(1978-80)	370.06	50.8	420.86	11.21
Sixth Plan(1980-85)	552.08	149.84	701.92	13.01
Seventh Plan(1985-90)	495.89	101.94	597.83	13.8
Annual Plan(1990-92)	183.61	31.12	214.73	14.28
EighthPlan(1992)(Ancipated)	551.46	76	627.46	14.37
Annual Plan(1997-98)	97.68	14.33	112.01	
AnnualPlan(1998)(Anticipated)	148.83	20.75	169.58	

Source: Same as Table-2.5

has increased from Rs. 249 crores during Second Plan to Rs. 551.46 crores during Eighth Plan. Till the end of the eighth plan 14.37 million hectare has been brought under flood protection. But to properly analyse the benefits of flood management we have to look into the fact whether the damage due to flood in India has declined or not. It has been observed

Table: 2.11 Flood Damage in India in Different Year

Year	Area Affected (M Ha)	Polulation Affected (Million)	Population Affected per affected Ha	Total Damages-Crops, Houses & Public Utilities at	Total Damages-Crops, Houses & Public Utilities at 1970-71 Prices
1971	13.25	59.74	5	632.45	632.45
1981	6.12	32.49	5	1196.5	465.0214
1991	6.36	33.89	5	1488.33	289.6147
1997	4.57	29.66	6	2831.18	319.9073

Source: Same as Table-2.5

that total damage of crops, houses and public utilities in India has declined from 1971 to 1991 but after that in 1997 it has increased (Table-2.11). Population affected per affected area has increased in 1997 as compared to 1991. So, the importance of flood management in India remains as it was in the earlier times in India. Overemphasis in irrigation and power generation might have diverted attention from flood management (Iyer, 2001). As the value of crops, houses and public utilities increases flood management should be given high priority to protect them. Drought management is also an important component of water management in India. Central Water Commission has identified the number of districts affected by drought. Percentage of area affected by drought is the highest in case of Rajasthan and Gujarat (Table-2.12). Drought conditions are also severe in case of Haryana, Madhya Pradesh and Maharastra. Central government has launched Drought Prone Area Programme (DPAP) in 1973-74 to tackle the special problems faced by areas constantly affected by severe drought conditions. Though the programme has created some positive impact in terms of creating durable public assets, its overall impact in effectively containing the adverse effects of drought was not found very much encouraging. Many state governments were also demanding inclusion of additional areas under the programme.

Table: 2.12 Identified Drought Prone States In The Country (1982)

State	No. of Districts	Area affected by droughts (Sq. Km)	% of area affected by droughts in droughts affected districts
Andhra Pradesh	8	32840	26.24
Bihar	7		0.00
Gujarat	12	106818	88.11
Haryana	4	8339	50.27
Jammu &Kashmir	2	2408	15.05
Karnataka	14	57646	37.88
Madhya Pradesh	11	37308	42.77
Maharastra	9	57665	46.59
Orissa	2	2002	8.76
Rajasthan	13	194203	88.70
Tamil Nadu	8	7452	8.86
Uttar Pradesh	6	4609	10.71
West Bengal	3		
Total	99	511290	47.29

Source: Same as Table-2.5

For all these reasons a High Level Technical Committee was constituted under the chairmanship of Prof. C. H. Hanumantha Rao in 1993 to critically review its contents, methodology and implementation. According to recommendations of the Hanumanta Rao Committee report in 1994-95, comprehensive guidelines were prepared for Watershed Development which was commonly applied to Drought Prone Areas Programme (DPAP), Desert Development Programme (DDP), Integrated Wasteland Development Programme and Employment Assurance Scheme (Watershed). The Committee proposed certain criteria for coverage and allocation under DPAP and DDP. The Committee proposed to include three eco-systems – arid, semi-arid and dry sub-humid – under DPAP/DDP. The proposed criteria for different eco-systems are spelt out in Table-2.13.

Table 2.13:Criteria for Coverage under DPAP and DDP Proposed by Hanumantha Rao Committee (1994)

Moisture Index	Permissible Programme	Ecosystem	% irrigated area
<-66.7	DDP	Arid	Less than 50
-66.6 to –33.3	DPAP	Semi-arid	Less than 40
-33.2 to 0	DPAP	Dry sub humid	Less than 30

Source: Hanumantha Rao Committee Report (1994)

It was suggested that arid and semi arid districts, where, area irrigated constitutes more than 50% and 40% respectively, of the net cultivated area, should be totally excluded from the programmes. Likewise, it was suggested that dry sub-humid districts with more than 30% under irrigation should be excluded. The basic objective of the DPAP programme is to minimize the adverse effects of drought on the production of crops and livestock and productivity of land, water and human resources. DDP programme has been launched to restore the ecological balance by conserving and harnessing land, water, livestock and human resource.

Table: 2.14 Coverage of Drought Prone Area Programmes (DPAP) (2000-2001)

State	No. of districts DPAP	No of Blocks DPAP	Area in sq kms. DPAP
Andhra Pradesh	11	94	99218
Bihar	6	30	9533
Chhattisgarh	8	29	21801
Gujarat	14	67	43938
Himachal Pradesh	3	9	3319
Jammu &Kashmir	2	22	14705
Jharkhand	12	91	34843
Karnataka	15	81	84332
Madhya Pradesh	23	105	89101
Maharastra	25	148	194473
Orissa	8	47	26178
Rajasthan	11	32	31969
Tamil Nadu	16	80	29416
Uttar Pradesh	15	60	35698
Uttaranchal	7	30	15796
West Bengal	4	36	11594
Total	180	961	745914

Source: Annual Report, 2000-2001, Ministry of Rural Development, Government of India.

DPAP has been implemented mainly in less drought affected districts like Maharastra, Andhra Pradesh and Gujarat (Table-2.14). DDP has been implemented mainly in more drought affected and desert areas which have been under great stress resulting in continuous depletion of vegetative cover, increase in soil erosion, and fall in ground water levels due to its continuous exploitation. Rajasthan and Gujarat have been given emphasis in this programme (Table-2.15).

Table: 2.15 Coverage of Desert Development Programmes (DPAP) (2000-2001)

State	Number of districts	Number of Blocks	Area in sq. kms
Andhra Pradesh	1	16	19136
Gujarat	6	52	55424
Haryana	7	44	20542
Himachal Pradesh	2	3	35107
Jammu & Kashmir	2	10	96701
Karnataka	6	22	32295
Rajasthan	16	85	198744
Total	40	232	457949

Source: Same as Table-2.14

Few studies have been done on the impact evaluation of the programmes under the common guidelines of Watershed management. We will make an attempt here to evaluate it in terms of impact on environment and socio-economic condition. In the earlier impact evaluation studies we have got less optimistic picture regarding the environmental effects. The Programme Evaluation Organisation (PEO), in a study of DDP, observed that the integrated micro watershed approach had not made substantial progress though there were reports of some progress as far as plantation/shelter belts, pasture development and sand dune stabilization are concerned during 1977-78 to 1987-88. It has also observed that the watershed approach had not made a specific impact on conservation of ground water levels and water harvesting structures in spite of achieving the target during the period 1973-74 to 1991-92 in case of DPAP. The programme had not made substantial impact on increasing the availability of fuel and fodder, or drinking water facilities. The encouraging effect of these programmes can be found in terms of checked out migration during drought period. In a more by recent study the Comptroller and Auditor General (CAG) Report (1999) it has been identified that low survival rates of plantations, and, poor core sector performance in Bihar, Karnataka, Maharashtra, MP and Rajasthan has impaired the beneficial impact of DPAP. In their study, Deshpande and Rajasekaran, (1997), has observed that in the scarcity zone the impact has been felt more, compared to the transition zone (Table-2.16). This has been the reason that the scarcity zone registered better adoption rates as compared to the transition zone .The above discussed results of the two zones clearly bring across the need for location-specificity of technology. Overall almost all the beneficiaries have noted beneficial impact in terms of increase in moisture retention and reduction in runoff/soil loss.

Table 2.16: Proportion Of Beneficiaries Adopting The Various Conservation Measures

Conservation Activity	Scarcity Zone	Transition Zone
Bunding Activity		
Contour Buds	86	39
Graded Bunds	38	33.52
Vegetative Bunds	94	77.40
Keyline Formation	8	17.05
Planting of trees		
Silviculture	52	27.72
Horticulture	50	58.02
Development of Pasture	10	1.52
Others	26	34.91

Source:Deshpande and Rajasekaran (1997), p.383.

In a Quick Evaluation Study (2000) on DDP and DPAP an increase in the average annual household income of the watersheds covered area has been observed. In case of DPAP, the percentage increase in average annual household income ranged from 0.1 to 84.9, while in the case of DDP, the range was 11.8 to 43.3. This is supported by the results of the impact evaluation studies conducted by Agro-economic Research Centres[1] that shows higher net income of beneficiaries on a per hectare basis (Gujarat, Tamil Nadu, Uttar Pradesh). In this case also the scarcity zone showed a better capacity for asset generation, compared to the transition zone (Table-2.17). However, the transition sector showed higher assets per household in the non-farm sector. In this case the non-beneficiaries reporting a higher income from by-products as well as farm assets and livestock is worth mentioning. Overall, the increment of income lies in the range of 17 to 47 percent for the beneficiaries, compared with the non-beneficiaries.

Table: 2.17 Income Position of Beneficiaries and Non- Beneficiaries

Items	Scarcity Zone		Transition Zone	
	Beneficiaries	Non-Beneficiaries	Beneficiaries	Non-Beneficiaries
Income (Rs. Per ha)				
From Agricultural products	4625	3126	7530	5610
From by-products	625	497	616	627
Income (Rs. Per household)				
From Agricultural products	15418	10891	13125	11161
From by-products	2082	1731	1074	1248
Assets(Rs. Per household)				
Farm Assets	5427	4390	2104	3067
Non-farm assets	26275	20210	26919	23276
Livestock	12120	9914	9277	16377

Source: Deshpande and Rajasekaran(1997),p. 387

[1] The impact studies by AERCs were conducted from 1994 to 1997 in 10 states, comprising 4 zones, namely, Western and Central Rainfed Zone(Gujarat, MP and Maharashtra); Southern Plateau and Hills Zone(AP and TN);Northern Alluvial Plains(Haryana and UP);and Hills Region with assured rainfall(Assam, HP and Darjeeling district of WB).Two watersheds were selected from each state for the analysis.

2.7 Watershed Development for Rainfed Areas

Watershed approach envisages a holistic development of agriculture and allied activities in the area, taking into account various kinds of land-use, based on crops, horticulture, agro-forestry, silvi-pasture and forests. National Watershed Development Project For Rainfed Areas (NWDPRA) is one of the largest projects in this context in terms of scope and extent. This project was first launched way back during the Sixth Plan when the Department of Agriculture and Cooperation launched a pilot project for water conservation and harvesting in rainfed areas in 19 watersheds located in as many as 15 states (Perspective Plan, 1997,p.40). Based on these experiences, the NWDPRA was launched in 1990-91 in 25 states and 2 union territories. The broad objectives of this project are enhancement of agricultural productivity in a sustainable manner; restoration of ecological balances in degraded and fragile rainfed ecosystems through scientific lan0d and water management which includes developing a network of low cost water harvesting structures, natural vegetative conservation for runoff management and recharge of ground water capability, and greening these areas through an appropriate mix of trees, shrubs and grasses. Reduction of regional disparity in terms of production between irrigated and rainfed areas and generation of sustained employment opportunities for the rural poor were also given prominence in the objective.

The NWDPRA has been restructured during the Ninth Plan based on the experiences of the Eighth Plan. The first-generation watershed development projects had led to gains in terms of increase in groundwater recharge; increase in the number of wells and other water bodies; reduction in soil losses; improvement in cropping pattern and higher crop yield but there was a drawback as far as **sustainability** of such projects was concerned. It was felt that the 'beneficiaries were too often merely passive recipients rather than active participants' (WARASA-JAN SAHBHAGITA: Guidelines for NWDPRA, 2000, MoA, GoI, p.2) in the development. As a result they ware unwilling to operate and maintain the completed structures. This has been precisely the reason that in the restructured NWDPRA **peoples' participation** emerged as one of the predominant themes. The restructured NWDPRA is the outcome of **the Common Approach for Watershed Development** jointly formulated and adopted by the MoA and the Ministry of Rural Development, GoI. Within the new structure focus has been given towards decentralization of procedures to impart flexibility in choice of technology; and, sustainable involvement of the watershed community in planning, execution and evaluation of the programme. In-situ moisture conservation; promotion of a sustainable farming system; equity for resource-poor families; and shift from subsidy-oriented development to self-reliance and convergence of schemes of government and non-government agencies is also given prominence. In this regard, it should be noted that the programmes of the Department of Land Resources focus on regions with a preponderance of community resources, the MoA schemes concentrate largely on privately owned cultivated areas. In this regard Common Approach to Watershed Development is an attempt to harmonize the implementation of programmes such as the NWDPRA, DPAP and DDP.

2.8 Hydro Electricity (HE) Power Development

It has already been discussed that water demand for power is going to increase at a large scale among all uses of water. The performance in this regard at all India level is not at all impressive. At the all India level only 16.6% of potential has been developed (Table-A.2.13). Within different regions of India the performance of Southern Region as a whole is most impressive. The state-wise picture clearly reveals that 80.7% of potential in Haryana and 78.5% of potential in Tamil Nadu and 71.1% of potential in Punjab, has been developed. The most miserable picture can be found in North-Eastern Region, which accounts for around 38% of countries total HE potential but only 1.22 % of potential has been developed. Percentage of HE power potential under development is also negligible. Percentage of HE power potential under development is highest in Western Region. Barring Southern and Western region no other regions of India will be able to develop at least 50% of its potential even after completion of potential under development. So, from the above analysis it is clear that **potential development of HE power has to be given emphasis to meet the future HE power demand.**

2.9 Participatory Irrigation Management (PIM)

It has been widely suggested that for the upkeep of the system PIM have to be adopted. Most of the issues in water management have their origin and solution at the local level. The National Water Policy (1987) has suggested progressive transfer of irrigation management to the WUA. In India PIM was initiated twenty years ago. Andhra Pradesh and West Bengal accounts for more than 50% of total WUAs of the country (Table-A.2.14). The area covered is also high in Andhra Pradesh but in case of West Bengal area covered is very marginal. WUAs in West Bengal are formed are of tube-well level. In fact most of the WUAs in the country are below the level of minor. It is observed to be easily successful in area served by groundwater through tube-wells. Full scale WUAs has hardly been formed in any parts of India. WUAs in Madhya Pradesh at the outlet level cover relatively larger area of 19.24% of total area covered in the country. The number and area covered by the WUAs in Assam, Bihar and Orissa is very insignificant. So, the spread of WUAs has been very slow, specially in some states and is confined to only at the minor level. The Working Group Report on Command Area Development Programme for the 9th and 10th plan has sought to include PIM as a full component.

2.10 State Policies in Water Management

Water policies of the government have changed its character and emphasis through time. It is mainly due to the changing urgency and priorities. The first ever evidence of deliberation about water management at the government level can be identified way back in 1878 through **First Famine Commission**. It made several suggestions on the basis of which the famine codes were promulgated from 1883 onwards. The **Second Famine Commission,** set up after the drought of 1896-97, has identified the topmost priority of irrigation in drought protection. After this, the **First Irrigation Commission** emphasized on the need of irrigation as a productive and protective means. Expenditure equals to three times the future annual cost of famine relief was recommended for the sake of preventing famine altogether. According to the Commission if the capital cost is not likely to exceed thirty times the net revenue, or a net return of three per cent on the actual outlay can be anticipated then protective works can be sanctioned. The **Second Irrigation Commission** was set up in 1969 in the face of drought conditions during late sixties and early seventies in several parts of the country and the continued food shortages. The Commission recommended construction of a basin plan that will have a comprehensive outline of development possibilities of land and water resources to meet the anticipated regional and local needs. The goals of the irrigation policy was suggested to be classified as maximization of production per unit of land in case of water abundant region, maximization of production per unit of land in case of regions of medium and low rainfall and maximum area served in case of drought affected areas. High priority was accorded for irrigation works in drought areas. The inadequacies in run-of-the-river systems was recommended to be met by the increased use of ground water, by the construction of storage reservoirs and by supplementing supplies by transferring water from an adjacent basin. Field-to field channels and separate drains for individual fields also appeared in the recommendation list. The Commission opined that proper attention should be given to maintain the ecological balance in the planning of major irrigation works and soil conservation in all major projects should be completed in the next 20 years. It agreed on the existing practice of accepting projects only if the benefit-cost ratio is more than 1.5 and recommended to examine the financial return of the projects. However the Commission was of the opinion to relax these criteria in case if irrigation projects in the drought affected areas. Regarding water rate, the Commission has observed that from the irrigator's point of view, the water rate should be related to the benefit which irrigation confers rather than to the cost of an irrigation project. The Commission recommended solving the inter-State disputes through River Basin Commissions. The Commission was of the opinion that State Governments should assume legal power to regulate deep aquifers and extend control of Government over it to provide control and regulation. Education and Training of the irritation engineers also took place in the recommendation list.

Policies under Five-Year Plans

The **First Five Year Plan** has envisaged that the utilisation of the water resources has to be planned on a national basis. **Several large irrigation schemes were taken up under during this period of which a number of them were multi-purpose in character** and in many cases they were meant to store monsoon flows. A long-term plan was made to double the area under irrigation from Government works over a period of 15 to 20 years. The total cost of irrigation projects included in the first plan was about Rs. 720 crores of which about Rs. 80 crores had been spent before the commencement of the plan, Rs. 340 crores has been spend during the plan and the balance was considered to be carried over to the second and third plans. Minor irrigation was given importance during this plan. A total of 2,650 tube-wells were constructed during this period. Greater economy and efficiency in use of available water supplies was also stressed. Lining of was emphasized in this regard.

The **Second Five Year Plan** has identified the need for integrated development of land and water resource. Evaluation of country's water resource has been given importance. The Plan recommend that the Central and State Governments should jointly undertake a careful survey of future possibilities of large and medium irrigation projects and for minor irrigation schemes like tanks and wells. Tubewell irrigation has been given importance in this plan where canal irrigation is not economically viable or in areas, which are susceptible to water-logging. It has directed to look into the scope for adopting dry-fanning techniques, contour-bunding, arrangements for the preservation of soil moisture etc. for future development of irrigation. Storage facilities are to be enhanced considering the water requirements of head reach and lower down areas. Along with irrigation, power generation, water supply, disposal of sewage, navigation was given importance. Conservation of soil and building of check dams for the safety of the works connected with river valley projects were given importance. The total of 195 new projects were included in the Second Plan, which was estimated to cost about Rs. 380 crores of which about Rs. 172 crores has been spent during the plan period. The balance was considered to be spent during the third and subsequent plans. It also emphasized the need to complete the works of the projects in hand to reap the benefits as soon as possible. An important point to note is that it has argued that barring some projects each and every project included in the plan has not to be investigated from technical, economic and financial aspects. Balance between Major and Minor Irrigation Projects with a preference towards the medium-sized projects was discussed in plan document.

In the **Third Five Year Plan** emphasis was given to completion of continuing schemes of the Second Five Year Plan. Field channels, field drainage, anti-waterlogging schemes got special attention in the plan document. **Medium irrigation projects were given priority in the Plan.** Special steps such as speeding up utilization of irrigation facility created, revision of water rates and introduction of compulsory water cess, recovery of betterment levy etc. were considered in the plan document to bring about substantial improvements in financial returns. By the end of the Third Plan, the volume of utilisation of surface water increased to 18.5 million hectare meters or nearly one-third of the total availability. During the whole third year plan Rs. 112 crores has been distributed for private tubewell irrigation from institutions such as the Agricultural Refinance Corporation, Land Development Banks, Central Co-operative Banks and Agro-Industries Corporations. It was felt that a detailed soil survey would aid land-use planning, soil conservation and irrigation and drainage works.

Drought of 1965-66 and 1966-67 and introduction of new varieties of seed has impelled to **shift in the emphases in the Fourth Five Year Plan from expansion of irrigation facility to the need for efficient use of water resource for optimal production from irrigated land**. Provision of field channels and drainage was given importance in this regard. Comprehensive river basin planning, and integrated development of land and water resource was given attention to enhance economic efficiency. To maximize production, due attention was prescribed to be given to other connected aspects of agricultural development in the command area of the projects. Expansion of major, medium and minor irrigation facility also continued in the Fourth Five Year Plan. Integrated use of groundwater and surface water has been given importance. New projects were preferred in the plan document in those areas, which are relatively deficient in assured rainfall as well as irrigation. Integrated use of groundwater and surface water has been given importance. Due to rapid expansion of tubewell facilities during this plan period the number of private tubewells reached 175,000 from a mere 80000 at the end of the Third Five Year Plan. It has mainly happened due to expansion of institutional credit facilities and rural electrification. Maintenance of the existing work, remodeling and construction of subsidiary irrigation works were considered to be taken care of. Regarding water charges the plan document expressed that beneficiaries should pay the charges to reduce the burden of interest charges of major projects on the rest of the economy. It also expressed that water rates should be reviewed after every 5 years. State governments were also prescribed to consider upward revision of the minor irrigation charges. Construction of drainage channels, embarkments, town and village protection schemes were to be done in an integrated manner in case of flood protection.

The stated objectives of the **Fifth Five Year Plan** were removal of poverty and achievement of self-reliance. The major strategies of the agricultural sector included assessment and exploitation of irrigation water, intensification in application of new technologies in agriculture and improving extension mechanisms for supply of inputs apart from attention to the special needs of problem areas and vulnerable sections of the society. In 1974-75 at the beginning of the plan Centrally sponsored **Command Area Development Programme (CADP)** was launched. Within this plan 38 command area development authorities were set up covering 50 irrigation projects.

In the **Sixth Five Year Plan** document priority was given on early completion of ongoing major and medium projects. It was also suggested to initiate action on a few selected projects to maintain the momentum of development in Seventh Plan and also meet the needs of drought prone, tribal and backward areas and remove regional imbalances. Adequate maintenance of the canals, modernisation of irrigation systems, conjunctive use of surface and ground waters, adoption of Warabandi and strengthening of Command Area Development (CAD) organizations were suggested in the plan document. Evaluation of the project performance, detailed surveys and investigations for preparation of new projects, participatory management in the command, catchment and watershed areas was given priority in the plan. Initiation of investigation on inter-basin transfer of water from surplus area to water short area was suggested in the plan. Soil conservation and afforestation, strengthening existing organisation in the States, flood forecasting and warning systems has been given priority in reducing flood damage. Desalinization of seawater to utilise it for production of high valued crops through drip irrigation was also discussed.

Completion of unfinished irrigation projects was given priority in the **Seventh Five Year Plan. New construction of medium projects in drought-prone, tribal, and backward areas was restricted and more emphasis was laid down on minor irrigation programmes. Highest priority was given to utilization of created potential** through field channels, land leveling and introduction of Warabandi. Development of field drainage was suggested to restrict water-logging. Satisfactory maintenance of canals and the distribution system by making adequate financial allocation was given priority in the plan. The plan document emphasized accelerated exploitation and exploration of groundwater in eastern and northeastern regions. Prevention of encroachment in flood-prone areas through legislation was also suggested.

In the **Eighth Five Year Plan** Strategy mphasis was given on completion of only ongoing Major and Minor irrigation projects. New construction was restricted to medium construction projects that will benefit the tribal and drought prone areas. Preparation of additional plan for rehabilitation and catchment treatment works, user participation in major and medium irrigation projects, CAD programme, moderanisation and improvement of older irrigation system was emphasised in the plan. In case of Minor irrigation speedy completion of ongoing surface water minor irrigation schemes, micro-development projects, discouraging overexploitation of groundwater through legislation and tariff, installation of sprinkler/drip irrigation in water scarce and drought-prone areas, conjunctive use of surface and ground water etc. was prescribed. Covering and restoring water logged and saline/alkaline lands, flood forecasting, flood control Master Plans for various basins has been discussed as Flood Control and Drainage Programme.

In the **Ninth Five Year Plan** the impact of National Water Policy (1987) could be felt considerably. This Policy along with other related policies will be discussed later in this section. The New Agricultural Policy developed during the Ninth Plan focused on the optimal use of land, water and genetic resources in a sustainable manner. The plan document suggested steps towards comprehensive and integrated development of natural water resource. It also suggested to consider the possibility of inter-basin transfer of surface water. Improvement of water use efficiency by reduction in conveyance and application losses, completion of all ongoing projects, restoration and modernization of old irrigation systems was given emphasis in this plan document. Farmer's involvement in irrigation management, reduction of gap between potential creation and utilization by strengthening the Command Area Development was prescribed as new plan agenda. Rational pricing of irrigation water to enhance water use efficiency and cover at least O&M expenses was urged. The plan emphasized on Participatory Irrigation Management through involvement of water users community and conjunctive use of ground and surface water. It has directed to develop and utilize ground water in the eastern region on sound technical, environmental and economic considerations.

National Water Policies

Water policies play an important role in efficient water management. It is argued that water policies are not suitable for meeting the challenges of the maturing water economy of the future (Hufschmidt,2002). Water policies alone will not serve the purpose of efficient water management. It has to be supplemented with other policies such as public finance, agriculture, energy, industry and commerce, health, human settlements, transport and environment. The present section will discuss the water policies adopted by Government of India and other the related policies. As agriculture accounts for a major proportion of water use we will discuss various agricultural policy taken by the government. We will also discuss the public finance aspect of water management.

National Water Policy (NWP), 1987 is the first comprehensive basin based approach to water resource management. It has identified water as a prime natural resource, a basic human need and a precious national asset. It has clearly stated that planning and development of water resources need to be governed by national perspectives. This policy has taken a broader view of total water resource as a part of a larger ecological system. All types of water resources such as rainfall, river waters, surface ponds and lakes and ground water have to be considered to be a part of a single system. The availability of water is identified to be highly uneven in both space and time and precipitation is confined to only about three or four months in the year and varies from 10 cm in the western parts of Rajasthan to over 1000 cm at Cherrapunji in Meghalaya. Further, water does not respect state boundaries. Rivers along with ground aquifers often cut across state boundaries. So, **resource planning in case of water has to be done for a hydrological unit such as a drainage basin as a whole,** or for a sub-basin to make best possible combination of options.

It is a comprehensive policy in the sense that it has mentioned that economic development and activities including agricultural, industrial and urban development, should be planned with due regard to the constraints imposed by the configuration of water availability. The policy has indicated that demands for water for diverse purposes such as domestic, industrial, agricultural, hydro-power, navigation, recreation, etc will increase through growth process and the expansion of economic activities. It has also discussed about the need for water zoning of the country. Economic activities were recommended to be guided and regulated in accordance with such zoning. As **irrigation is the principal consumptive use of water further development of a substantial order is necessary** if the food and fiber needs of 1390 million polulation by 2025 AD has to meet. Producion of foodgrains has to increase from 208 million tones in 1999-2000 to 350 million tones in 2025 AD. The National Agricultural Policy (2000) has mentioned that over the next two decades, the aim is to attain a growth rate in excess of 4 per cent per annum in the agriculture sector. To feed the population, production of food grains has to be raised to around 240 million tons by the year 2000 A.D. Moreover, The National Agricultural Policy (2000) has also mentioned that growth has to be based on efficient use of resources and conservation of our soil, water and bio-diversity. Along with this the drinking water needs of people and livestock, have also to be met. The demand for water for domestic need from rural society is expected to increase sharply as the development programmes improve economic conditions in the rural areas though the domestic and industrial water needs have largely been concentrated in or around the principal cities. The demand for water for Hydro & Thermal power generation and for other industrial uses is also likely to increase substantially. As a result water scarcity is imminent and so its utmost efficiency in water utilisation and a public awareness of the importance of its conservation is warranted. That is why, comprehensive plans is to be taking into account to cater irrigation needs along with various other water uses so that the available water resources are determined and put to optimum use. In this regard appropriate organizations, in the form of special multi-disciplinary units should be set up in each state. Multipurpose projects has to be made to provide for irrigation, flood mitigation, hydro-electric power generation, navigation, pisciculture and recreation wherever possible with primary focus on provision for drinking water.

A common approaches and guidelines are necessary for problems regarding time and cost overruns, environmental protection, rehabilitation of project-affected people and livestock, water-logging and soil salinity, overexploitation of the country's groundwater resources, equity and social justice in regard to water distribution, public health consequences of water impoundment, dam safety, etc though planning and implementation of individual irrigation or multi-purpose projects is done at the State level. The study of the impact of a project during construction and later on human lives, settlements, occupations, economic and other aspects should be an essential component of project planning. Economic evaluation of projects in hilly areas is also directed to consider the need to provide assured drinking water, possibilities of hydro-power development and proper approach to irrigation in such areas. It is also suggeated to look into physical features and constraints such as steep slopes, rapid run-off and the incidence of soil erosion. The needs of Scheduled Castes and Scheduled Tribes and other weaker sections of society have to be taken care of through special projects in area inhabited by them. The irrigation intensity in all irrigation projects should be such as to extend the benefits of irrigation to as large a number of farm families as possible, keeping in view the need to maximize production. In this regard, we must mention that in the National Agricultural Policy (2000) growth with equity, growth, which is widespread across regions and farmers has also been given emphasis.

It is argued that quality of project preparation and management has to be upgraded to overcome time and cost overruns and deficient realization of benefits. Optimal allocation of resources and early completion of on-going projects has to be emphasized to avoid under-funding of projects. Appropriate annual provisions have to be made for maintenance and modernization of structures and systems created through massive investments. Regular monitoring of structures and systems and necessary rehabilitation and modernisation programmes should be undertaken. Concerted efforts have to be given to wipe out the gap between the potential created and its utilization. Command area development approach is suggested to be adopted in all irrigation projects. Water rates should be adequate to cover the annual maintenance and operation charges and a part of the fixed costs. It should convey the scarcity value of the resource to the users and foster the motivation for economy in water-use. Along with this assured and timely supplies of irrigation water has to be ensured. The Report of Tenth Finance Commission (1995-2000) recommended that the irrigation receipts should cover not only O and M costs but also give a return of at least 1 per cent per annum on capital. Earlier Finance Commissions barring the last two were also of the same view. Due to dismal performance of cost recovery the previous two finance Commissions only recommended for receipts that will cover only the cost of operation and maintenance. The

Tenth Finance Commission took a liberal view in case of hilly states by recommending recovery of only 75% of O &M. The NWP (1987) mentioned that the interests of small and marginal farmers have to be taken care of while fixing the water rates for surface water and ground water. The National Agricultural Policy (2000) has also argued for bridging the gap between irrigation potential created and utilised, completion of all on-going projects, restoration and modernization of irrigation infrastructure including drainage, evolving and implementing an integrated plan of augmentation and management of national water to increase availability and use of irrigation water. The policy has also mentioned about evolution of new bio-technologies that will promote plants which consume less water, are drought resistant, pest resistant, contain more nutrition, give higher yields and are environmentally safe.

The NWP (1987) has recommended building up of master plan for flood control and management for each flood prone basin. Watershed management, flood forecasting, providing flood-cushion in storage projects etc. was given emphasis to minimize the loss of life and property on account of floods. Regarding drought management it has suggested soil-moisture conservation measures, water harvesting practices, the minimization of evaporation losses, the development of the ground water potential and the transfer of surface water from surplus areas where feasible and appropriate. Development of pastures, forestry or other modes of development which are relatively less water-demanding were given prominence in the policy prescription. There should be a close integration of water-use and land-use policies in this regard.

Regarding exploitation of ground water resources the policy prescription is that exploitation should be so regulated as not to exceed the recharging possibilities. Groundwater recharge projects should be developed and implemented for augmenting the available supplies. This will ensure social equity. Conjunctive use of groundwater and surface water can also solve the problem. Periodical reassessment on a scientific basis of the ground water potential is absolutely necessary in this regard. The National Agricultural Policy (2000) has mentioned that demand for electricity for agricultural sector (mainly to extract groundwater) has to be met adequately. It has argued for promotion of technically sound, economically viable,. environmentally non-degrading, and socially acceptable use of country's natural resources such as land, water and genetic endowment to promote sustainable development of agriculture.

The role of education, regulation, incentives and disincentives has taken place in the policy document to built an awareness of water as a scarce resource and improve water use efficiency. The need for a perspective plan for standardized training in information systems, sector planning, project planning and formulation, project management, operation of projects and their physical structures and systems and the management of the water distribution systems has been emphasized in the policy.

Among other things efforts should has to be made to involve farmers progressively in various aspects of management of irrigation systems, particularly in water distribution and collection of water rates. Monitoring of quality has been emphasized for both surface water and ground water. Safety measures of dams have to be taken care of. Overall, a standardized national information system should be established with a network of data banks and data bases, integrating and strengthening the existing Central and State level agencies and improving the quality of data and the processing capabilities.

Since 1987 a number of issues and challenges have emerged in the development and management of the water resources. This has brought the need to develop National Water Policy,2000. In many cases it has broadly remained same as the National Water Policy,1987. In some cases it has changed its priorities or focused on a new issue. The planning and allocation priorities for the NWP (1987) was drinking water, irrigation, hydro-power, navigation, industrial and other uses. In NWP (2000) it has slightly changed to drinking water, irrigation, hydro-power, ecology, agro-industries and non-agricultural industries and lastly navigation and other use. It has identified that in improving water quality, improvements in existing strategies, innovation of new techniques resting on a strong science and technology base are needed to eliminate the pollution of surface and ground water resources. Inter-basin transfers, artificial recharge of ground water and desalination of brackish or sea water as well as traditional water conservation practices like rainwater harvesting, including roof-top rainwater harvesting has been emphasised in the policy. Promotion of frontier research and development has to be developed in this purpose. Institutional setup on a hydrological unit basis, along with a multi-sectoral, multi-disciplinary and participatory approach as well as integrating quality, quantity and the environmental aspects has prominently figured out in the policy prescription. Command area development approach is to be adopted in all irrigation projects. Proper drainage facility along with reclamation of waterlogged and saline affected land has to be taken care of. Emphasis on selective linings in the conveyance system, modernisation and rehabilitation of existing systems including tanks, recycling and re-use of treated effluents and adoption of traditional techniques like mulching or pitcher irrigation and new techniques like drip and sprinkler has been the important dimension of the policy. In case of water rates it has argued that subsidies inherent in it has to be well targeted to the disadvantaged and poorer sections of the society. Participatory approach in water resource management through water users association and local bodies and private sector participation in planning, development and management of water resources projects for diverse uses has to come in the forefront. Flood control has been given priority even at the cost of sacrificing irrigation and power benefits.

It is considered that states of India will formulate their own water policy under auspices of the NWP (1987) keeping in mind local options and constraints. The NWP (2002) has also mentioned that the success of the NWP will largely depend on time bound formulation of state water policies. Unfortunately, as of now, only a few states have been able to come up with their own State Water policy.

In the case of Rajasthan State Water Policy the order of the priorities is like drinking water, irrigation, power generation and industrial and other uses. Privatisation in urban water supply especially for meter reading, billing etc. has been considered. There are some laudable policy initiatives in this regard. In the domestic sector introduction of domestic water saving devices, water meters on all consumers, progressive water tariff structure, auditing of water balance from distribution systems; in the Industrial sector progressive water tariff, water recycling facilities, treated urban sewage water for cooling and other processes; in the agriculture sector sufficient water rates on volumetric basis for maintenance, treated sewage water for non-edible crops, saline water for tolerant crops, improvement in irrigation practices and reduction of water losses and lastly watershed management for each basin through afforestation, soil conservation, livestock management and treatment and disposal of sewage etc. has been given special emphasis.

In the case of Uttar Pradesh the priorities of water use are providing adequate water for drinking and domestic use, providing water for irrigation, hydro power generation, providing water for industries including Agro industries and lastly provide water for navigation, recreation, health and for other uses. The state inherits 74000 km of channels, some of which are more than 150 years old. In this case modernisation and upgradation of these channels is absolutely needed to cater for future requirements. As most of the system are fed by run-of the river schemes "Conveyance Management" also needs to be improved. As 7.336 million ha has been recognised as flood prone in the state out of about the 29.44 million ha. of geographical area, preparation of a perspective plan upto 2025 is considered to tackle the areas which are worst affected both in terms of frequency and extent of flood. For management of ground water demand side management, conjunctive use of surface and ground water has been prescribed. Participatory approach to water resource management has to be encouraged though water users association and local bodies.

2.11 Conclusion

With the increasing population and growth of the economy the total demand for water in India is estimated to increase in the near future and more so within the next twenty-five years. Though agriculture will remain as the main water consuming sector but the growth of water demand will mostly increase in industry and energy sector within the next twenty five to fifty years. Other sectors will also demand water in an increasing quantity. Within the agricultural sector demand for water for rice cultivation is maximum and will remain same within the next twenty-five years. During the last one decade, growth of demand for water has been maximum for wheat followed by sugarcane. Within the next ten years demand for water will increase mostly for rice followed by wheat. Between next ten to twenty years demand for water for rice will continue to grow faster than any other crop followed by oilseeds. Demand for water in case of sugarcane will also grow at the fastest rate within next twenty to twenty-five years among all other crops.

As population density of different states varies and availability of surface and groundwater also varies, the water scarcity or abundance varies spatially. Rajasthan turns out to be the most water stress region of India with limited inland and ground water resource and moderately high population density. Punjab and Uttar Pradesh seem to be relatively water abundant state in terms of inland water resource. Though replenishable groundwater is moderately available in Punjab but water for tubewell irrigation does not have much potential. In case of Uttar Pradesh also well irrigation potential does not seem to be high. Well irrigation potential is high enough in the eastern Indian states. Lack of sufficient storage facility has impaired proper management of abundant inland water resource in the hilly states. Replenishable groundwater resource and groundwater resource for irrigation is also abundant in these states. In many cases groundwater resource for irrigation has hardly been exploited.

Well irrigation has got increasing priority through time. Canal irrigation also plays an important part in the country's irrigation network. A balanced approach has to be taken so that the groundwater and surfacewater is used conjunctively. In case of area irrigated by different crops, area irrigated under wheat is getting more prominence than rice especially in the nineties. It is basically a welcome sign as wheat is less water consuming crop than rice and has prominent role in the country's food security. Another important observation is that the area irrigated under non-food crop has increased by a larger rate than area irrigated by food crop. Regarding food security of the country this observation is of high concern and should be investigated further.

Success of rural & urban water supply schemes has been highly uneven. Additional surface water has to be tapped by means of creating new reservoirs, especially in the hilly states. Groundwater potential has also to be properly utilized wherever possible. In this case proper attention should be given to Assam, Arunachal Pradesh and Tripura. Safe drinking water should get the highest priority in water resource planning as mentioned in the National Water Policy (1987 and 2002).

Water losses due to flood has increased in the nineties. Priority is to be given to flood management more than irrigation and power generation. In case of drought management some schemes like Drought Prone Area Programme and Desert Development Programme have been launched by the government under the common guidelines of Watershed development. Benefits have been realized from scarcity zone and as well as transition zone as a result of these programme. Management of water resource in the rainfed areas has also been initiated through Watershed Development.

To meet the future additional demand of HE power the potentials in this regard has to be developed properly. North–Eastern states has to be given priority in this regard as lot of potential in these areas are not properly developed.

It has been observed that Participatory Irrigation Management through WUA has not reached to the desired extent and confined to only one or two states. Steps have to be taken to usher in PIM in each and every state and its level of operation has to be widened.

There has been considerable change in the emphasis in the direction of policy and initiatives to manage water resource efficiently. Expansion of irrigation facility has been the main focus in the early plans. But there has been a shift in the emphasis in the Fourth Five Year Plan from expansion of irrigation facility to the need for efficient use. In this direction Command Area Development Programme was launched during the Fifth Five Year Plan. Expansion of irrigation with emphasis on new construction facility has led to less attention in the performance of irrigation and the sector's broader management till the end of Sixth Five Year Plan. The New Water Policy (1987) has given emphasis on management of water resource comprehensively. It has given importance on efficient water management and proper maintenance of irrigation infrastructure. Restructuring management of irrigation systems and Participatory Irrigation Management has been suggested. From Eighth Five Year Plan the emphasis was shifted to early completion of ongoing projects. Modernisation and improvement of older irrigation system. CAD programmes has been given in this plan. This motto has been continued in the Ninth Five Year Plan also. Improvement of water use efficiency has been given topmost importance. But here the question arises whether the lack of efficiency is well pervasive in each and every state. If it is not then the logic of shift in emphasis from expansionary to efficient use does not hold for each and every region or state. Moreover, creation of new potential is also a part of efficient management of water resource. Tapping of water resource through creation of new storage facility also leads to efficient management of water resource. This measure also gets importance in the context of increasing demand for water in each and every sector in the near future. So, creation of new potential is utterly important, which we will discuss at length in the next chapter. The discussion will be mainly based on Major and Medium irrigation system, which is largely infested with the problem of inefficiency in water use.

Chapter 3

Water Resource Management In Major and Medium Irrigation

As it has already been discussed that irrigation accounts for most of the water use. The issue of management of irrigation therefore is most important in managing the country's total water resources. Irrigation sector in India is marred with several problems such as low utilization of irrigation capacity, spatial and interpersonal disparity in distribution of irrigation benefits, conveyance loss and wastage in field application, deterioration of financial performance, overexploitation of groundwater, waterlogging, siltation and other related problems. All these problems together lead mismanagement of water resource. It has been identified that inclination towards the groundwater exploitation through wells has been rising steeply in India. But it must be mentioned that for the development of irrigation, water resource as a whole proper utilization of surface water along with groundwater is absolutely necessary. Different Five Year Plans have also identified the need for conjunctive use of ground and surface water.

The Major and Medium irrigation sector is suffering from a host of problems ranging from low utilization of created potential to the ailing financial position. Steps have also been taken to get rid of these problems. Command Area Development Programme has been launched to do away with the inefficiencies of the irrigation sector. It is now time to look into the efficacies of this programme. It has also been observed that the big dam projects entail different environmental hazards like waterlogging, loss of forest cover, submergence of land and displacement of people from the submerged area. Minor irrigation faces fewer problems due to control over timing of irrigation operation, high dependability during drought years and copiousness of irrigation. But the scope for new irrigation capacity is much more in surface water than groundwater and surface water resources are best for irrigation devlopment through major and medium irrigation schemes only. In this context proper development of surface water irrigation gets paramount importance. That is why it is absolutely necessary to look at the problems of Major and Medium (M&M) irrigation sector. In this chapter we will discuss about the mismanagement of irrigation water resource mainly focusing on the Major and Medium Irrigation sector. We will discuss about the creation of ultimate irrigation potential to analyse the scope of M&M irrigation. Next we will go on to discuss about the inefficiency in utilization of the potential already created. In this context we will also analyse the much talked about Command Area Development Programme, which has been devised to curb inefficacies in irrigation. Lastly we will discuss about environmental hazards and displacement of people from their habitat, which has evoked questions about the social and environmental viability of M&M irrigation sector.

3.1 Creation and Utilisation of Ultimate Irrigation Potential

Taking India as a whole we can observe that the percentage of ultimate potential created has been greater in case of minor irrigation projects than the major and medium irrigation projects (Table-A.3.1). In states like Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Punjab, Rajasthan, Tripura and West Bengal, we can also observe the same scenario. A adverse picture can be observed in Andhra Pradesh, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharastra, Manipur, Orissa and Tamil Nadu. The percentage of ultimate irrigation potential utilized has been less than potential created in both major and medium and minor irrigation projects. In the case of West Bengal though the percentage of ultimate irrigation potential created is higher in minor irrigation projects, but percentage utilization of ultimate irrigation potential is higher in major and medium projects. In the case of Maharastra, it is interesting to note that though percentage of ultimate irrigation potential created is greater in major and medium projects, but the percentage of ultimate irrigation potential utilized is greater in minor irrigation projects. The problem of low utilization of potential created in case of major and medium irrigation projects has been an issue of major concern, which will be discussed later on. At the all India level, around 44% of ultimate irrigation potential in major and medium irrigation has not been created till the end of Eighth Five Year Plan while the same for minor irrigation is 30%. In cumulative terms, utilization of created potential has been 48.59% in major and medium irrigation while it has been 64.84% in minor irrigation at the end of Eighth Five Year Plan. **So, on an overall basis, lots of ultimate irrigation potential have still to be created in major and medium irrigation. The remaining unexploited potential is more in major and medium than minor irrigation though the situation also varies from state to state.**

During the First Five Year Plan the percentage of potential created and utilised in major and medium irrigation projects has been higher than minor irrigation projects (Table-A.3.2).

This difference has been widened during the Second Five Year Plan. Due to prior importance to minor irrigation projects during the pre-plan period the percentage of potential created and also potential utilized for major and medium and minor irrigation projects in the cumulative sense has been almost equal at the end of the second year plan (Table-A.3.3). During the Third Five Year Plan equal importance was given to both major and Medium and the minor irrigation. After Third Five Year Plan, attention gradually shifted towards to the minor irrigation system. During the Fourth Five Year Plan, only 36% of potential created by public sector in irrigation was meant for major and medium irrigation system. Barring the Fifth Plan and Annual Plan (1999-2000) period, all other Plans have given greater importance to minor irrigation. The gap took its highest form during the Sixth and Seventh Five Year Plan. As a result the proportion of potential created for major and medium irrigation was a meager 38% and consequently the same in case of minor irrigation reached as high as 62% in cumulative sense at the end of Eighth Five Year Plan. This has also created imbalance in exploitation of ground and surface water. From this discussion we can easily find out the reason for only 56% of creation of ultimate irrigation potential in case of major and medium irrigation and a higher 71% of creation of ultimate irrigation potential in case of minor irrigation projects at the end of Eighth Five Year Plan. Almost same amount of difference can be noticed in terms of potential utilization in cumulative sense between major and medium and minor irrigation. **Greater emphasis of public sector towards the minor irrigation has led to lower percentage of creation and utilization of ultimate irrigation potential in major and medium irrigation. Imbalance in utilization of surface and ground water has occurred due to this biased government policy.**

3.2 Utilisation of Created Potential

It is interesting to note that barring during Sixth and Eighth Five Year Plans and some Annual Plans whenever the percentage of potential created for major and medium irrigation has been greater than the percentage of potential created for minor irrigation the same difference between the two types of irrigation in terms of potential utilization is lesser and whenever the percentage of potential created for minor irrigation has been greater than the percentage of potential created for major and medium irrigation the same difference between two types of irrigation in terms of potential utilization is higher (Table-A.3.2). This is precisely due to the reason that barring the Sixth and Eighth Five Year Plan and some Annual Plans, in all cases the potential utilization of minor irrigation projects has been higher than potential creation while the reverse is true for major and medium irrigation projects (Table-A.3.4).

In our previous section we have already mentioned about the problem of low utilization of created potential for major and medium irrigation projects. Till the end of Annual Plan (1978-80) almost full potential created by the minor irrigation system has been utilized. During the Second Plan and Third Plan the utilization of potential created for major and medium irrigation systems has been high enough at over 95%. It has gradually declined during the Fourth and Fifth Plans. From the Annual Plan (1978-80) it started to increase again. The cumulative figures shown a declining trend till the Forth Five Year Plan but remained at a constant 85% from Fifth Plan to Annual Plan (1990-92). During the Eighth Plan it has increased by a big margin. During Annual Plan (1990-92) and particularly Annual Plan (1998-99) the performance of major and medium irrigation in terms of utilization of created potential has been very impressive. The performance of minor irrigation schemes from the Sixth Plan in terms of utilization of created potential has not been so much impressive as earlier. Still at the end of Eighth Plan utilization of created potential for the minor irrigation in cumulative sense has been higher than major and medium irrigation schemes (Table-A.3.5). So we can argue that **at the all India level the performance of minor irrigation schemes in terms of utilization of created potential in cumulative sense has been better than major and medium irrigation schemes though performance of major and medium irrigation has much improved during the last decade as compared to the earlier period.** Taking together the major and medium and minor irrigation performance in terms of utilization of created potential in a cumulative sense has declined till the end of Sixth Five Year Plan but has become stable at 89% after that.

We would also like to discuss the performance of major and medium irrigation schemes in terms of utilization of created potential at state level considering the data in cumulative sense. For our discussion we will only concentrate on performance from Sixth Five Year Plan to Annual Plan (1997-98).

In the case of Andhra Pradesh the performance of major and medium irrigation schemes is better not worse than the minor irrigation schemes. Utilization of created potential is as high as over 90% in both cases (Table-A.3.6). This may well be the reason why both type of irrigations have got equal importance as indicated by the almost equal percentage of potential created by each irrigation systems. Nearly half of the ultimate irrigation potential of the state has not been utilised in both cases till the Eighth Five Year Plan. So it seems that irrigation water is well managed in the state and has potential for further exploitation simultaneously through both major and medium and minor irrigation schemes.

In the case of Arunachal Pradesh there is hardly any major and medium irrigation projects and the ulilisation of created potential in minor irrigation is at only around 85%.

Only around half of the irrigation potential created has been utilized in Assam in case of major and medium irrigation projects while the performance of minor irrigation projects are far better. The performance of major and medium irrigation projects are gradually increasing. This may be the reason why percentage of potential created in major and medium irrigation is very low but gradually increasing at a very slow pace. It must be mentioned that only 20% of the ultimate irrigation potential has been utilized till the Eighth Plan in major and medium irrigation. This is why better water management strategies have to be taken for the future development and utilisation of its resource.

In the case of Bihar only around 80% of the potential created in major and medium irrigation projects has been utilized till the end of the Eighth Five Year Plan. The performance of minor irrigation in the state is better but still poor. Only 35% of its ultimate irrigation potential in major and medium irrigation projects has been utilised. Emphasis on new potential creation for the major and medium irrigation projects is also low till Eighth Five Year Plan. In the case of this state, better management of irrigation water is the urgent need.

The performance in terms of utilisation of created potential in Goa has improved a lot during the nineties and has reached a 92% mark. But the importance on new potential creation is very less and around 80% of its ultimate irrigation potential is still untapped. Stress should be given in favour of creating new potential in major and medium irrigation.

In the case of Gujarat the performance of major and medium irrigation projects in terms of utilisation of potential created is around 89% and slightly below than minor irrigation. Less than 50% of the potential of the state is created in major and medium irrigation. Only 40% of its ultimate irrigation potential in major and medium irrigation projects has been utilised.

Only 88% of the ultimate irrigation potential has been utilized in major and medium irrigation projects in Haryana while it is almost 10% higher in minor irrigation. Over 50% of the potential of the state is created in major and medium irrigation. More efficient use of water through major and medium irrigation is expected.

The performance of major and medium irrigation projects is absolutely dismal and is also deteriorating in Himachal Pradesh. Only a marginal potential has been created in this type of irrigation. Almost 90% of its ultimate irrigation potential has remained unutilized.

In the case of Jammu & Kashmir also performance of major and medium irrigation projects is poor while minor irrigation projects has performed well. Around 40% of the ultimate irrigation potential has remained unutilised.

In Karnataka also 88% of irrigation potential created in major and medium irrigation system has been utilised. Around 52% of potential created in the state is from major and medium irrigation projects and 40% of its ultimate irrigation potential has remained unutilised.

In Kerala also the also the performance of major and medium irrigation projects is same as Karnataka with 50% of its ultimate irrigation potential unutilised.

In the case of Madhya Pradesh the performance of major and medium irrigation projects is absolutely dismal with only 70% of potential created is getting utilised. Around 44% of the created potential is from major and medium irrigation projects and only 27% of ultimate irrigation potential has been utilised.

In Maharastra only miserably 56% of potential created has been utilised in major and medium irrigation till the Eighth Five Year Plan. The performance of minor irrigation system is far better than this. This has been the reason why nearly 57% of its ultimate irrigation potential has been created but only 31% has been utilised in major and medium irrigation.

In the case of Manipur neither the performance of major and medium irrigation system nor the performance of minor irrigation system is impressive. In both cases, around 80% of created potential has been utilised.

In Orissa the performance of major and medium irrigation system is far more impressive than the minor irrigation. More than 90% of potential created has been utilized till Eighth Five Year Plan in major and medium irrigation. More potential has been crated in major and medium than minor irrigation. Around 60% of its ultimate irrigation potential in major and medium irrigation has not been created and utilised. So scope for greater expansion of irrigation potential for major and medium irrigation system exists.

In the case of Punjab the performance of utilisation of created potential is highly impressive in both major and medium and minor irrigation. Only around 20% of ultimate irrigation potential in major and medium irrigation has remained to be created and utilised. Ultimate irrigation potential in case of minor irrigation has been fully utilised. So further expansion of irrigation potential in the state is only possible through creation of the remaining potential in major and medium irrigation.

More than 90% of potential created has been utilised in both type of irrigation in Rajasthan till the Eighth Five Year Plan. The performance of minor irrigation has been far more impressive. Around 82% of its ultimate irrigation potential has already been utilized in major and medium irrigation system.

In the case of Tamil Nadu around 100% of potential created in major and medium irrigation has been utilised. Further expansion of major and medium irrigation is not possible in the state, as ultimate irrigation potential has been fully utilised. Opportunity exists in the state to create and utilise more minor irrigation facility.

In Tripura also 100% of potential created has been utilized in major and medium irrigation. Moreover only about 2% of its total irrigation potential has been created in major and medium irrigation and 2% of the ultimate irrigation potential in major and medium irrigation has only been created and utilised. So opportunity of further expansion of potential creation in major and medium irrigation exists in the state.

Only 87% of potential created has been utilised in Uttar Pradesh in case of major and medium irrigation. The performance of minor irrigation is a bit better. More than 50% of ultimate irrigation potential of the state still remains unutilised in major and medium irrigation.

In the case of West Bengal, 92% of ultimate irrigation potential has only been utilised in major and medium irrigation. The performance of this system is far better than the minor irrigation system. Around 40% of ultimate irrigation potential has not been utilized till the Eighth Plan in major and medium irrigation.

From the above analysis we can easily figure out that at the all India level, performance of major and medium irrigation system in terms of utilization of created potential has not been impressive and infact been worse than minor irrigation. But it has been argued that estimation and quantification of potential creation and potential utilization if faulty (Mitra, 1996; Vaidyanathan, 1999). It has been argued that low utilisation of created potential does not mean that water is getting wasted. Low utilisation ratio may occur due to biasness in cropping pattern towards heavily-irrigated crop (Dhawan,1986; Vaidyanathan 1991). Moreover, different states adopt different criteria for reporting potential utilisation (Mitra, 1996). There are also ambiguities in definitions of 'potential' and differing interpretations of the guidelines (Vaidyanathan, 1999)

It has been shown in our discussion that underperformance of system in terms of low utilisation ratio, is not even among different states. Various estimated low utilisation of created potential in respect of irrigation schemes across different regions vary from as low as 15% to as high as 50% (Mirta, 1996). But all these estimates have been conducted long ago and the situation has changed a lot in this respect. Impressive performance in major and medium irrigation system can be found in Andhra Pradesh, Orissa, Punjab, Tamil Nadu and Tripura. Even in some cases further opportunity of expansion of major and medium irrigation potential exists. Performance of Goa, Karnataka, Rajasthan and West Bengal is moderate. The performance of major and medium irrigation system in some states is even better than the minor irrigation system. **So the argument of low utilisation of created potential in major and medium irrigation system does not hold for each and every state. Better system performance in terms of utilisation of created potential in minor irrigation than major and medium irrigation also does not hold for each and every state.** Expansion of major and medium irrigation potential can also be adopted as a strategy for better irrigation water management in many cases. In this regard we can argue that **strategies of irrigation water management needs to be adopted at state or more local level rather than at all India level.**

3.3 Command Area Development Programme (CADP) in Irrigation Management

Even after unprecedented expansion of irrigation facility after independence, the country observed stagnation in agricultural production at 1970 level. The Second Irrigation Commission (1972) and the Committee of Ministers set up by erstwhile Ministry of Commerce in their report in 1973, identified that due to isolated treatment of activities of irrigated agriculture a wide gap has been seen between potential created (PC) and potential utilised

(PU). In this direction in 1974-75 a Centrally Sponsored Command Area Development Programme (CADP) was launched. It was envisaged as an integrated and co-ordinate approach to development of irrigated land where centre will act as a facilitator to set the stage and pass the responsibility to the States once they get attuned to the needs of the programme. On farm development and making available agricultural inputs and extension services were also on the agenda. It was assumed that the above outlet canal system is operated, maintained and managed satisfactorily by concerned irrigation department. So, below outlet area, which is owned and operated by the farmers, an area was chosen as the area of operation for CADP.

To manage water resource more efficiently a host of programmes were adopted. We will discuss here only a few on farm development programmes, which are related to Major and Medium irrigation. These are as follows:

(1) Development of field channels (FC) and field drains (FD)

(2) Land leveling and shaping (LL)

(3) Warabandi (WB) and fair distribution of water to individual farmer

(4) Reclamation of waterlogged area

Other programmes included in CADP were selection and introduction of suitable cropping pattern, development of conjunctive use of surface and ground water, development and modernisation, maintenance and efficient operation of irrigation system etc.

Till 2001out of 598 on-going projects CADP is operating in 236 major and medium projects covering 23 Mha of Cultivable Command Area (CCA). Many projects were dropped due to completion of the core components. In 2000-2001, 18 projects out of 29 have been dropped due to this reason (Table-A.3.7). It means that other projects are taking long time to complete. This has resulted in thin spreading of resource, locking up of the capital and consequent lack of desired result. But the number of ongoing projects have increased constantly (GOI, 2001). Number of on-going projects have increased at a maximum rate of 6.5% between 1984-85 and 1994-95 (Table-3.1). It has declined to 3.8% between 1994-95 and 2000-2001 due to completion of 18 projects in 2000-2001. It should be noted that the growth rate of Culturable Command Area (CCA) is minimum between 1984-85 and 1994-95 while the number of ongoing projects increased at a maximum rate during this period.

Table: 3.1 Compound Growth rate of on-going M & M projects included in CADP

	On-going (cumulative)	CCA
Between 1974-75 and 1984-85	5.35	2.01
Between 1984-85 and 1994-95	6.47	1.25
Between 1994-95 and 2000-2001	3.77	1.54

Source: Report of the Working Group on Command Area Development for 10th Five-Year Plan, Planning Commission, Government of India, 2001

It implies that projects included during this period are of smaller CCA than other periods. During 1974-75 and 1984-85 the growth rate of number of on-going projects were high and CCA was highest, implying that increasing number of large projects (in terms of CCA) was adopted during this period.

We would now like to analyse the performance of the projects yearwise on all India basis and then statewise. Progress in terms of potential creation has been maximum between 1973-74 and 1984-85, compound growth rate being 6% (Table-3.2).

Table: 3.2 Compound Growth Rate of Cumulative Potential Created and Utilised in CADP

	Potential Created	Potential Utilised
Between 1973-74 and 1984-85	6.082786	6.69192
Between 1984-85 and 1994-95	1.56592	1.404893

Source: Government of India, Ninth Five Year Plan, Planning Commission, New Delhi, 1998

Potential utilization has increased by a slightly greater percentage between these periods. The growth rate of these two variables between 1984-85 and 1994-95 has been substantially low. Performance in terms of Utilisation of Created Potential improved from 70% at 1979-80 to 80% at 1994-95 (Table-3.3). There have been little ups and downs of the performance within the time period. It has greatly improved in 1984-85 as compared to 1979-80. After the initial decline of performance from the next year it has started to improve slowly once again and has reached at 81% in 1993-94.

Table: 3.3 Potential Created, Utilised and Percentage of Utilisation of Created Potential (Cumulative) in CADP

Year	Potential Created (P)	Potential Utilised (U)	U/P
1973-74	6.68	5.11	76.50
1979-80	11.26	7.89	70.07
1984-85	12.79	10.42	81.47
1985-86	13.9	10.18	73.24
1986-87	14.28	11.04	77.31
1987-88	14.42	10.93	75.80
1988-89	14.5	11.43	78.83
1989-90	14.59	11.08	75.94
1990-91	14.81	10.9	73.60
1991-92	14.83	11.41	76.94
1992-93	15.01	11.89	79.21
1993-94	14.8	11.99	81.01
1994-95	14.94	11.98	80.19

Source: Same as 3.2

Table: 3.4 Statewise Percentage of No. of Projects, Culturable Command Area, Creation and Utilisation of Total Irrigation Potential, Utilisation of Potential Created (Cumulative) for CADP (1994-95)

1	2	3	4	5	6
Andhra Pradesh	3.70	6.28	81.50	72.20	88.59
Arunachal Pradesh	0.53	0.00	0.00	0.00	
Assam	3.17	0.39	68.42	60.44	88.33
Bihar	3.70	11.79	79.42	55.35	69.70
Goa	1.06	0.08	55.98	50.58	90.34
Gujarat	19.58	4.72	80.97	62.21	76.83
Haryana	4.76	2.94	60.22	32.49	53.95
Himachal Pradesh	1.59	0.04	92.79	63.96	68.93
Jammu & Kashmir	5.29	0.32	54.50	24.43	44.83
Karnataka	6.35	9.18	68.33	60.28	88.21
Kerala	7.41	0.83	101.55	92.23	90.82
Madhya Pradesh	12.17	7.77	77.52	63.67	82.14
Maharastra	8.47	5.99	55.13	29.05	52.68
Manipur	1.59	0.15	105.83	88.34	83.48
Meghalaya	0.53	0.00	0.00	0.00	
Nagaland	0.53	0.00	0.00	0.00	
Orissa	5.29	3.46	70.80	63.74	90.02
Rajasthan	2.12	4.56	102.37	110.41	107.85
Tamil Nadu	4.23	3.37	123.54	86.67	70.16
Tripura	0.53	0.02	0.00	0.00	
Uttar Pradesh	5.29	29.24	58.13	45.07	77.54
West Bengal	2.12	8.82	57.80	51.61	89.29
D&N Haveli	0.00	0.04	0.00	0.00	
Daman & Diu	0.00	0.02	0.00	0.00	
Total	100.00	100.00	71.63	57.47	80.23

Source: Water and Related Statistics, CWC

Please refer the next page for the Legends

Legends of the Table 3.4

1. State	4. Creation of Total Irrigation Potential
2. No. of Ongoing Projects	5. Utilisation of total Irrigation Potential
3. Culturable Command Area	6. Utilisation of Potential Created

In 1994-95, out of 189 projects, 19.6% were going on in Gujarat and 12.2% were going on in Madhya Pradesh (Table-3.4). But CCA was highest in Uttar Pradesh at 29.2%, followed by Bihar at 11.8%. In terms of creation of total (ultimate) irrigation potential Tamil Nadu, Manipur, Rajasthan and Kerala have reached the highest level at more than 100%. Plenty of potential are still remaining in Jammu & Kashmir, Maharastra, Goa, West Bengal and Uttar Pradesh. Though overall creation of total irrigation potential is at 71.6% but the utilization of total irrigation potential at 57.5%. In this context we will try to analyse the performance in terms of utilisation of irrigation potential created. It is around 80% on overall basis but varies from state to state. In Rajasthan whole irrigation potential created has been utilised. In Kerala, Goa, Orissa and West Bengal almost 90% potential created has been utilised. But the performance is miserable in states like Jammu & Kashmir, Maharastra and Haryana. So, from this analysis it is clear that **the expansion and performance in terms of utilisation of potential created of CADP has not been even in all the states.** It is generally argued that development of FC, FD, LL and WB has been designed for better management of irrigation water. We would like to see to what extent these programmes have been effective in reducing the gap between irrigation potential created and utilised.

Firstly, we would like to discuss about the spread and progress of these programmes in the command areas. Between the end of Seventh and Eighth Plan the growth rate of Warabandi programme has been maximum at 22% among all the programme components followed by FD. (Table-A.3.8). The growth rate is high in Tamil Nadu, Kerala and Orissa. High growth of FD at around 50% has been observed in Jammu & Kashmir. The growth rate for the same is at 19% in Karnataka and 15.6% in Manipur while it is at 9% at all India basis. LL has progressed by considerably high margin in Manipur followed by Orissa. The overall growth of FC is at 4.4% between the end of Seventh and Eighth Plan. Maximum progress in this regard has been observed in Goa. It is followed by Haryana, Manipur and Himachal Pradesh. It should be noted at this point that overall 67.2% of potential created has been supported by FC facility (Table-3.5). In Manipur, Kerala and Orissa only around 25% of potential created has been supported by FC. In states like Uttar Pradesh and Maharastra the entire potential has been supported by FC. Overall only 4.8% of potential created has been supported by FD considering all CADP projects in the country. FD facility has been marginal in case of Haryana, Gujarat, Andhra Pradesh, Kerala and Tamil Nadu. It is totally absent in Bihar and Goa. It is relatively higher in Assam and Maharastra. In case of LL also, the progress is minuscule with only 11.36% of potential being covered. There is also wide disparity with respect to its coverage. In most of the states it is marginal. In Maharastra it has supported 69% of potential created followed by Karnatak and Jammu and Kashmir. WB facility has hardly taken off the ground in West Bengal. It is only marginal in Bihar, Madhya Pradesh and Manipur. In Jammu and Kashmir entire potential is supported by WB. Overall only 27% of potential created in CADP has been supported by WB. So, from this discussion it is clear that the **development of the core components of CADP to manage irrigation water efficiently has been insufficient and highly uneven within the states**.

Now, we look into the effect of FC, FD, LL and WB programmes on percentage of utilisaion of created potential. From Table-3.5 we can easily make out that development of different programmes varied within each state. We have to calculate an index of the development of these core components of CADP programmes and compare it with percentage utilization of created potential. So, in this case we will go for a Principle Component analysis with variables cumulative FC, FD, LL and WB as a percentage of cumulative potential created. The First Principle Component, based on correlation matrix of the variables, explains maximum 43% of variation in the data matrix (Table-A.3.9). Barring WB, in all other variables, the loading is above 0.5. We have then calculated the scores for each and every state. Table-3.5 gives us the scores of each and every state. Now if we compare the scores with the percentage utilisation of created potential then we will find that there exists no relationship between these two variables. The correlation coefficient of score and percentage utilisation of potential created is low at 0.161, which is insignificant. It has already been mentioned that due to thin spreading of the resource and locking up of the capital the results of development of CADP have not reached the desired level. It has also been identified that to realize the optimum benefits from CADP, co-ordinated and paripassu implementation of all the on farm development programmes has to be made (GOI, 1998). Other factors, like improper selection and introduction of suitable cropping pattern, restricted conjunctive use of ground water and surface water, lack of modernisation, maintenance and efficient operation of irrigation system etc. have impaired the performance of CADP programme (GOI, 2001). Allocation of water in the rotational water supply system is sometimes biased in favour of larger and more powerful landowners (Vaidyanathan, 1999). This also may have also led to poor performance.

Table: 3.5 Field Channel (FC), Field Drainage (FD), Land Levelling (LL), Warabandi (WB), Potential Utilisation as a percentage of Potential Created (Cumulative) and Scores for the States (1994-95)

State	FC	FD	LL	WB	Score	U/P
Andhra Pradesh	52.41	0.83	22.05	22.91	1.69	88.59
Assam	32.56	26.67	0.00	55.26	-0.38	88.33
Bihar	54.87	0.00	0.07	3.39	0.16	69.70
Goa	35.86	0.00	1.38	67.59	-0.19	90.34
Gujarat	61.95	0.32	19.03	27.50	-0.98	76.83
Haryana	64.22	0.00	10.19	59.09	-0.65	53.95
Himachal Pradesh	44.66	5.83	0.00	70.87	0.94	68.93
Jammu & Kashmir	66.97	7.26	43.38	140.65	-1.14	44.83
Karnataka	69.71	2.23	47.59	10.30	0.01	88.21
Kerala	25.63	0.88	0.17	21.81	-0.22	90.82
Madhya Pradesh	53.40	2.70	2.68	4.35	-0.74	82.14
Maharastra	99.43	34.58	68.90	23.07	0.75	52.68
Manipur	24.10	16.87	9.12	8.43	-0.51	83.48
Orissa	26.92	6.33	0.20	41.78	2.79	90.02
Rajasthan	60.84	3.34	6.97	30.48	-0.60	107.85
Tamil Nadu	35.77	0.92	0.00	15.12	0.04	70.16
Uttar Pradesh	135.20	2.58	0.28	67.59	-0.89	77.54
West Bengal	3.07	11.02	0.24	0.00	-0.07	89.29
Total	67.22	4.78	11.36	26.99		80.23

Source: Government of India, Ninth Five Year Plan, Planning Commission, New Delhi, 1998 & Water and Related Statistics, CWC

So, from this above analysis it is clear **that the impact of Field Channel, Field Drainage, Land Levelling and Warabandi on utilisation of created potential till 1994-95 has been insignificant.**

We will also try to make a note about the role of CADP in reclamation of Waterlogged Areas in major and medium projects. It has already been discussed that due to over-use of water, seepage from distribution system, existence of certain soil strata waterlogging in irrigated area is increasing due to expansion of canal irrigation. It was attempted to remove the problems of waterlogging with the coordinated steps by removing system deficiencies, structural and non-structural measures for improving irrigation management, implementation of drainage schemes and use surface and ground water conjunctively. In the year 1996 steps were taken in this direction under CADP. The details of the schemes are given in Table-A.3.10.

3.4 Submergence of Land and the issue of Displacement in case of Large Dams

It has been argued that in many quarters large dams have negative impacts on the ecosystem. Sometimes, even losses are argued to be irreversible in nature (Dames and Development,2000). It has been argued that due to submergence of land under the reservoirs of the dams, large areas of forestland have been swallowed by the big river valley projects. The loss of vegitation cover leads to increase in sedimentation, stormflow and annual water yield, decrease in water quality, and a variable changes in the seasonal timings of water yield. Along with this most of the dams take long time to get completed. For this reason labours working in the project site exploit forest resource for their livelihood (Singh, 1990). Along with this, loss of flora and fauna becomes conspicuous. Moreover, many important measures like soil preservation, water replenishment and microclimatic stabilisation have often been ignored. Compensatory afforestation, as vowed by the government, has been able to offset just a fraction of the total loss. Till date, efforts to counter the ecosystem damage caused by large dams have had only limited success due to limited efforts to understand the ecosystem and the scope, nature and intensity of impacts. Assessments of anticipated impacts has also been inadequate. By 1980 a total area of 2028.24 thousand hectare has been submerged (Table-A.3.11). The loss of area due to submergence is staggering in case of Almatti, Hirakud Gandhi Sagar, Pong, Srisailam, Ukai etc. Strategy for efficient water management for major and medium schemes demands proper steps on the part of the government, so that environmental and ecological balance is maintained inspite of submergence of area on such a massive scale. Otherwise the **social cost of large dams due to environmental degradation will become much larger than the social benefit.**

We will now just make a note of another problem, which is very much related to the former. Due to large reservoir created in big dams, displacement of large number of people, mostly tribals and weaker sections has occurred, creating untold misery to the oustees. By the late eighties a total of 1385273 people have been displaced due to submergence (Table-A.3.12). The figures are staggering in case of Kangsabati Kumari, Pong, Tungabhadra etc. Other than cash compensation for land and house submerged no compensation has been provided for loss of employment or disruption of livelihood. Land provided in the relocation sites are of inferior variety or unproductive. No effort has been given on the part of the government to minimize the loss of essentials of social, cultural and spiritual value. **If proper rehabilitation of the oustees are not made then the social cost of big dams may supersede the social benefit** and will lead to inefficient management of water resource through big dams.

3.5 Conclusion

From the discussion it is clear that there remains a lot of opportunities to exploit more surface water resource, as around 44% of ultimate irrigation potential has not been utilised. On the other hand, only around 30% of the groundwater potential is remaining to be created. It has been argued that due to biasness in government policy towards the minor irrigation creation of ultimate irrigation potential in major and medium irrigation has been low. This has also resulted in imbalance in exploitation of surface and groundwater resource. It has been seen that the utilization of created potential has been low but improving in India. These observations vary from state to state. The optimum policy should be to exploit the remaining water resource in an efficient manner. It has been observed that the performance of major and medium irrigation in utilization of created potential has been low in most of the states. But in some cases the performance is quite impressive. **So, we argue that if opportunity exists in exploitation of remaining water resource in a particular area and irrigation system is well managed in terms of utilization of created potential then it is better to look into the ways by which the unexploited resources can be tapped. On the other hand if system performance is poor then emphasis has to be given to better utilization of already created potential. There cannot be any general strategy of emphasizing on system**

performance in case of India. As the performance of irrigation systems and unutilised resource varies from state to state, **separate policy should be adopted for each and every state in managing water resource.** Irrigation has been a state subject. So, individual states are expected to take greater responsibility and frame policies that will be more commensurate to their needs to manage water resource efficiently.

Command Area Development Programmes (CADP) has been initiated in India from 1974-75 to manage irrigation water resource more efficiently. Different programmes such as Field Channel (FC), Field Drainage (FD), Land Levelling (LL) and Warabandi (WB) have been designed under CADP to bridge the gap between potential created and utilised. Progress has been observed in the CADP areas in narrowing down the gap through time. But the effect of FC, FD, LL and WB on utilisation of created potential has been found to be insignificant. Long duration of projects, lack of co-ordination between different on-farm development programmes, improper cropping pattern, lack of maintenance and inefficient operation of irrigation system have been cited as the reasons behind such low performance of FC, FD, LL and WB. CADP has also taken steps to reclaim waterlogged area in the command.

It has been observed that the social cost due to submergence of land and consequent displacement is staggeringly high, especially in the case of some individual projects. Efficient management of large irrigation systems also demand sufficient compensatory steps by the government and minimise the loss.

Creation of additional potential involves a huge cost. That is why the financial aspect of potential created is also important consideration in exploitation of remaining potential. That basic sustainability of major and medium irrigation and efficient management of the system in terms of utilization of potential created is also related to expenditure on operation and maintenance of the system. Cost recovery plays an important role in making provisions for working expenditure in operation and maintenance. All these financial aspects of management of water resource in major and medium irrigation has been discussed in the next chapter.

Chapter 4

Financial Aspects of Water Resource Management In Major And Medium Irrigation

Efficient management of water resource also entails efficient financial management of the infrastructure for water resource management. In this regard financial sustainability of irrigation projects is of paramount importance. During the colonial era investment in irrigation projects were considered only when a reasonable rate of financial return was obtainable after covering operating costs. In independent India this criteria was relaxed in the face of severe drought and famine. The Second Irrigation Commission recommended to examine the financial returns of the projects and accept a project if its financial return is more than 1.5. The Commission argued that the rule could be relaxed in favour of irrigation projects in the drought affected areas where a lower limit of unity may be accepted. During 1951 to 1990 more than Rs 600 billion (at 1988-89 prices) has been spent to create a huge canal irrigation network while direct financial recovery from these schemes was miserably Rs 3 billion (at 1988-89 prices). It has made capital investment a sunk cost. Moreover, resource obtained through direct cost recovery is only half for proper operation and maintenance (O&M) (Gulati, Svendsen, Roy Choudhury, 1995). This essentially leads to underperformence of irrigation system and ultimately inefficient water resource management. In this section we will first analyse the nature of public investment in irrigation and also its relation with cost of major & medium (M&M) irrigation projects. Revenue expenditure in M&M irrigation has important bearing on the system performance. Working expenditure in O&M expenditure has implications in utilization of created potential. We have discussed about revue expenditure in this regard. It has been argued that cost recovery in M&M irrigation positively influence the working expenditure. We will examine this hypothesis in this chapter.

4.1 Pattern of Capital Expenditure

Planning Commission provides information about capital expenditure on major and medium irrigation projects along with minor and Command Area Development (CAD) programmes. The nature and composition of capital expenditure has undergone an overall change during the plan periods. During the First Plan 85% of the expenditure has been made for M&M irrigation (Table-A.4.1). From the Second Plan expenditure on minor irrigation got importance. The share of M&M has declined from one Plan to another till the Fourth Plan. It has declined in the Fourth Plan to 51.6% but after that has increased and remained between 59% to 63% in different Plan periods. CAD programmes have started from the Fifth Plan and have absorbed 3% of total expenditure. Its share has increased to 7.7% during the Seventh Plan but has declined to 5.7% during the Eighth Plan. It should be mentioned in this context that the development of CAD programmes facilitates the functioning of the M&M projects. From the Annual Plan (1966-69) the share of minor irrigation has declined more or less constantly with a slight upward jump from Sixth to Seventh Plan. During the Eighth Plan 64% was spent on M&M, 30% on minor irrigation. After that during the Eighth Five Year Plan the share has declined marginally. So, from this discussion we can argue that expenditure on **M&M irrigation gets the highest prominence among all irrigation related expenditure but its share has declined considerably by 20% in Eighth Plan as compared to the First Plan.**

The expenditure on M&M irrigation has generally increased from one plan to another barring decline by a small margin between First to Second Plan (Table-A.4.2). It must be mentioned in this context that between First and Second Plan the growth rate of total plan expenditure in all sectors has been very high at 16.4%. The total capital expenditure has increased by a greater rate than the capital expenditure in M&M irrigation between two plan periods barring between Third and Fourth Plan as shown in Table-A.4.2. The growth rate of total plan expenditure in all sectors has been marginal between these two plans. Between Fourth and Sixth Plan expenditure in M&M irrigation has increased at best by 7.55%. The total growth of capital expenditure in all the sectors taken together is marginally higher at 9% between the same two plans. The difference between the growth rate of expenditure on M&M irrigation and all other sectors have widened again between Sixth and Seventh Plan. The growth rate of capital expenditure in M&M irrigation between First and Eighth Plan has been 3.03%, which is very close to 5.6% of growth rate of capital expenditure. So, from the above discussion it can be argued that **the growth rate of capital expenditure on all India basis has been less but very close to growth rate of capital expenditure in all the sectors in the long run but in the short run the growth rate of expenditure in M&M has been much less than that of in all other sectors.**

In states like Andhra Pradesh, Bihar, Karnataka and Tamil Nadu the capital expenditure in M&M irrigation as a percentage of total capital expenditure has increased in 1987-90 as compared to 1980-83 (Table-A.4.3). In other states we can observe the opposite scenario. In most of the states barring Goa, Gujarat, Haryana, Orissa and Punjab the percentage has declined in 1995-98 as compared to 1987-90. If we compare the two extreme years 1980-83 and 1995-98 then we will observe that excepting in Karnataka and Gujarat the percentage of capital expenditure M&M irrigation has declined in 1995-98 as compared to the earlier period. So, in the state level also we can observe that **barring a few states in most of the cases the capital expenditure in M&M irrigation as a percentage of total capital expenditure has continuously declined from 1980-83.**

Capital expenditure in M&M irrigation has declined in Haryana, Kerala, Orissa, Rajasthan and Uttar Pradesh in 1987-90 as compared to 1980-83 (Table-A.4.4). Rate of growth of capital expenditure in M&M irrigation has increased by a larger margin between 1987-90 and 1995-98 than between 1980-83 and 1987-90 in states like Gujarat, Karnataka, Maharastra and Punjab. In case of other states we have observed the opposite scenario. In almost half of the states like Andhra Pradesh, Bihar, Kerala, Madhya Pradesh, Maharastra, Rajasthan and Tamil Nadu the difference between the growth rate of capital expenditure between 1987-90 and 1995-98 in M&M irrigation and total capital expenditure has increased from the same between 1980-83 and 1987-90. In case of Punjab and Karnataka the growth rate of capital expenditure in M&M irrigation has been higher than the growth rate of total capital expenditure in both between 1980-83 and 1987-90 and between 1987-90 and 1995-98. During the second time interval the difference has widened. So in this case no general pattern can be discerned among the states. The **growth rate of capital expenditure in M&M and total capital expenditure show varying nature in different states.**

4.2 Cost of Major and Medium Irrigation

We will calculate the capital cost of M&M irrigation development by adjusting the capital expenditure to inflation rate, gestation lag that exists between the time investment is undertaken and the time irrigation potential is created. In adjusting to the inflation rate we will rather take a straightforward and general way of adjusting expenditure to Wholesale

Price Index (WPI) at 1985-86 prices. In case of adjusting to the gestation lag we will take the approach taken by Gulati, Svendsen and Roy Choudhury (1995). Gestation lag varies from project to project and also between major and medium projects. It even varies over time. For major irrigation projects the gestation lag may go upto 20 years but for medium irrigation projects the gestation lag varies between 5 to 7 years. In our case an average estimated gestation lag is needed for a state level analysis. We will take here an average gestation lag of 12 years. There is another important aspect associated with it. We have to take into account the social rate of discount, which gives us the value the society attaches to consumption now versus consumption at some time in the future. We will carry out our analysis at three different alternative social discounting rates as 5%, 7.5% and 10%. In calculating the expenditure with all these adjustments we will first convert the expenditure at current prices to 1985-86 constant prices. After that we will multiply the chosen social discount rate with expenditure at constant prices. If the expenditure at constant prices is E and social discount rate is e then the total value of expenditure after t gestation lag will become $E^* = E\ (1+e)\ t$. E^* is the expenditure which includes the value the society attaches to consumption now versus consumption after t periods. After completing all these adjustments we have divided the expenditures by potential created in each and every year. We will concentrate on the time period 1985 to 1996. In this section we will also go for a statewise analysis to look into the relation between the expenditure pattern and cost of M&M irrigation.

We will start our discussion with Andhra Pradesh. The capital cost of irrigation is higher here than the all India average (Table-A.4.5). The cost has increased to a massive 22.62% from 1985-88 to 1993-96. Though the cost of irrigation is high in this case, the capital expenditure in M&M irrigation has increased between 1985-88 and 1993-96 (Table-A.4.6). As a result 60.9% of ultimate irrigation potential has already been created. New potential creation might have increased the cost in this state.[1] The share of capital expenditure in M&M irrigation has declined in 1993-96 as compared to 1985-88. This implies that the importance of M&M irrigation has declined in total capital expenditure due to probably increase in cost and substantial potential creation.

[1] Gulati, Svendsen and Roy Choudhry are of the opinion that in western and southern regions of India as land is undulating cost of construction of canal networks has increased. Moreover, especially in northern and western regions drainage works, which are required for many large-scale projects to alleviate waterlogging and salinisation problems, increases the cost of mega projects.

In case of Assam we can observe that the cost of irrigation development is extremely low than the all India level.[2] Cost has also declined between the time periods under consideration. But the capital expenditure on the M&M has been low as a percentage of total state capital expenditure and it has declined between 1985-88 and 1993-96. Hugh potential has also remained unused. So, it seems that there has been a mismanagement of water resource in the state from financial point of view. Lot of new investment in this sector is needed.

The cost of irrigation in Gujarat was below average in 1985-88 but it went to above average level in 1993-96. The growth rate of cost has been 10.27%. It has been seen that the total expenditure on irrigation has increased. The state spends substantial proportion of total capital expenditure on M&M irrigation and the share has also increased marginally.

In case of Haryana during 1985-88 the cost was below average but it increased to the above average level in 1993-96. The reason may be that the capital expenditure on irrigation has declined along with its share in total capital expenditure in the state. Only around 30% of the ultimate potential has remained to be utilized. It may be the case that to exploit the remaining potential the state has to bear higher cost.

In Himachal Pradesh cost of irrigation is below average and has declined in 1993-96 as compared to 1985-88. Around 78% of the potential has remained to be utilized. Expenditure on irrigation has to increase in the state.

The cost of irrigation in Karnataka is below average but has increased. Total capital expenditure on M&M has also increased. The state spends a substantial proportion of its capital expenditure on M&M irrigation and the share has increased. Already, 66.6% of its potential has been exploited and so it may be the case that cost of irrigation has increased to exploit increasing potential.

Kerala is in a comfortable position as cost of irrigation has declined from the above average level during 1985-88 to a below average level during 1993-96. But the expenditure on M&M has increased by marginal amount. The state of M&M irrigation in total capital expenditure has been low and also declined in 1993-96 as compared to 1985-88. Around

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[2] Gulati, Svendsen and Roy Choudhry are of the opinion that the northern and eastern regions of India benefit from the flow of large rivers in the Indo-Gangetic Plain. So, the cost of irrigation is lower in this region than the western and southern regions.

50% of its potential has remained unutilized. So, from financial point of view there lies inefficiency in water resource management. Greater increase in expenditure in M&M irrigation and increase in share of M&M irrigation in total capital expenditure is likely for better future policy initiative.

In case of Madhya Pradesh cost of irrigation is below average and also has declined from 1985-88 to 1993-96. Total expenditure on M&M irrigation has declined along with its share. Around 62% of ultimate irrigation potential has not been created. So, the state should spend larger amounts to tap the remaining irrigation potential.

The capital cost of irrigation has increased in Maharastra and it is also higher than the average level in both 1985-88 and 1993-96. It has been observed that the expenditure on M&M in the state has increased but the share of M&M irrigation in total expenditure has declined sharply in 1993-96 as compared to 1985-88. Potential created as a percentage of ultimate irrigation potential has reached 57% in the state. Increasing cost for exploiting increasing potential may have led to increase in the capital expenditure in the state.

In case of Orissa cost of irrigation has declined from an above average to a below average level between 1985-88 and 1993-96. But capital expenditure of the state has declined. The share of M&M irrigation in total capital expenditure has also declined sharply. Around 57% of potential of the state is still unexploited. Increasing expenditure in M&M irrigation is suggested in this case.

It has been observed that in case of Punjab the cost of irrigation is low and has also declined by a massive 14.2%. Expenditure on capital in M&M has also increased by 12.2% in the state. It has already exploited 83.8 % of ultimate irrigation potential in M&M. Water management in M&M irrigation in the state is highly efficient from financial point of view.

. The cost of irrigation has been below average and has also declined in Rajasthan. Expenditure on M&M has also increased between 1985-88 and 1993-96. It has exploited 82.7% of its ultimate irrigation potential in M&M. This may have been the reason that the share of capital expenditure in M&M irrigation has declined in 1993-96 as compared to 1985-88. In this case also management of water resource in M&M irrigation is highly efficient from financial point of view.

In case of Uttar Pradesh the cost of irrigation is below average but has increased by a small margin. The expenditure on M&M irrigation has declined along with share of M&M in total capital expenditure. In this state 64% of ultimate irrigation potential has remained has remained unexploited. So, it can be argued that the remaining ultimate potential can be exploited in the state through increase in expenditure.

Cost of irrigation has declined in West Bengal from an above average level to an below average level. The capital expenditure of the state in M&M has increased only marginally. It has also been observed that 44% of ultimate irrigation potential has not still been created. So, the state is expected to exploit its remaining ultimate irrigation potential through further increase in expenditure.

From the above analysis we could see the relationship between capital cost of irrigation and expenditure. In states like Andhra Pradesh, Karnataka and Maharastra expenditure has increased probably due to rise in cost. In case of Assam, Kerala, Orissa and Madhya Pradesh though the cost of irrigation has declined but barring Kerala capital expenditure has not increased to exploit the remaining unexploited ultimate potential. In case of Kerala capital expenditure has increased only marginally. So, we can say that **in some cases there exists an inefficiency of water management in terms of tapping remaining ultimate irrigation potential from financial point of view.** Punjab and Rajasthan seems to be the most well managed state in this respect.

4.3 Revenue Expenditure

Revenue expenditure in all the states has increased during the period 1980-81 and 1997-98 (Table-A.4.7). The constant growth rate of revenue expenditure has been greater than that of capital expenditure in all the states barring Karnataka. Excepting Gujarat and Maharastra share of revenue expenditure on M&M in total revenue expenditure for all the states has declined in 1998-99 as compared to 1980-81 (Table-A.4.8). This implies that revenue expenditure is increasing but due to fiscal constraints or growing revenue expenditure in other sectors a smaller proportion of revenue is getting spent in 1998-99 as compared to 1980-81. Revenue expenditure on irrigation has an impact on its performance. It has been argued by the Committee of Ministers that the revenue expenditure or the operational and maintenance (O&M) or the working expenditure is an important factor in proper utilisation of created potential. It should be mentioned at this point that the revenue receipts in the form of cost recovery from M&M irrigation projects has been insufficient to cover the revenue expenditure. If we calculate the constant proportionate growth rate per period between 1976-77 and 1995-96 at 1980-81 prices then we will find that while working expenditure (WE) has increased by 6.81%, the increase in gross recovery (GR) has been insignificant (Table-4.1). This situation is unsustainable, more so in a situation of growing stress on the state budget as indicated by the falling share of revenue expenditure on M&M irrigation in total revenue expenditure of the state (Table-A.4.8).

Table: 4.1 Constant Proportionate Rate of Growth Per Period Between 1976-77 and 1995-96 (at 1980-81 constant prices)

	Capital Outlay	Gross Receipts	WorkingExpenses
B	0.013298	0.002099	0.065886
significance of t statistics	0	0.783	0
Growth	1.34	0.21	6.81

Source: Water and Related Statistics, CWC

The GR/hectare has increased in some states but it has remained substantially low than the WE. In most of the states only a small percentage of working expenses has been recovered. In 1975-76 at the all India level 91% of WE was recovered. It has now plummeted down to 10.4% in 1995-96 (Table-A.4.9). The scenario is more or less same in case of in all the states. In Gujarat, Haryana, Kerala, Madhya Pradesh, Punjab, Rajasthan and West Bengal the GR as a percentage of WE has declined continuously. In case of Andhra Pradesh, Karnataka, Maharastra, Orissa, Tamil Nadu and Uttar Pradesh this decline is also observable but with sudden upward jumps in-between. GR as a percentage of WE has increased in 1995-96 in Bihar as compared to 1990-91. This has been mainly due to the decline in the WE.

In a sustainable situation WE has to be covered by GR. Between 1987-90 and 1993-96 WE per hectare of potential utilisation has gone up by 1.91% while GR per hectare of potential utilization has gone up by a greater margin of 5.65% (Table-A.4.10). This buoyant situation is not prevalent in each and every state. In states like Andhra Pradesh, Bihar, Jammu and Kashmir, Maharastra, Tamil Nadu and Uttar Pradesh GR/hectare has increased by a greater percentage than the WE/hectare. In case of Bihar the WE/hectare has infact declined. In other states the GR/hectare has declined. In case of Gujarat and Punjab the GR/hectare has declined by a smaller margin than the decline in WE/hectare. GR/hectare has declined by a greater margin than the WE/hectare in Kerala and West Bengal. In Haryana, Karnataka, Madhya Pradesh, Orissa and Rajasthan GR/hectare have declined but WE/hectare has increased. So, there is no uniform relation between the growth of GR and WE. If we observe the difference between GR/hectare in 1987-90 and 1993-96 then we will see that this difference does not match with the difference between WE/ hectare in the two mentioned time periods (Table-A.4.11). If the two changed in the same direction then also we find a weak correspondence between the two variables. In many states like Bihar, Haryana, Karnataka, Madhya Pradesh, Orissa and Rajasthan the direction of change in WE/hectare and GR/hectare are different. So, the increase or decline in the GR is not well reflected in the WE. This gives us the idea that GR from irrigation is not well directed to the WE This is because of the fact that the irrigation development budgets are not well connected with the level of receipts generated by irrigation water charge (Gulati, Svendsen, Roy Choudhury). So, we can argue that **weak institutional framework often impairs the provisioning of WE through GR.** Increase in the GR can only weakly and indirectly affect the system efficiency through increase in the WE.

Another important factor, which should be mentioned in this section, is that the entire WE or O&M expenditure has not been fully directed to maintenance and repairs (M&R) works. Within O&M expenditure direction and establishment expenditure accounts for a major part and is increasing much faster than the outlay on M&R works. Moreover, the wages and salary component of M&R expenditure has risen sharply due to built-up of surplus staff and periodic salary revision (GOI, 1992). During the late eighties and early nineties an increase in the share of establishment has been observed in almost all the states (Table-A.4.12). The increment has been sharp in Maharastra and Uttar Pradesh. In Madhya Pradesh no such change has been observed. Gulati, Svendsen and Choudhury (1995) have also observed a similar upward trend in direction and administration in total operation and maintenance expenses. Also, in most of the states the share of establishment has been greater than the share of works. In Maharastra, Uttar Pradesh and West Bengal the share of works has been greater than the share of establishment in few years. In Madhya Pradesh share of works has been greater than share of establishment in all the years under observation. In Punjab the share of establishment has been much higher than the share of works. This paucity of fund for physical works has led to deterioration in the condition of the structure and the distribution networks (GOI, 1992).

4.4 Gross Recovery

Cost recovery in M&M irrigation projects has become an important issue in efficient management of irrigation system. If the cost recovered can be directed to WE then it will lead to improvement in system performance. Low irrigation water charges have been argued to be the single most important factor behind the low GR of M&M irrigation system (World Bank, 1998). Along with this, even higher WE also indirectly lead to higher GR. It has been argued that higher WE leads to better system performance which again leads to greater satisfaction on the part of the farmers. Greater satisfaction of the farmers again leads to better GR (World Bank, 1999). We will examine these arguments in this section.

Successive Finance Commissions, Vaidyanathan Committee Report on Pricing Irrigation Water (1992) and several other government documents has argued for at least full cost recovery (O&M) of M&M irrigation projects. According to the Comptroller and Auditor General (CAG) there are three types of expenditure of canal irrigation. They are (i) working expenditure of operating and maintaining canal works, (ii) interest payments on capital invested in canal works, and (iii) capital outlay. It is argued in different quarters that cost of canal irrigation has to be recovered through proper water charges. Full cost recovery is possible if and only if the benefits of canal irrigation exceed the cost. Here in this section we will examine whether the benefit of canal irrigation exceeds the cost in different states. Dhawan (1999) has calculated the book-value cost of canal irrigation by using the following expression:

$$TC = WE + r\,K + d\,K$$

Where TC = Total Cost

WE = annual working expenditure

K = cumulative capital outlay

r = rate of interest

d = depreciation rate

After 1987-88, separate information on (r.K) is not provided and has got added to WE. For simple calculation d is taken to be 1%. Gain from canal irrigation is calculated by subtracting the canal yield of rainfed land from the irrigated land, i.c,

Gain from canal irrigation = Canal irrigated yield – unirrigated yield

Information about irrigated yield is available for different crops separately and no information is available for canal irrigated yield. In this case for an approximate estimate of canal irrigated yield we will utilise the results obtained by Dhawan (1999) with the statistics for the period 1980-81 to 1992-93. Canal irrigation yield has been found to be lower than overall irrigated yield by 37% in Haryana, 34% in Tamil Nadu and 28% in Punjab. In Madhya Pradesh canal irrigated yield was found to be higher by 17% than the overall yield. In case of Uttar Praadesh, Bihar and Andhra Pradesh the yield differential is not significant. Using these results we have calculated the gain from canal irrigation for the states. Also, we have considered the yield of crops for which corresponding gross area irrigated is highest among different crops. Now, to convert the gain from canal irrigation from real (Kg/hectare) to monetary terms (Rs/hectare) we have multiplied the gain with the corresponding year's Minimum Support Price (MSP). The MSP for paddy has been Rs 270/quintal and for wheat it has been Rs 330/quintal in 1992-93. In this way we have calculated the TC and gain from canal irrigation. The comparison of TC and gain from canal irrigation along with the table is shown in Figure-1. Few abbreviations used in the calculation are as follows:

R-K = Rice in Kharif

R-W = Rice in Winter

R-A = Rice in Autumn

R-II C = Rice as II Crop

W = Wheat

In all cases the gain from canal irrigation is greater than TC. The difference between these two is highest in Madhya Pradesh and lowest in Bihar. So, **full recovery of total cost can be done in all the states we have considered, as gain from canal irrigation is always greater than total cost.** But this analysis has taken many approximations. A detail study in this respect is urgently needed. We have not considered the distribution of gain from canal irrigation among different farm sizes and amount of gain can be allowed to be retained. This aspect will be discussed later in this section.

Water rate in India is fixed according to consumptive need of crop. It is collected on the basis of area irrigated. It varies from state to state, project-to-project, crop to crop and also from one season to another season. Table-A.4.13 gives us an approximate picture of irrigation need and water rates for different crops for different states. Water rates are supposed to be fixed according to the irrigation depth, with water charges for crops needing higher irrigation depth will be higher and vice versa. According to that criterion we can observe that cotton is underpriced in Gujarat while oilseeds and coarse cereals are overpriced. In Karnataka Wheat is underpriced and oilseed is overpriced. Pulses are underpriced in Madhya Pradesh and wheat is overpriced in Orissa but it is underpriced in Punjab. In Uttar Pradesh cotton is underpriced and oilseeds is overpriced. **All these anomaly in pricing of irrigation water for different crops has implication for efficient management of irrigation water resource**. But in this context one should keep in mind that underpricing of irrigation water for foodgrain is supportable in the context of food security of the country.

We will now look into the relation between the GR, WE and water rates. Since water rates vary from project to project, crop to crop and season to season within a state we have calculated the simple average of water rates taking into consideration the minimum and the maximum rate (Table-A.4.14). We will regress gross recovery (GR) per hectare on working expenditure (WE) per hectare and water rate. In case of water rate we will take simple average (SA) of water rates, minimum water rate (MI) and the maximum water rate (MA) separately and construct three models. The models are as follows:-

Model I $GR = 25.8 + 0.045\ WE + 0.248\ SA$ $\quad R^2 = 0.823$

(0.356) (0.001) (0.051)

Model II $GR = 27.37 + 0.054\ WE + 1.04\ MI$ $\quad R^2 = 0.825$

(0.317) (0.00) (0.057)

Model III $GR = 27.58 + 0.045\ WE + 0.132\ MA$ $\quad R^2 = 0.818$

(0.328) (0.001) (0.073)

Detail results of the models are in Table-A.4.15. Each of these three models shows us that increase in GR is positively affects WE. This observation vindicates the argument of the World Bank that if system performance improves through increase in working expenditure in O&M then yield and income of the farmers will improve. This will lead to greater satisfaction of the farmers and larger gross recovery. Water charges play an important role in GR. All the three variables relating to water charges SA, MI and MA are significant. It may be noted at this point that increase in the minimum water charges influence the GR to the maximum extent among all three variables relating to water charges. In India water charges in some cases are abysmally low. **Increase in the water charges, specially existing lowest water rates will influence in increasing the GR.**

Implication of distribution of water among different size of farms

Dhawan (1999) has focused on the ability to pay of the farmers in full cost recovery of irrigation projects. He argues that while fixing the pitch of canal water charge two conditions (i) inter-farmer variation in the accrual of benefits of canal irrigation, and (ii) margin of benefit to be allowed to retain, has to be taken account of. This is important due to the fact that small farmers in India obtain less benefit than the large farmers. Retention of benefits also plays an important factor when the accrual of benefit to the small farmers is small. These distributional factors have to be kept in mind in case of full cost recovery when canal irrigation benefits exceed cost. He has suggested that canal irrigation tariff cannot be more than four-ninths of the mean value of unit benefits accruing to farmers due to canal irrigation. Vaidyanathan (1991) has also argued that large farmers have sufficient power in the rural economy to make the distribution of canal irrigation water in their favour. So, in determining the pitch of water charges distribution of benefits of canal water becomes more important than the average income benefits to all the farmers taken together. Dhawan has formulated a certain expression, which should be accounted in determining the pitch of water charge.

$$P = B\, f_1 (1 - f_2)$$

where P = maximum canal fee recoverable from farmers

B = mean value of income benefits due to canal irrigation

f_1 = small and marginal farmer's benefits relative to B

f_2 = retention margin of benefits allowed to small and marginal farmers

In this section we would consider the question of how the distribution of canal irrigation water and its benefit affects the cost recovery of the states.

National Sample Survey (NSS) 48th round provides us with the data on percentage distribution of net irrigated area by major source of irrigation for broad size-class of operational holding for each season separately and all seasons together. It also provides the estimated net irrigated area by different size classes. We have calculated the net canal irrigated area for different broad size class. Then we have calculated the correlation coefficient between the canal-irrigated area for broad size-class of operational holding and the average size of operational holding (Table-A.4.16). The average size for size class 0.002-0.20 hectare is 0.101 hectare, for size class 0.21-0.50 hectare is 0.355 hectare, for size class 0.51-1 hectare is 0.755 hectare, for size class 1.01-2 hectare is 1.505 hectare, for size class 2.01-4 hectare is 3.005 hectare, 4.01-10 hectare is 7.005 hectare and for size class 10.01 hectare and above is 15 hectare. We have then ranked the states according to the correlation coefficients for all season, Kharif season and Rabi Season separately and named the variable as RCAS (Rank of Correlation Coefficient Between Canal Irrigated Area For Different Farm Sizes and Size of Farm) (Table-A.4.17). We have also ranked states according to the GR/hectare for 1990-93 and named the variable as RGR. Then we have calculated the Spearman's rank correlation coefficient between RGR and RCAS for all seasons taken together, Kharif season and Rabi season. From Table-A.4.17 we can see that all the correlation coefficients are significant. This bears the implication that **if canal irrigated area in a state is more and more skewed in favour of the large farmers than GR/hectare will be higher**. This result is supportive of the observation made by Reddy (1998) in his study on Rajasthan where he has found that willingness and ability to pay for canal water charges increases with increasing size of farms in the endowed region. So, economic status of the farmers does matter in recovery of canal water changes. Dhawan (1994) in his study using the data of Farm Management Studies (FMS) has shown that in Maharastra and Uttar Pradesh as there has been a positive association between fertilizer application and farm size. So benefits from each unit of irrigated area has been positively associated with the farm size. If benefit from irrigation is positively associated with farm size then it is obvious that GR from canal irrigated land will be positively associated with size of the farm. The above mentioned study was done with 30 years back data. New micro level studies in this area are urgently needed when we are seriously concerned about the full cost recovery of irrigation projects.

4.5 Conclusion

From the above discussion it is clear that there prevails a situation of mismanagement in water resource from financial point of view. This issue is important in view of growing expenditure on M&M irrigation projects by the government. In some cases the expenditure on M&M irritation projects takes the major share of investment among all irrigation related expenditures. It also takes away a major share of total capital expenditure in many states. It has been observed that capital cost of the irrigation has declined in many states in recent times than earlier periods. Total capital expenditure on irrigation in many of these states has also declined with enough ultimate potential still to be utilized. This is one situation of mismanagement of water resource from financial point of view. The states should have increased expenditure to create new potential.

Here another important aspect is that in each and every state revenue expenditure on M&M irrigation projects is abysmally low. Revenue expenditure in M&M irrigation projects is important in the sense that working expenditure on O&M determines the efficiency of the system. Most of the irrigation projects in India are underperforming due to insufficient expenditure on O&M. In this context it should be noted that there has been a shift in emphasis from irrigation expansion to irrigation performance. In this regard reduction of capital expenditure on M&M irrigation and increase in expenditure in the revenue account seems to be logical. But a better policy could be continuation with expansionary irrigation policies where the capital cost is declining and a large percentage of ultimate irrigation potential has not been utilized. Along with this O&M expenditure has to increase by increasing gross recovery from beneficiaries of canal irrigation. But it has been observed the in all the states percentage of recovery of working expenses has declined in the mid-nineties as compared to mid-seventies and in many states it has even declined as compared to early nineties. Another important point is that the expenditure on repairs and maintenance works is getting less prominence than expenditure on establishment and the share of establishment in total O&M expenditure is showing an upward trend. Our suggestion is that as repairs and maintenance works is important determinant of system performance it should be brought within the capital expenditure.

Increase in recovery from M&M projects is imperative to make sufficient provision for working expenditure. Proper institutional mechanisms should be arranged so that gross recovery gets directed to working expenses. In this regard it is absolutely necessary to increase the low abysmal prices of water. Increase in working expenditure also improves the gross recovery. This is because increasing working expenditure in O&M improves system performance which inturn increases farmer satisfaction. Greater farmer satisfaction leads to larger recovery. Anomaly in water price fixation according to the consumptive need of the crops has also to be rectified. Full recovery of working expenditure, interest and depreciation is possible as the gain from canal irrigation is greater than the cost (barring capital cost) of providing it. But along with this it should to taken into consideration that the ability and willingness to pay for the small farmers are less than the large farmers. We have also found that in states where distribution of canal irrigated area is skewed towards the small farmers gross recovery is less. This is probably due to the reason that the benefit of canal irrigation accrues less to the small farmers than the large farmers. This is because other agricultural inputs are more easily available to the large farmers than the small farmers. An optimum policy initiative will be to make institutional changes for comprehensive development of the small farmers to wipe out the difference of benefits accruing to them and the large farmers.

Chapter 5

SUMMARY RESULTS AND CONCLUSION

In the whole discussion we have tried to look into the scenario of water management, especially the irrigation water management from different angles. We have at first considered the water resource sector as a whole. In **Chapter-2** we have seen that irrigation accounts for most of the water resource of the country. Within the next 50 years demand for water will increase in all the sectors. The maximum increase will be registered by the energy sectors. The importance of irrigation may decline in the coming 50 years but it will still absorb around 74% of the water resource in 2050 and it will continue to do so. The rice production absorbs a major part of irrigation water resource. The growth of demand for water will be maximum for sugarcane in the next twenty to twenty-five years.

The supply of water resource varies among the states of India. Water availability also differs in terms of inland and groundwater resource within a state. Rajasthan appears to be the most water stress state in the country. Generally the states in the hilly region are abundant with inland water resource. But these resources have not been properly exploited due to lack of proper storage facility. Ground water potential is also abundant in these states. Most of these states like have hardly exploited their groundwater resource for irrigation when it is largely available. Potential for well irrigation is also high in the eastern region. In our discussion we have observed that the abundance or scarcity of water among different states or even among different regions varies widely. We cannot comment generally about the water availability within the country and also within different regions. So, we have carried out our study at the state level. Had it been done at more local level we could have obtained a varying scenario within a state.

We have also observed that during the last one decade growth rate of well irrigation has been higher than that of canal irrigation. But canal irrigation also accounts for a substantial part of irrigation in India. If we look at state level scenario then we will find that balance between surface and groundwater in a state is hardly maintained. Again, a more micro level study may give us more pathetic picture.

We have observed that the irrigated area under sugarcane has declined in some of the water stress region and has increased in the relatively water abundant region during the nineties. The growth rate of area irrigated under wheat is substantially higher than rice in the nineties. These two observations implies that irrigation water resource has been well managed in India in the nineties as sugarcane is extremely water consuming crop and wheat is less water consuming. On the other hand during the eighties the area irrigated under non-food crops has increased more steeply than the area irrigated under food crops. This difference has narrowed in the nineties. Studies have to be done on a larger extent on the implication of this observation on the food security of the country.

The achievement of rural and urban drinking schemes in different states has been uneven. But one important point emerges from the observations is that new investment is needed in creating reservoirs in the hilly state and ground water has to be properly utilized in the eastern region of India.

Flood management in India has not at all been satisfactory as losses due to flood has increased in recent times. This has been due to increasing priority to irrigation and power generation. But the potentials for Hydro Electric power have not been properly developed, especially in the North -Eastern states. Proper exploitation of Hydro Power potentials is urgently needed to meet the demand in the near future.

Drought Prone Area Programme and Desert Development Programme have been initiated to manage drought by the government under the common guidelines of Watershed development. These programmes have also yielded benefits in scarcity and transition region.

A discussion on policies to manage water resource has been carried out in Chapter-2. What emerges out in the discussion is that there has been a shift in the emphasis from expansionary to efficient management of water resource since the Fourth Five Year Plan. System performance got paramount importance in this regard. Command Area Development Programme (CADP) has been introduced from the Fifth Five Year Plan. Under CADP system performance was supposed to improve through development of field channel, field drainage, landlevelling and introduction of Warabandi facility. But till the Sixth Five year Plan, system performance and sector's management got less importance. Efficient water management and proper maintenance of irrigation infrastructure was emphasized in the New Water Policy (1987). Restructuring management of irrigation systems and Participatory Irrigation Management has been suggested. In the Eighth and Ninth Five Year Plan importance was given to early completion of ongoing projects, modernisation and improvement of older irrigation system. Here we should add that in managing surface water resource efficiently creation of new potentials also plays an important role in the face of growing demand for water in all the sectors. It is true that the improvement in the performance of the already created system will cater to the increasing demand but the situation of underperformance may not exist to the same extent in each and every state or even at a more local level. In that case expansionary policy may help in tapping the runoff in areas where the system performance is more or less satisfactory.

In **Chapter–3** we have got results that we actually anticipated. We have observed that in many cases lot of ultimate irrigation potential in M&M irrigation has to be created and the system performance in terms of utilization of created potential is not unimpressive. In many states like Andhra Pradesh, Goa, Kerala, Orissa, Punjab, Rajasthan, Tamil Nadu, Tripura and West Bengal, utilization of created potential is above 90%. There has been varying picture among states in terms of potential creation. In case of many states the only a small percentage of ultimate irrigation potential has been created and in some cases almost entire ultimate irrigation potential has been created. We could find that importance of the government to the minor irrigation has resulted in creation of only 56% of ultimate potential in M&M irrigation. This has also resulted in imbalance in exploitation of groundwater and surface water resources. Till the end of Eighth Plan 38.7% of the total potential has been created in major and medium irrigation while the rest has been created in minor irrigation works. So, we argue that new potential has to be created in M&M irrigation sector where performance of the system is more or less impressive. But in this context it should be kept in mind that the social cost of submergence of land, displacement of people has to be reduced through government initiative. If the performance is below par then emphasis has to be given to efficiently utilise the already created potential. Command Area Development Programmes in this regard has to be made more efficient. Till 1994-95 its effect on utilization of potential created has been insignificant.

It has been observed in **Chapter-4** that capital cost of M&M irrigation is lumpy. Many states of India spend around 50% of their total capital in M&M irrigation. The capital expenditure in M&M irrigation has declined in many cases, especially during 1987-90 and 1995-98. Their share in total capital expenditure has also declined in many cases during 1995-98 as compared to 1980-83. It has been observed that in several cases the capital cost of irrigation has declined between 1985-88 and 1993-96. But the capital expenditure in M&M irrigation has also declined during the same time while lot of ultimate potential has not still been created. This means that the states did not to take the advantage of falling cost of irrigation. This type of expenditure pattern on the part of the states leads to inefficient management of major and medium irrigation water resource from financial point of view.

Revenue expenditure in M&M irrigation projects is important consideration in the sense that working expenditure on O&M determines the efficiency of the system. Though revenue expenditure has increased at the statelevel but revenue expenditure or working expenditure per unit of potential utilized has declined in many states during 1993-96 as compared to 1987-90. It has been suggested that working expenditure has to be increased through increase in gross recovery. It has been observed that percentage recovery of working expenses through gross receipts has declined more or less continuously in the states from mid-seventies to early nineties. During the mid nineties it has increased in many states. Also, gross recovery per unit of potential utilized in many states has declined during 1993-96 as compared to 1987-90. Moreover, gross recovery is not well directed to meet the working expenditure. We have observed that increase in the gross recovery is very much possible by increase in the water charges, especially in the minimum water charges. It should be noted here that in India water charges are fixed according to consumptive need of the crops. It has been observed in the study that high water consuming crops are priced comparatively low and low water consuming crops are priced comparatively high. Increase in working expenditure also improves the gross recovery. This is because the increasing working expenditure in O&M improves system performance which inturn increases farmer satisfaction. Greater farmer satisfaction leads to larger recovery. Full recovery of working expenses, interest charge and depreciation has to be done, as the average gain from canal irrigation is more than the cost. But while fixing the pitch of water charge it should kept in mind that the small farmers derive less benefit than the large farmers but they retain higher benefit than the large farmers. We have also observed that gross recovery from M&M irrigation is inversely related to the distribution of irrigated land to the small farmers. Institutional change is urgently needed in this regard so that the difference between benefits derived by the small and large farmers gets narrowed down. In this regard we would further argue that participatory irrigation management has to be encouraged so that the benefits from irrigation improves and equity is maintained in deriving benefits. In the Chapter-2 we have noticed that participatory irrigation management through water users association is concentrated in one or two states and its level of operation in all the states is low. Full-scale water users association has hardly been formed in any parts of India.

From the above discussion it is clear that the problem and prospects of irrigation and water resource as a whole varies from one state to another. There are some common prescriptions in water resource management in M&M irrigation but large part of policies should vary from one state to another. Among the major common policy prescriptions, the improvement of system performance comes at the first place. This is possible through increase in working expenses and also satisfactory execution of Command Area Development Programme. Keeping the fiscal constraints of the states in mind we can argue that working expenses of the states can be increased through increase in gross recovery in M&M irrigation. But gross recovery per hectare of potential utilised in all the states are presently low and much less than working expenditure per hectare. So, we argue that gross recovery in all the states has to be increased. Participatory irrigation management may play a significant role in this regard. Full scale water users association has to be formed in each and every state. The policy prescription regarding mainly potential creation differs from one state to another. A shift in emphasis from expansionary policy to system efficiency may not hold good in every state. We have observed that per year potential creation has declined in almost each and every state during 1985-88 as compared to 1993-96 (Table-A.5.1). This type of situation may not commensurate to the situation when total demand for water in the country will grow at a rate of 2.2% between 2000 and 2025. That is why we argue that separate policies are needed to manage the M&M irrigation water resource in different states. We have made an effort to delineate some of the policy prescription state wise in the remaining part of this chapter.

In **Andhra Pradesh** only around 39% of net cropped area is irrigated. So there is demand for irrigation in the state. Around 40% of ultimate irrigation potential in M&M irrigation has not been still utilized in this state. More than 90% of the potential created in the state has been utilized. But as capital cost is comparatively high and has increased by 22.6% between 1985-88 and 1993-96. The capital expenditure on M&M irrigation of the state has increased due to new potential created and rising cost. It must be mentioned that potential creation per year has declined by 29% in 1993-96 as compared to 1985-88. This may be due to raising cost. New potential creation in the state can be carried out at slow pace. System performance has to be improved in the state to fully utilize the potential created to increase the water available for utilization. But it is clear that the logic of shift in emphasis does not hold in this case.

In case of **Assam** only 20% of net cropped area is irrigated and 80% of its ultimate potential in M&M irrigation has not been created. The performance of the system in terms of utilization of created potential is miserably bad. The capital cost of irrigation is low and it has also declined. But capital expenditure in M&M irrigation has also declined. This is due to the decline in potential creation per year by 25%. So, in case of this state we can see an utter mismanagement of water resource both from physical and financial characteristics. We must mention here that government policy has exempted North-Eastern states from contributing in gross recovery. This may have led to this kind of situation. At first performance of the irrigation system has to improve. Otherwise the capital already invested will become a sunk cost. New potential creation in the state can be carried out at slow pace.

Around half of the net cropped area in **Bihar** is out of irrigation facility. More than 50% of ultimate irrigation potential has not been utilized in the state. System performance in the state is also not good. The capital cost of irrigation is also high in the state. So, given this situation the state should take steps for the improvement in system performance rather than new potential creation.

System performance is below satisfactory level in **Gujarat**. Capital cost of the state is also high and remaining potential is also low in the state. So, at the first place policies should be formulated to increase the utilization of potential created to irrigate the 70% of unirrigated area. Potential creation at slow rate can continue in this state.

In case of **Haryana** 77% of net cropped area is under irrigation. In this state 70% of ultimate irrigation potential has been utilized. Utilisation of created potential is around 88.2% in the state. Cost of capital in the state is high and has also increased between 1985-88 and 1993-96. Due to rising cost capital expenditure and potential creation per year has also declined. The state should concentrate on better utilization of the potential already created rather than on new potential creation.

Capital cost of irrigation is low and has also declined in **Himachal Pradesh**. Though less than 20% of net cropped area is irrigated and huge amount of potential has remained unutilized. As utilization of potential created is abysmally low in the state better utilization of created potential can make more water resource available for utilization. New potential creation has to come at the second place.

In **Jammu and Kashmir** capital cost of irrigation development is high but utilization of created potential is quite low. So the best policy for the state is to emphasise on better utilization of created potential rather than new potential creation.

Only about 22% of net cropped area in the state is irrigated in **Karnataka**. The capital cost of irrigation development is low and 34% of ultimate irrigation potential in M&M irrigation has not been created. But the system performance is also below par. So the state has to take steps to increase the utilization of the M&M irrigation potential created at the first place. New potential creation can come at the second place.

In case of **Kerala** only 15% of net cropped area is irrigated. Around 50% of ultimate irrigation potential of the state in M&M irrigation has not been created till the Eighth Five Year Plan. In this state 90% of potential created in M&M irrigation has been utilized. The capital cost of irrigation is comparatively low and has also declined. It is observed that potential creation per year has declined by 6.3% in this state. Policies in the state should be designed to increase potential creation per year. Performance of the system has to be maintained or even improved in the state.

Within the total net cropped area 30% of the area is irrigated in **Madhya Pradesh**. A huge amount of ultimate irrigation potential has remained to be utilized and capital cost of irrigation is low. System performance is low in the state, as only 70% of potential created has been utilized. State policies should emphasize to utilize the created potential to a greater extent rather than to create new potentials.

In case of **Manipur** also policies should emphasize to utilize more potentilal already created. The capital cost of irrigation is also high in the state.

System performance in **Orissa** is reasonably satisfactory. Only 33% of net cropped area is irrigated in the state and more than 50% of ultimate irrigation potential has not been utilized. The capital cost of irrigation is also low in the state. So, state policies has to be directed to create more irrigation potential per year. The logic of shift in emphasis does not hold in this case.

In case of **Punjab** 93% of net cropped area is irrigated and 84% of ultimate irrigation potential has been created. As almost the entire potential created in M&M irrigation has been utilized in the state and capital cost of irrigation is low the state policies should concentrate on creation of further potential per year. It can be noted here that further potential creation is needed in the state to arrest overexploitation of groundwater. Moreover, potential created in the state can be used to serve other adjoining areas through water transfer. The logic of shift in emphasis also does not hold in this case.

Though only around 30% of net cropped area is irrigated in **Rajasthan** but only around 16% of ultimate irrigation potential has remained to be created in the state. As system performance is satisfactory, further increase in potential creation per year can be initiated in the state to exploit the remaining ultimate irrigation potential. Any shift in emphasis from expansionary to system performance is unreasonable in this case.

In case of **Tamil Nadu** almost all ultimate irrigation potential has been utilized and full potential created in the state has been utilized. This is the reason that potential creation per year has fallen by 29% in 1993-96 as compared to 1985-88. It is to be taken care of that the existing impressive system performance of the state is maintained.

Only 2% of ultimate irrigation potential has been utilized in **Tripura** and only 12.6% of net cropped area has been irrigated in the state. The system performance in the state is too much impressive. But the potential creation per year has declined in the state in 1985-88 as compared to 1993-96. So, potential creation per year has to be accelerated in the state. Shift in emphasis from expansionary to system performance is not at all needed.

In **Uttar Pradesh** around 33% of net irrigated area is not under irrigation and around 44% of the ultimate irrigation potential has not been utilized. Capital cost of irrigation is comparatively low. But the system performance of the state is not satisfactory. So, in the first place improvement of system performance has to be emphasized and then attention could be given to new potential creation.

West Bengal is a state where system performance is satisfactory and lot of ultimate irrigation potential has still remained to be created. Capital cost of irrigation is also low in the state. This may be the reason that potential creation per year has increased by 6.8% in the state between 1985-88 and 1993-96. The state has to continue with high margin of potential creation per year. In this case also the logic of shift in emphasis does not hold.

From the above discussion it is clear that if we carry out our study at the local level then expansionary irrigation policy becomes logical in many cases. In states like Andhra

Pradesh, Kerala, Orissa, Punjab, Rajasthan, Tamil Nadu, Tripura and West Bengal the logic of shift in emphasis from expansionary to system performance to utilise more potentials does not hold. Further, in most of these states potential creation per year has to increase to meet the growing demand for water. It is true that in all the states gross recovery per unit of working expenditure is low. To tackle this problem we have to take different measure rather than reducing the speed of potential creation. Gross recovery can be increased by encouraging participatory irrigation management. It will also increase system performance through greater provisioning of working expenditure. Low rate of gross recovery should not be used as logic for thwarting public investment in M&M irrigation.

Lastly we should admit that this study has many limitations. At the first place we have not taken into account the topographical and geographical conditions explicitly. While it has been argued that study has to be done and policies has to be framed at local level but we have carried out our study at the state level. Moreover, due to non-availability of recent data we could not take the recent picture under consideration. Moreover, any study on M&M irrigation projects has to consider explicitly the demand for water for Hydro Power electricity generation, drinking water, industrial use, rural and urban use etc. These issues has not been dealt with sufficient importance. Another important aspect in case of M&M irrigation is its effect on environment and human habitat. The institutional aspect of water resource management has also not been given due importance. Further study in this area has to integrate all these aspect and look into the problem at more local level, preferably basin or sub-basin level.

Appendix Tables

Table: A.2.1 Percentage of Net Area Under Irrigation-By Sources (1985-86)

State	Government Canal	Private Canal	Tanks	Wells	Other Sources	Irrigation Intensity	Cropping Intensity	% Irrigated of Net Cropped Area	% Irrigate of Gros Croppe Area
Andhra Pradesh	50.40	0.00	22.22	24.19	3.19	1.23	1.16	33.93	35.84
Arunachal Pradesh	0.00	0.00	0.00	0.00	100.00	1.05			
Assam	12.41	50.87	0.00	0.00	36.71	1.00	1.40	21.14	15.08
Bihar	34.65	0.00	4.31	37.25	23.79	1.36	1.37	36.47	36.31
Gujarat	21.53	0.00	1.81	76.49	0.18	1.23	1.01	23.61	28.89
Haryana	52.82	0.00	0.04	46.82	0.31	1.64	1.55	61.89	65.67
Himachal Pradesh	7.29	0.00	0.00	4.17	88.54	1.76	1.67	16.47	17.35
Jammu &Kashmir	39.35	53.87	0.97	1.29	4.52	1.36	1.41	42.35	41.07
Karnataka	43.88	0.00	14.45	28.72	12.96	1.20	1.10	16.47	18.05
Kerala	32.43	1.35	14.86	12.84	38.51	1.35	1.31	13.51	13.92
Madhya Pradesh	42.75	0.07	4.90	43.86	8.42	1.04	1.19	15.23	13.42
Maharastra	20.52	1.28	14.94	56.51	6.75	1.31	1.13	10.34	11.99
Manipur	0.00	0.00	0.00	0.00	100.00	1.15	1.31	46.43	40.98
Meghalaya	0.00	0.00	0.00	0.00	100.00	1.02	1.10	25.91	24.06
Mizoram	0.00	0.00	0.00	0.00	100.00	1.00			
Nagaland	0.00	0.00	0.00	0.00	100.00	7.25	1.07	4.35	29.44
Orissa	50.99	0.00	13.99	35.03	0.00	1.29	1.46	26.46	23.32
Punjab	38.27	0.00	0.00	61.63	0.11	1.77	1.71	87.92	91.00
Rajasthan	37.12	0.00	2.70	59.54	0.64	1.24	1.17	19.98	21.30
Sikkim	0.00	0.00	0.00	0.00	100.00	1.00	1.41	16.84	11.94
Tamil Nadu	30.95	0.00	26.87	41.18	1.00	1.30	1.20	43.88	47.51
Tripura	0.00	0.00	0.00	0.00	100.00	1.41	1.65	11.33	9.69
Uttar Pradesh	33.71	0.00	1.54	61.55	3.20	1.23	1.45	57.28	48.63
West Bengal	37.52	0.00	13.76	37.26	11.46	1.00	1.50	35.78	23.93
Total	36.9	1.17	7.38	48.3	6.226	1.3	1.3	29.6	30.5

Source: Statistical Abstract of India

Table: A.2.2 Percentage of Net Area Under Irrigation-By Sources (1990-91)

State	Government Canal	Private Canal	Tanks	Wells	Other Sources	Irrigation Intensity	Cropping Intensity	% Irrigated of Net Cropped Area	% Irrigatc of Gros Croppe Area
Andhra Pradesh	43.40	0.00	22.48	30.27	3.85	1.25	1.20	39.06	40.70
Arunachal Pradesh	0.00	0.00	0.00	0.00	100.00	1.04		20.76	13.05
Assam	12.55	50.82	0.00	0.00	36.63	1.00	1.41	21.14	15.02
Bihar	32.57	0.00	3.44	45.39	18.61	1.25	1.36	43.45	39.98
Gujarat	19.41	0.00	1.29	79.18	0.12	1.19	1.14	26.22	27.51
Haryana	51.43	0.00	0.02	48.00	0.55	1.63	1.66	72.71	71.58
Himachal Pradesh	7.64	15.78	1.41	3.82	71.36	1.68	1.69	17.07	16.96
Jammu &Kashmir	40.46	53.00	0.67	0.44	5.43	1.46	1.46	40.80	40.90
Karnataka	40.79	0.00	11.35	33.77	14.09	1.23	1.13	20.36	22.10
Kerala	31.28	1.11	14.67	19.71	33.23	1.15	1.34	14.84	12.69
Madhya Pradesh	35.56	0.05	3.65	49.75	11.00	1.03	1.22	22.06	18.55
Maharastra	37.40	0.00	0.00	62.60	0.00	1.24	1.18	14.39	15.18
Manipur	0.00	0.00	0.00	0.00	100.00	1.15	1.44	46.64	37.20
Meghalaya	0.00	0.00	0.00	0.00	100.00	1.02	1.19	22.87	19.56
Mizoram	0.00	0.00	0.00	0.00	100.00	1.00		12.50	9.64
Nagaland	0.00	0.00	0.00	0.00	100.00	1.02	1.11	31.02	28.61
Orissa	46.73	0.00	14.95	38.32	0.00	1.20	1.52	30.68	24.12
Punjab	38.82	0.24	0.00	57.12	3.83	1.80	1.78	92.71	94.05
Rajasthan	34.67	0.00	4.72	59.97	0.64	1.19	1.18	23.84	24.00
Sikkim	0.00	0.00	0.00	0.00	100.00	1.00	1.57	16.88	10.77
Tamil Nadu	32.40	0.03	22.37	44.61	0.59	1.22	1.19	42.53	43.64
Tripura	64.80	0.00	16.00	15.20	4.00	1.00	1.67	18.04	10.82
Uttar Pradesh	30.29	0.00	0.99	65.77	2.95	1.40	1.47	60.94	57.97
West Bengal	37.53	0.00	13.77	37.25	11.45	1.30	1.62	35.83	28.76
Total	35.4	1	6.14	51.4	6.115	1.3	1.3	33.6	34

Source: Same as Table-A.2.1

Table: A.2.3 Percentage of Net Area Under Irrigation-By Sources (1995-96)

State	Government Canal	Private Canal	Tanks	Wells	Other Sources	Irrigation Intensity	Cropping Intensity	% Irrigated of Net Cropped Area	% Irrigate of Gros Croppe Area
Andhra Pradesh	37.33	0.00	18.12	40.16	4.39	1.29	1.23	38.76	40.67
Arunachal Pradesh	0.00	0.00	0.00	0.00	100.00	1.00		19.46	14.75
Assam	12.41	50.87	0.00	0.00	36.71	1.00	1.43	20.72	14.53
Bihar	29.86	0.00	3.80	49.57	16.77	1.24	1.37	50.27	45.72
Gujarat	19.81	0.00	1.17	79.02	0.27	1.22	1.05	31.16	36.25
Haryana	49.80	0.00	0.04	49.00	1.16	1.66	1.67	76.99	76.87
Himachal Pradesh	3.96	0.00	0.99	11.88	83.17	1.76	1.71	17.78	18.31
Jammu &Kashmir	34.72	59.59	0.52	0.52	4.66	1.14	1.46	52.59	41.01
Karnataka	41.27	0.00	9.99	34.75	13.99	1.24	1.15	22.09	23.79
Kerala	30.12	1.17	14.33	21.35	33.04	1.36	1.35	15.10	15.20
Madhya Pradesh	30.28	0.02	3.46	53.44	12.80	1.04	1.27	30.01	24.67
Maharastra	19.75	1.21	14.37	61.20	3.47	1.23	1.19	14.33	14.77
Manipur	0.00	0.00	0.00	0.00	100.00	1.15	1.30	46.43	41.21
Meghalaya	0.00	0.00	0.00	0.00	100.00	1.00	1.20	21.84	18.22
Mizoram	100.00	0.00	0.00	0.00	0.00	1.29		6.42	8.26
Nagaland	0.00	0.00	0.00	0.00	100.00	1.16	1.08	29.38	31.58
Orissa	45.41	0.00	14.59	40.00	0.00	1.26	1.56	33.66	27.22
Punjab	35.25	0.00	0.00	61.27	3.48	1.92	1.87	92.95	95.16
Rajasthan	28.61	0.00	3.61	66.90	0.88	1.22	1.19	31.57	32.34
Sikkim	0.00	0.00	0.00	0.00	100.00	1.00	1.49	16.84	11.27
Tamil Nadu	29.33	0.04	19.50	50.55	0.57	1.21	1.17	49.14	50.79
Tripura	60.00	0.00	14.29	11.43	14.29	1.71	1.54	12.64	14.08
Uttar Pradesh	26.34	0.00	0.50	69.90	3.26	1.45	1.48	67.10	65.80
West Bengal	37.52	0.00	13.76	37.26	11.46	1.30	1.64	34.99	27.76
Total	31.01	1.04	5.83	55.7	6.474	1.3	1.3	37.6	38.3

Source: Same as Table-A.2.1

Table: A.2.4 Growth Rate Of Net Area Under Irrigation-By Sources Between 1985-86 &1990-91

State	Government Canal	Private Canal	Tanks	Wells	Other Sources	Net Irrigated Area	Gross Irrigated Area	Net area sown	Gros area sown
Andhra Pradesh	0.94		4.25	8.77	7.94	4.00	4.36	1.12	1.74
Arunachal Pradesh					7.10	7.10	6.96		
Assam	0.22	-0.02			-0.05	0.00	0.00	0.00	0.07
Bihar	2.30		-0.99	7.75	-1.39	3.57	1.88	0.01	-0.06
Gujarat	-0.66		-5.20	2.13	-6.23	1.42	0.80	-0.68	1.79
Haryana	2.51		-9.71	3.57	15.36	3.06	2.87	-0.21	1.11
Himachal Pradesh	1.66			-1.02	-3.54	0.72	-0.26	-0.01	0.20
Jammu &Kashmir	-0.23	-1.10	-7.79	-20.13	2.96	-0.78	0.61	-0.04	0.70
Karnataka	3.24		-0.18	8.21	6.53	4.76	5.25	0.41	1.08
Kerala	1.67	-1.55	2.13	11.57	-0.57	2.41	-0.80	0.50	1.05
Madhya Pradesh	3.95	0.00	1.65	10.60	13.76	7.85	7.49	0.15	0.74
Maharastra	20.95			9.48		7.27	6.15	0.41	1.26
Manipur					0.09	0.09	-0.05	0.00	1.90
Meghalaya					-1.57	-1.57	-1.62	0.92	2.54
Mizoram					0.25	0.25	0.25		
Nagaland					49.08	49.08	0.75	0.63	1.32
Orissa	1.16		4.32	4.81		2.94	1.40	-0.06	0.71
Punjab	1.46			-0.36	106.34	1.16	1.61	0.10	0.94
Rajasthan	3.24		17.03	4.81	4.40	4.66	3.79	1.02	1.33
Sikkim					0.00	0.00	0.00	-0.04	2.09
Tamil Nadu	-0.13		-4.60	0.55	-10.95	-1.05	-2.23	-0.43	-0.56
Tripura					-41.42	11.51	4.05	1.60	1.78
Uttar Pradesh	-0.84		-7.24	2.66	-0.29	1.31	3.99	0.06	0.40
West Bengal	0.01		0.01	-0.01	-0.02	0.00	5.45	-0.03	1.64
Total	2.01	-0.33	-0.83	4.14	2.51	2.88	3.21	0.29	0.96

Source: Same as Table-A.2.1

Table: A.2.5 Growth Rate Of Net Area Under Irrigation-By Sources Between 1990-91 & 1995-96

State	Government Canal	Private Canal	Tanks	Wells	Other Sources	Net Irrigated Area	Gross Irrigated Area	Net area sown	Gross area sown
Andhra Pradesh	-3.80		-5.05	4.91	1.79	-0.86	-0.25	-0.71	-0.23
Arunachal Pradesh					3.04	3.04	2.26	4.38	-0.22
Assam	-0.22	0.02			0.05	0.00	0.00	0.40	0.68
Bihar	0.17		3.99	3.73	-0.18	1.92	1.79	-1.01	-0.91
Gujarat	4.62		2.19	4.16	22.50	4.20	4.66	0.66	-0.96
Haryana	0.57		10.76	1.63	17.48	1.21	1.62	0.06	0.19
Himachal Pradesh	-12.05		-6.51	25.86	3.42	0.30	1.31	-0.51	-0.24
Jammu &Kashmir	2.13	7.80	0.00	9.00	2.13	5.30	0.18	0.09	0.13
Karnataka	1.96		-0.83	2.31	1.58	1.73	1.83	0.08	0.34
Kerala	-0.25	1.57	0.04	2.13	0.39	0.51	3.98	0.16	0.30
Madhya Pradesh	3.19	-12.94	5.43	8.10	9.85	6.56	6.88	0.20	0.95
Maharastra	-12.69			-1.24		-0.79	-1.04	-0.71	-0.49
Manipur					-0.09	-0.09	0.05	0.00	-1.98
Meghalaya					-0.52	-0.52	-0.87	0.39	0.55
Mizoram						-2.88	2.13	10.96	5.35
Nagaland					1.03	1.03	3.64	2.13	1.62
Orissa	0.98		1.08	2.44		1.56	2.58	-0.30	0.13
Punjab	-2.23			1.08	-2.18	-0.32	0.90	-23.03	0.66
Rajasthan	2.04		0.49	8.38	13.15	6.03	6.46	0.24	0.30
Sikkim					0.00	0.00	0.00	0.04	-0.90
Tamil Nadu	0.03	10.76	-0.72	4.63	1.39	2.04	1.92	-0.86	-1.13
Tripura	-8.31		-8.97	-12.05	20.11	-6.89	3.71	-0.01	-1.61
Uttar Pradesh	-0.75		-11.09	3.31	4.11	2.06	2.82	0.11	0.24
West Bengal	-0.01		-0.01	0.01	0.02	0.00	-0.01	0.48	0.70
Total	-0.47	3.06	1.11	3.83	3.35	2.18	2.48	-0.52	0.08

Source: Same as Table-A.2.1

Table: A.2.6 Growth Rate Of Net Area Under Irrigation-By Sources Between 1985-86 &1995-96

State	Government Canal	Private Canal	Tanks	Wells	Other Sources	Net Irrigated Area	Gross Irrigated Area	Net area sown	Gross area sown
Andhra Pradesh	-1.46		-0.51	6.82	4.82	1.54	2.03	0.20	0.75
Arunachal Pradesh					5.05	5.05	4.58		
Assam	0.00	0.00			0.00	0.00	0.00	0.20	0.37
Bihar	1.23		1.47	5.72	-0.79	2.74	1.84	-0.50	-0.48
Gujarat	1.95		-1.57	3.14	7.18	2.80	2.71	-0.01	0.40
Haryana	1.53		0.00	2.60	16.41	2.13	2.24	-0.07	0.65
Himachal Pradesh	-5.44			11.61	-0.12	0.51	0.52	-0.26	-0.02
Jammu &Kashmir	0.94	3.25	-3.97	-6.70	2.54	2.22	0.39	0.03	0.41
Karnataka	2.60		-0.51	5.22	4.03	3.23	3.53	0.24	0.71
Kerala	0.71	0.00	1.08	6.75	-0.09	1.45	1.56	0.33	0.68
Madhya Pradesh	3.57	-6.70	3.52	9.34	11.79	7.20	7.18	0.17	0.85
Maharastra	2.76	2.59	2.76	3.98	-3.49	3.16	2.49	-0.15	0.38
Manipur					0.00	0.00	0.00	0.00	-0.05
Meghalaya					-1.05	-1.05	-1.24	0.65	1.54
Mizoram					-100.00	-1.33	1.18		
Nagaland					22.72	22.72	2.19	1.38	1.47
Orissa	1.07		2.69	3.62		2.25	1.99	-0.18	0.42
Punjab	-0.40			0.36	42.07	0.42	1.25	-12.23	0.80
Rajasthan	2.64		8.45	6.58	8.69	5.34	5.11	0.63	0.82
Sikkim					0.00	0.00	0.00	0.00	0.58
Tamil Nadu	-0.05		-2.68	2.57	-4.98	0.49	-0.18	-0.64	-0.84
Tripura					-16.12	1.90	3.88	0.79	0.07
Uttar Pradesh	-0.79		-9.18	2.99	1.89	1.68	3.40	0.09	0.32
West Bengal	0.00		0.00	0.00	0.00	0.00	2.69	0.22	1.17
Total	0.76	1.35	0.14	3.99	2.93	2.53	2.84	-0.12	0.52

Source: Same as Table-A.2.1

Table: A.2.7 Percentage of Crops Gross Irrigated (1985-86)

State	Rice	Jowar	Bajra	Maize	Wheat	Barley	Other cereals & Pulses)	Sugarcane	Other food Crops	Total Food-Crops	Cotton	Other non-food crop	Total Non-Food Crops
Andhra Pradesh	74.9	0.4	0.8	1.2	0.21	0	1.7	3.8	6.4	89.3	2	8.69	10.7
Arunachal Pradesh	100	0	0	0	0	0	0	0	0	100	0	0	0
Assam	93	0	0	0	0	0	1	0	0.2	94.2	0	5.77	5.77
Bihar	50.1	0	0	5.3	37.9	0.3	0.6	0.6	4.4	99.2	0	0.81	0.81
Gujarat	8.26	2.3	5.7	0.4	11.9	0.4	1.7	3	11	44.9	12	22	33.7
Haryana	15.7	1.2	2.3	0.4	44.1	1.5	6.3	2.7	2	76.1	9.3	14.6	23.9
Himachal Pradesh	30.2	0	0	13	37.9	3	2.4	0.6	7.1	94.1	0	5.92	5.92
Jammu & Kashmir	56.5	0	0	5.2	12.8	0.2	3.8	0	5	83.5	0	16.5	16.5
Karnataka	31	7.2	1.4	6.8	3.13	0	8	8.4	7.9	73.9	8.5	17.6	26.1
Kerala	70.9	0	0	0	0	0	0	0.3	7.3	78.4	0	21.6	21.6
Madhya Pradesh	29.1	0.1	0	0.2	43.8	1.1	11	2.3	6.3	93.6	1.9	4.44	6.38
Maharastra	16.1	16	1.9	1.6	19.7	0	5.2	13	22	94.8	4.5	4.79	9.26
Manipur	100	0	0	0	0	0	0	0	0	100	0	0	0
Meghalaya	100	0	0	0	0	0	0	0	0	100	0	0	0
Mizoram	100	0	0	0	0	0	0	0	0	100	0	0	0
Nagaland	87.9	0	0	0	8.62	0	0	0	3.4	100	0	0	0
Orissa	66.4	0	0	0.2	2.45	0	5.9	2	16	93.5	0	6.48	6.48
Punjab	26	0	0.4	2.3	45.3	0.6	1.5	1.1	1.6	78.8	8.5	12.7	21.2
Rajasthan	1.32	0.4	3.6	3.8	38.4	6.3	8.8	0.7	6.1	69.4	7.8	22.8	30.6
Sikkim	100	0	0	0	0	0	0	0	0	100	0	0	0
Tamil Nadu	64.2	2	1.3	0.4	0	0	2.4	5.9	6.9	83.2	3.9	12.9	16.8
Tripura	43.9	0	0	0	4.88	0	0	0	22	70.7	0	0	0
Uttar Pradesh	12.4	0	0.1	1.6	58.7	2.2	4.9	11	4.4	95.2	0.2	4.63	4.82
West Bengal	65.5	0	0	0	11.6	0.1	0.4	0.1	6.1	83.6	0	16.4	16.4
Total	32.02	1.38	1.07	1.89	32.07	1.24	4.20	4.79	6.26	84.93	3.89	10.23	14.13

Source: Same as Table-A.2.1

Table: A.2.8 Percentage of Crops Gross Irrigated (1991-92)

State	Rice	Jowar	Bajra	Maize	Ragi	Wheat	Barley	Other cereals & Mllates)	Pulses	Sugarcane	Total Food Crop	Oilseeds	Cotton	Total Non-Food Crops
Andhra Pradesh	69.47	0.32	0.56	1.73	0.77	0.12	0.00	0.01	0.38	4.32	84.96	11.51	1.73	15.04
Arunachal Pradesh	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00
Assam	91.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10	0.00	94.31	0.00	0.00	5.69
Bihar	43.69	0.00	0.00	7.12	0.01	41.20	0.19	0.06	0.43	0.51	98.74	0.87	0.00	1.26
Gujarat	11.78	1.18	6.68	1.02	0.00	14.27	0.35	0.11	2.47	5.99	55.27	23.84	11.71	44.73
Haryana	14.60	1.34	2.43	0.16	0.00	40.84	1.07	0.01	3.37	3.59	69.00	11.19	7.01	31.00
Himachal Pradesh	28.65	0.00	0.00	14.04	0.11	39.08	2.58	1.03	2.23	0.46	93.75	2.75	0.00	6.25
Jammu & Kashmir	55.42	0.02	0.27	6.90	0.00	12.97	0.13	2.38	0.92	0.04	83.96	10.81	0.02	16.04
Karnataka	28.65	5.47	1.31	6.98	3.10	2.50	0.00	0.08	2.33	9.99	67.38	24.27	5.16	32.62
Kerala	59.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54	69.88	26.79	0.00	30.12
Madhya Pradesh	23.90	0.03	0.00	0.24	0.00	42.87	0.59	0.01	13.76	1.60	88.96	7.10	3.05	11.04
Maharastra	12.57	14.85	2.38	1.14	0.00	15.17	0.00	0.14	6.25	18.03	86.07	9.04	2.82	13.93
Manipur	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00
Meghalaya	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00
Mizoram	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00
Nagaland	97.84	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00
Orissa	67.03	0.00	0.00	0.72	1.13	1.25	0.00	0.00	5.83	2.00	93.67	5.49	0.00	6.33
Punjab	28.87	0.10	0.11	1.27	0.00	43.93	0.58	0.01	0.92	1.45	78.72	1.99	10.03	21.28
Rajasthan	0.68	0.08	2.82	2.26	0.00	31.83	4.33	0.02	5.00	0.55	53.53	32.44	8.72	46.47
Sikkim	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00
Tamil Nadu	60.11	1.18	0.71	0.55	1.42	0.00	0.00	0.03	1.51	7.31	79.93	15.67	2.74	20.07
Tripura	79.04	0.00	0.00	0.00	0.00	0.80	0.00	0.00	2.79	0.60	99.00	0.20	0.00	1.00
Uttar Pradesh	17.17	0.05	0.28	2.25	0.00	50.54	1.41	0.04	4.46	10.65	91.47	4.28	0.08	8.53
West Bengal	61.41	0.00	0.00	0.00	0.00	10.76	0.01	0.00	0.39	0.31	79.71	14.58	0.00	20.29
Total	30.71	1.23	1.02	2.01	0.31	29.79	0.89	0.05	3.69	5.50	81.35	10.41	3.65	18.65

Source: Same as Table-A.2.1

Table: A.2.9 Percentage of Crops Gross Irrigated (1996-97)

State	Rice	Jowar	Bajra	Maize	Ragi	Wheat	Barley	Other cereals & Mllates	Pulses	Sugarcane	Total Food Crop	Oilseeds	Cotton	Total Non-Food Crops
Andhra Pradesh	67.93	0.31	0.4	2.09	0.54	0.16	0	0	0.22	5.69	85.97	9.48	3.08	14.03
Arunachal Pradesh	91.67	0	0	0	0	0	0	0	0	0	100	0	0	0
Assam	93.01	0	0	0	0	0	0	0	1.05	0	94.23	0	0	5.77
Bihar	44.32	0	0	7.16	0.02	39.6	0.15	0.17	0.41	0.71	98.26	1.01	0	1.74
Gujarat	11.31	0.44	5.96	1.1	0	14.41	0.3	0.08	2.64	6.37	54.24	20.89	15.73	45.76
Haryana	17.3	1.42	1.86	0.08	0	41.44	0.63	0.02	2.28	3.32	69.66	9.91	13.54	30.34
Himachal Pradesh	28.41	0	0	13.64	0	38.64	2.27	1.14	2.84	0.57	94.32	2.27	0	5.68
Jammu & Kashmir	55.48	0	0	4.03	1.79	14.32	0.22	0.45	1.12	0	82.1	11.19	0	17.9
Karnataka	31.73	4.89	1.28	8.33	2.19	3.23	0	0.03	2.4	9.79	72.96	19.4	4.44	27.04
Kerala	50.43	0	0	0	0	0	0	0	0	0.86	61.8	35.19	0	38.2
Madhya Pradesh	19.22	0.02	0	0.18	0	46.45	0.44	0	16.14	1.07	89.14	7.11	2.89	10.86
Maharastra	13.18	15.27	2.1	1.08	0	16.51	0	0	7.59	13.88	86.44	9.24	2.83	13.56
Manipur	100	0	0	0	0	0	0	0	0	0	100	0	0	0
Meghalaya	100	0	0	0	0	0	0	0	0	0	100	0	0	0
Mizoram	55.56	0	0	0	0	0	0	0	0	0	77.78	22.22	0	22.22
Nagaland	84.93	0	0	0	0	2.74	0	0	0	0	90.41	9.59	0	9.59
Orissa	73	0	0	0.97	0.71	0.66	0	0	3.71	2.25	95.23	4.11	0.04	4.77
Punjab	29.36	0.03	0.07	1.31	0	42.39	0.47	0.54	1.07	1.76	78.54	2.48	10.02	21.46
Rajasthan	0.77	0.01	0.74	0.39	0	35.35	2.46	0.01	5.24	0.39	53.03	32.81	9.49	46.97
Sikkim	100	0	0	0	0	0	0	0	0	0	100	0	0	0
Tamil Nadu	60.2	1.08	0.3	0.81	0.81	0	0	0	0.99	7.74	80.37	14.91	2.42	19.63
Tripura	75	0	0	0	0	1.67	0	0	3.33	0	98.33	1.67	0	1.67
Uttar Pradesh	20.34	0.02	0.25	1.82	0	48.04	1.05	0.03	4.37	10.79	91.49	3.93	0.06	8.51
West Bengal	61.42	0	0	0	0	10.76	0	0	0.4	0.32	79.73	14.57	0	20.27
Total	30.27	1.05	0.74	1.8	0.2	30.56	0.64	0.09	4.03	5.34	81.2	10.14	4.48	18.8

Source: Same as Table-A.2.1

Table: A.2.10 Compound Growth Rate of Crops Gross Irrigated between 1985-86 and 1991-92

State	Rice	Jowar	Bajra	Maize	Wheat	Barley	Other cereals & Pulses	Sugar-cane	Total Food-Crops	Cotton	Total Non-Food Crops	Total irrigated area
Andhra Pradesh	2.35	-0.95	-2.59	10.96	-5.77		-53.80	6.07	2.79	1.51	9.78	3.65
Arunachal Pradesh	5.77								5.77			5.77
Assam	-0.03								0.30		0.05	0.29
Bihar	-0.86			6.57	2.86	-4.97	-30.96	-2.12	1.35		9.07	1.42
Gujarat	6.62	-10.24	3.13	19.69	3.57	0.33	-36.44	12.98	4.01	0.51	5.36	0.49
Haryana	1.57	5.11	3.87	-12.14	1.48	-3.30	-65.32	7.87	1.13	-1.90	7.37	2.80
Himachal Pradesh	-0.33			1.81	1.06	-1.74	-12.46	-3.65	0.48		1.45	0.54
Jammu & Kashmir	0.52			5.71	1.11	-8.16	-6.63		0.95		0.33	0.85
Karnataka	4.48	1.12	4.14	6.45	1.94		-51.05	8.87	4.27	-2.58	9.85	5.87
Kerala	-3.49							13.16	-2.39		5.22	-0.49
Madhya Pradesh	3.97	-8.16		11.61	7.09	-3.24	-65.08	1.40	6.56	15.86	17.76	7.47
Maharastra	0.55	3.92	8.76	-1.16	0.38		-42.48	10.75	3.14	-2.93	12.19	4.82
Manipur	-0.04								-0.04			-0.04
Meghalaya	-2.03								-2.03			-2.03
Mizoram	0.21								0.21			0.21
Nagaland	2.43				-31.87				0.62			0.62
Orissa	2.83			23.91	-8.31			2.36	2.70		2.27	2.68
Punjab	3.27	38.64	-18.18	-8.28	0.96	0.49	-58.44	6.18	1.45	4.33	1.56	1.47
Rajasthan	-5.68	-20.63	0.83	-3.43	2.02	-1.06	-62.81	1.90	0.81	7.28	12.86	5.27
Sikkim	0.00								0.00			0.00
Tamil Nadu	-1.01	-8.67	-9.84	6.89			-51.72	3.73	-0.58	-5.72	3.07	0.09
Tripura	14.04				-23.53				9.36			3.40
Uttar Pradesh	9.93	6.02	27.62	9.62	1.50	-3.46	-52.92	3.79	3.37	-10.12	14.48	4.06
West Bengal	3.41				3.27	-23.53		25.46	3.69		8.32	4.52
Total	2.61	1.31	2.51	4.41	2.07	-2.26	-49.97	5.73	2.59	2.21	8.23	3.33

Source: Same as Table-A.2.1

Table: A.2.11 Compound Growth Rate Between Gross Area Under Irrigation 1991-92 and 1996-97

State	Rice	Jowar	Bajra	Maize	Ragi	Wheat	Barley	Other cereals & Mllates	Pulses	Sugarcane	Total Food Crop	Oilseeds	Cotton	Total Non-Food Crops	Total irrigated area
Andhra Pradesh	1.01	1.15	-5.11	5.34	-5.62	7.39			-8.88	7.23	1.70	-2.41	13.86	0.05	1.46
Arunachal Pradesh	0.49										2.26				2.26
Assam	0.04								-1.28		-0.36			-0.06	-0.35
Bihar	2.62			2.45	10.76	1.52	-2.88	25.21	1.43	9.36	2.23	5.36		9.18	2.33
Gujarat	3.96	-13.99	2.42	6.35		5.02	1.52	-0.65	6.22	6.09	4.42	2.08	11.19	5.29	4.81
Haryana	5.50	3.23	-3.34	-10.33		2.27	-8.43	20.11	-5.72	0.38	2.17	-0.49	16.34	1.54	1.97
Himachal Pradesh	0.00			-0.41		-0.06	-2.33	2.13	5.09	4.56	0.29	-3.58		-1.71	0.17
Jammu & Kashmir	0.11			-10.13		2.09	10.76	-28.36	4.05		-0.36	0.78		2.30	0.09
Karnataka	2.40	-1.88	0.00	3.93	-6.44	5.64		-14.59	0.92	-0.08	1.94	-4.06	-2.62	-3.36	0.33
Kerala	0.54									13.75	1.25	9.58		8.81	3.76
Madhya Pradesh	2.11	-3.58		0.68		8.38	0.78		10.12	-1.66	6.70	6.69	5.54	6.30	6.66
Maharastra	0.22	-0.16	-3.24	-1.84		0.98			3.21	-5.78	-0.64	-0.29	-0.66	-1.25	-0.72
Manipur	0.05										0.05				0.05
Meghalaya	-0.04										-0.04				-0.04
Mizoram	-9.20										-2.88				2.13
Nagaland	1.03					31.95					1.86				3.93
Orissa	-0.52			3.98	-10.97	-13.79			-10.65	0.16	-1.88	-7.72		-7.58	-2.20
Punjab	1.07	-22.38	-7.79	1.40		0.02	-3.21	140.22	3.95	4.73	0.69	5.26	0.72	0.91	0.74
Rajasthan	7.69	-24.21	-19.53	-26.25		7.30	-6.14	2.13	6.05	-2.23	4.87	5.31	6.88	5.29	5.07
Sikkim	0.00										0.00				0.00
Tamil Nadu	0.58	-1.23	-15.42	8.57	-10.15				-7.71	1.71	0.66	-0.45	-1.91	0.11	0.55
Tripura	2.59					20.11			7.39		3.53	58.49		14.87	3.67
Uttar Pradesh	6.04	-10.84	0.37	-1.73		1.48	-3.25	-1.59	2.11	2.78	2.52	0.79	-1.06	2.45	2.52
West Bengal	0.00					-0.01			0.40	0.51	0.00	-0.02		-0.02	-0.01
Total	1.91	-0.98	-4.07	-0.05	-6.56	2.73	-4.38	12.51	4.02	1.62	2.17	1.66	6.52	2.37	2.21

Source: Same as Table-A.2.1

Table: A.2.12 Compound Growth Rate of Crops Gross Irrigated between 1985-86 and 1996-97

State	Rice	Jowar	Bajra	Maize	Wheat	Barley	Other cereals & Mllates	Sugar-cane	Total Food Crop	Cotton	Total Non-Food Crops	Tot irrig d ar
Andhra Pradesh	1.74	0.00	-3.74	8.37	0.00			6.59	2.29	6.95	5.25	2.6
Arunachal Pradesh	3.34								4.16			4.1
Assam	0.00								0.00		0.00	0.0
Bihar	0.71			4.68	2.25	-4.03	-9.50	2.94	1.75		9.12	1.8
Gujarat	5.40	-11.97	2.81	13.43	4.23	0.87	-22.13	9.80	4.20	5.23	5.33	2.4
Haryana	3.34	4.25	0.53	-11.32	1.84	-5.67	-39.00	4.40	1.60	6.01	4.68	2.4
Himachal Pradesh	-0.18			0.79	0.55	-2.01	-6.11	0.00	0.39		0.00	0.3
Jammu & Kashmir	0.34			-1.81	1.56	0.00	-17.22		0.35		1.22	0.5
Karnataka	3.53	-0.25	2.24	5.30	3.60		-36.96	4.71	3.20	-2.60	3.63	3.3
Kerala	-1.68							13.43	-0.75		6.84	1.4
Madhya Pradesh	3.12	-6.11		6.50	7.68	-1.44		0.00	6.62	11.05	12.40	7.1
Maharastra	0.40	2.04	3.13	-1.47	0.65			2.90	1.41	-1.91	5.87	2.2
Manipur	0.00								0.00			0.0
Meghalaya	-1.13								-1.13			-1.1
Mizoram	-4.18								-1.21			1.0
Nagaland	1.79				-7.99				1.18			2.1
Orissa	1.29			14.42	-10.84			1.35	0.59		-2.33	0.4
Punjab	2.27	6.50	-13.61	-4.00	0.53	-1.21	-7.74	5.52	1.10	2.67	1.26	1.1
Rajasthan	0.18	-22.28	-8.99	-14.57	4.39	-3.40	-41.13	0.00	2.64	7.10	9.35	5.1
Sikkim	0.00								0.00			0.0
Tamil Nadu	-0.29	-5.36	-12.42	7.65				2.81	-0.02	-4.01	1.71	0.3
Tripura	8.69				-6.11				6.67			3.5
Uttar Pradesh	8.15	-2.01	14.42	4.31	1.49	-3.36	-34.18	3.33	2.99	-6.11	8.84	3.3
West Bengal	1.85				1.77			13.43	2.00		4.44	2.4
Total	2.30	0.26	-0.54	2.36	2.37	-3.23	-27.69	3.84	2.40	4.14	5.52	2.8

Source: Same as Table-A.2.1

Table: A.2.13 Statewise and Regionwise Hydro Electric (HE) Power Potential Development

State	Percentage of HE Power Potential Assessed at 60% Load Factor (MW) Within the Region	Percentage of HE Power Potential Development at 60% Load Factor	Percentage of HE Power Potential Under Development at 60% Load Factor
Northern Region (NR)			
Jammu & Kashmir	24.83	6.7	5.15
Himachal Pradesh	38.62	17.28	5.42
Punjab	3.06	71.19	18.8
Haryana	0.21	80.73	18.23
Rajasthan	0.97	66.21	2.75
Uttar Pradesh	32.31	11.75	13.69
Total (NR)*	35.88	15.12	8.44
Western Region (WE)			
Madhya Pradesh	48.85	21.19	43.36
Gujarat	7.20	33.9	27.06
Maharastra	43.32	45.48	7.59
Goa	0.63	0	0
Total (WR)*	6.76	32.49	26.42
Southern Region (SR)			
Andhra Pradesh	27.03	48.2	1.18
Karnataka	40.39	53.01	7.56
Kerala	21.38	48.91	9.53
Tamil Nadu	11.21	78.48	5.6
Total (SR)*	12.81	53.69	6.04
Eastern Region (ER)			
Bihar	9.62	22.3	39.22
Orissa	35.47	55.5	0.45
West Bengal	31.95	5.11	0.55
Sikkim	22.95	4.48	8.5
Total (ER)*	6.65	24.5	6.06
North-Eastern Region (NE)			
Meghalaya	3.36	11.37	0
Tripura	0.03	94.44	0
Manipur	3.69	6.22	4.07
Assam	1.10	31.81	25.88
Nagaland	3.26	5.38	2.49
Arunachal Pradesh	83.99	0.06	0.4
Mizoram	4.57	0.07	2.53
Total (NE)*	37.91	1.22	0.97
TOTAL (All Region)	84044**	16.59	6.36

* Percentage of HE Power Potential Assessed at 60% Load Factor (MW) Within India

** HE Power Potential Assessed at 60% Load Factor (Mega Watts)

Source: Central Electricity Authority, Hydro Policy Directorate

Table: A.2.14 Water Users Association (WUAs) Formed and Area Covered (Upto March 2001)

State	Percentage of WUAs formed	System level at which WUAs formed	Percentage of area covered
Andhra Pradesh	26.35	Minor	61.76
Assam	0.04	Minor	0.08
Bihar	0.00	Distributory	0.15
Goa	0.11	Minor	0.06
Gujarat	1.22	Minor & LIS	0.24
Haryana	6.59	Outlet	2.57
Himachalo Pradesh	2.24	Minor schemes	0.45
Jammu & Kashmir	0.00	Minor	0.01
Karnataka	1.95	Minor	1.78
Kerala	10.06	Outlet	1.90
Madhya Pradesh	3.76	Outlet	19.24
Maharastra	0.63	Minor	1.18
Manipur	0.16	Minor	0.63
Orissa	0.42	Minor	0.95
Rajasthan	1.07	Minor	2.39
Tamil Nadu	19.78	Minor	6.10
Uttar Pradesh	0.00	Minor	0.01
West Bengal	25.60	Tube wells	0.48
Total	39055*		7771**

*Number of WUAs formed

** Approximate area covered (000 hectare)

Source: Report of the Working Group on Command Area Development Programme for 10th Five Year Plan

Table: A.3.1 Statewise Percentage of Ultimate Irrigation Potential Created and Utilised Till the Eighth Five Year Plan

State	Major & Medium (Surface Water)	Major & Medium (Surface Water)	Minor Irrigation (Surface Water)	Minor Irrigation (Surface Water)	Minor Irrigation (Ground Water)	Minor Irrigation (Ground Water)	Minor Irrigation (Total)	Minor Irrigatin (Total)	Irrigation Potential (Major& Medium Minor)	Irrigation Potential (Major& Medium Minor)
	P	U	P	U	P	U	P	U	P	U
Andhra Pradesh	60.90	57.68	59.30	51.28	44.63	43.74	50.02	46.51	54.85	51.47
Arunachal Pradesh			52.67	46.00	16.67	16.11	48.81	42.80	48.81	42.80
Assam	20.31	14.23	42.25	35.79	22.49	16.56	32.89	26.68	28.64	22.47
Bihar	43.12	35.75	72.57	64.84	84.54	74.48	81.22	71.80	62.67	54.25
Goa	20.97	19.35	74.00	64.80	6.55	5.86	37.78	33.15	28.79	25.78
Gujarat	45.00	40.00	65.33	53.23	63.95	60.98	64.10	60.12	54.71	50.23
Haryana	69.30	61.13	83.60	73.60	105.95	102.64	105.21	101.68	81.33	74.72
Himachal Pradesh	22.00	12.00	57.45	49.57	23.09	17.06	49.74	42.28	45.81	37.99
Jammu & Kashmir	69.60	59.20	91.45	88.23	1.69	1.55	34.10	32.84	40.63	37.70
Karnataka	66.64	58.88	83.47	80.81	30.11	29.49	43.93	42.78	53.43	49.52
Kerala	51.30	46.40	59.18	56.13	16.25	14.61	36.70	34.39	42.15	38.87
Madhya Pradesh	38.63	27.02	52.07	44.39	18.19	16.89	24.44	21.96	29.19	23.65
Maharastra	57.00	31.41	81.53	62.82	44.72	43.38	53.82	48.19	55.28	40.51
Manipur	46.67	38.52	59.40	47.40	0.16	0.14	12.79	10.21	20.36	16.54
Meghalaya	0.00	0.00	49.88	41.65	16.19	15.86	35.54	30.67	31.31	27.02
Mizoram			18.57	16.29			18.57	16.29	18.57	16.29
Nagaland	0.00	0.00	89.33	76.40			90.53	77.33	79.88	68.24
Orissa	43.28	40.08	74.97	62.08	17.49	14.32	28.54	23.50	34.56	30.28
Punjab	83.77	81.70	91.00	87.40	117.28	115.28	116.84	114.81	100.21	98.16
Rajasthan	82.69	75.93	79.00	70.22	119.21	116.12	109.07	104.54	94.92	89.20
Sikkim	0.00	0.00	51.80	40.60			51.80	40.60	37.00	29.00
Tamil Nadu	103.07	103.00	72.46	72.04	46.31	46.30	54.09	53.96	67.37	67.26
Tripura	2.00	2.00	78.00	70.00	25.93	25.93	54.70	50.28	35.94	33.10
Uttar Pradesh	56.34	48.91	88.39	82.89	132.52	120.16	129.58	117.67	99.56	89.49
West Bengal	62.30	57.17	105.13	92.73	55.20	42.33	69.25	56.52	66.94	56.73
Total States	56.43	48.66	70.56	62.55	71.09	65.38	70.98	64.78	64.90	58.05
Grand Total	56.37	48.59	70.53	62.52	71.18	65.47	71.04	64.84	64.91	58.05

Note: P= potential created, U=potential utilized

Source: Water and Related Statistics, CWC

Table: A.3.2 Planwise Percentage of Irrigation Potential Created and Utilised for Major & Medium and Minor Irrigation

Plan	Major & Medium Irrigation (Surface Water)	Minor Irrigation (Total)	Major & Medium Irrigation (Surface Water)	Minor Irrigation (Total)
	Potential Created		Potential Utilised	
Pre-plan(upto 1951)	42.93	57.07	42.93	57.07
First Plan(1951-56)	68.04	31.96	52.59	47.41
Second Plan(1956-61)	75.86	24.14	74.81	25.19
Third Plan(1961-66)	49.74	50.26	48.61	51.39
Annual Plan(1966-69)	43.16	56.84	43.77	56.23
Fourth Plan(1969-74)	36.90	61.97	30.19	68.26
Fifth Plan(1974-78)	51.37	48.63	39.44	60.56
Annual Plan(1978-80)	41.24	58.76	35.44	64.56
Sixth Plan(1980-85)	12.36	87.42	15.04	84.98
Seventh Plan(1985-90)	19.67	80.34	19.39	80.60
Annual Plan(1990-92)	17.98	81.98	19.85	80.15
Eighth Plan(1992-97)	42.82	57.18	48.10	52.36
Annual Plan(1997-98)*	45.32	54.68	40.05	59.95
Annual Plan(1998-99)*	46.70	53.30	54.57	45.43
Annual Plan(1999-2000)*	58.83	41.17	59.52	40.48

* Anticipated Figures

Source: Same as Table-A.3.1

Table: A.3.3 Planwise Percentage of Irrigation Potential Created and Utilised for Major & Medium and Minor Irrigation (Cumulative)

	Major & Medium Irrigation(Surface Water)	Minor Irrigation (Total	Major & Medium Irrigation(Surface Water)	Minor Irrigation (Total
	Potential Created		Potential Utilised	
Pre-plan(upto 1951)	42.93108	57.06892	42.93108	57.06892
First Plan(1951-56)	46.42422	53.57578	43.86981	56.13019
Second Plan(1956-61)	49.28314	50.71686	46.94457	53.05543
Third Plan(1961-66)	49.34465	50.65535	47.17128	52.82872
Annual Plan(1966-69)	48.75387	51.24613	46.82844	53.17156
Fourth Plan(1969-74)	46.83619	53.16381	44.29696	55.70304
Fifth Plan(1974-78)	47.51716	52.48284	43.66837	56.33163
Annual Plan(1978-80)	47.0077	52.9923	43.01453	56.98547
Sixth Plan(1980-85)	42.46722	57.53278	40.07684	59.92316
Seventh Plan(1985-90)	39.09833	60.90167	37.13094	62.86906
Annual Plan(1990-92)	37.90926	62.09074	36.11881	63.88119
Eighth Plan(1992-97)	38.21071	61.78929	36.7948	63.2052
Annual Plan(1997-98)*	38.3222	61.6778	36.84546	63.15454
Annual Plan(1998-99)*	38.45351	61.54649	37.20172	62.79828
Annual Plan(1999-2000)*	38.77217	61.22783	37.50801	62.49199

* Anticipated Figures

Source: Same as Table-A.3.1

Table: A.3.4 Planwise Irrigation Potential Utilised As A Percentage Of Potential Created In India

Plan	Major & Medium Irrigation(Surface Water)	Minor Irrigation (Total)	Irrigation (Major, Medium & Minor)
Pre-plan(upto 1951)	100.00	100.00	100.00
First Plan(1951-56)	51.49	98.8	66.61
Second Plan(1956-61)	96.45	102.05	97.81
Third Plan(1961-66)	95.16	99.56	97.36
Annual Plan(1966-69)	103.01	100.50	101.58
Fourth Plan(1969-74)	74.27	100.00	90.79
Fifth Plan(1974-78)	61.66	100.00	80.30
Annual Plan(1978-80)	78.21	100.00	91.01
Sixth Plan(1980-85)	87.39	69.79	71.80
Seventh Plan(1985-90)	85.08	86.63	86.34
Annual Plan(1990-92)	103.17	91.37	93.45
Eighth Plan(1992-97)	94.71	77.23	84.33
Annual Plan(1997-98)*	73.76	91.50	83.46
Annual Plan(1998-99)*	134.66	98.25	115.26
Annual Plan (1999-2000)*	79.59	77.36	78.67

* Anticipated Figures
Source: Same as Table-A.3.1

Table: A.3.5 Planwise Irrigation Potential Utilised As A Percentage Of Potential Created In India (Cumulative)

Plan	Major & Medium Irrigation(Surface Water)	Minor Irrigation (Total	Irrigation (Major,Medium & Minor)
Pre-plan(upto 1951)	100.00	100.00	100.00
First Plan(1951-56)	90.11	99.90	95.35
Second Plan(1956-61)	91.06	100.00	95.59
Third Plan(1961-66)	91.61	99.94	95.83
Annual Plan(1966-69)	92.57	100.00	96.38
Fourth Plan(1969-74)	90.27	100.00	95.44
Fifth Plan(1974-78)	85.62	100.00	93.17
Annual Plan(1978-80)	85.09	100.00	92.99
Sixth Plan(1980-85)	85.12	93.94	90.20
Seventh Plan(1985-90)	85.12	92.52	89.63
Annual Plan(1990-92)	85.60	92.43	89.84
Eighth Plan(1992-97)	86.18	91.55	89.50
Annual Plan(1997-98)*	85.97	91.55	89.41
Annual Plan(1998-99)*	86.89	91.64	89.82
Annual Plan(1999-2000)*	86.72	91.49	89.64

* Anticipated Figures
Source: Same as Table-A.3.1

Table: A.3.6 Statewise And Planwise Achievement Of Irigation Potential Created and Utilised(Cumulative) ('000 hec)

State	Plan	Potential Utilisation as a percentage of Potential Created			Created Potential as a percentage of total Potential Created		Potential Utilisation as Percentage of total Utilised Potential	
		Major & Medium Irrigation(Surface Water)	Minor Irrigation (Total)	Irrigation (Major,Medium & Minor)	Major & Medium	Minor Irrigation(Total)	Major & Medium	Minor Irrigation(Total)
1	2	3	4	5	6	7	8	9
ANDHRA PRADESH	Sixth Plan	92.87	93.81	93.29	55.35	44.65	55.10	44.90
	Seventh Plan	94.82	92.81	93.85	51.68	48.32	52.21	47.79
	Annual Plan (1990-92)	94.93	92.54	93.76	51.04	48.96	51.67	48.33
	Eighth Plan	94.71	92.99	93.84	49.30	50.70	49.76	50.24
	Annual Plan* (1997-98)	94.21	90.92	92.51	48.34	51.66	49.22	50.78
ARUNACHAL PRADESH	Sixth Plan		85.07	85.07	0.00	100.00	0.00	100.00
	Seventh Plan		88.75	88.75	0.00	100.00	0.00	100.00
	Annual Plan (1990-92)		85.98	85.98	0.00	100.00	0.00	100.00
	Eighth Plan		86.73	86.73	0.00	100.00	0.00	100.00
	Annual Plan* (1997-98)		85.27	85.27	0.00	100.00	0.00	100.00
ASSAM	Sixth Plan	56.12	89.26	82.62	20.04	79.96	13.61	86.39
	Seventh Plan	67.36	81.73	78.69	21.15	78.85	18.10	81.90
	Annual Plan (1990-92)	63.07	81.18	76.93	23.43	76.57	19.20	80.80
	Eighth Plan	70.05	81.12	78.46	23.97	76.03	21.40	78.60
	Annual Plan* (1997-98)	69.00	75.26	73.85	22.57	77.43	21.08	78.92
BIHAR	Sixth Plan	78.60	92.17	86.36	42.83	57.17	38.98	61.02
	Seventh Plan	82.36	90.13	87.16	38.25	61.75	36.14	63.86
	Annual Plan (1990-92)	82.97	89.34	87.04	36.19	63.81	34.50	65.50
	Eighth Plan	82.91	88.41	86.57	33.51	66.49	32.10	67.90
	Annual Plan* (1997-98)	82.94	86.46	85.30	33.00	67.00	32.08	67.92
GOA	Sixth Plan	0.00	95.10	88.89	6.54	93.46	0.00	100.00
	Seventh Plan	38.46	93.02	69.54	43.05	56.95	23.81	76.19
	Annual Plan (1990-92)	92.31	90.76	91.40	41.40	58.60	41.81	58.19
	Eighth Plan	92.31	87.75	89.52	38.92	61.08	40.13	59.87
	Annual Plan* (1997-98)	92.31	87.38	89.29	38.69	61.31	40.00	60.00
GUJARAT	Sixth Plan	61.23	96.12	82.63	38.66	61.34	28.65	71.35
	Seventh Plan	71.31	95.83	86.19	39.32	60.68	32.53	67.47
	Annual Plan (1990-92)	79.13	94.94	88.68	39.60	60.40	35.34	64.66
	Eighth Plan	88.89	93.78	91.80	40.43	59.57	39.15	60.85
	Annual Plan* (1997-98)	89.38	93.18	91.65	40.39	59.61	39.39	60.61

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Table: A.3.6 Statewise And Planwise Achievement Of Irrigation Potential Created,Utilised(Cumulative) ('000 hec)

1	2	3	4	5	6	7	8	9
HARYANA	Sixth Plan	90.74	98.13	93.84	58.10	41.90	56.18	43.82
	Seventh Plan	88.62	97.78	92.50	57.59	42.41	55.18	44.82
	Annual Plan (1990-92)	88.01	97.32	92.00	57.17	42.83	54.69	45.31
	Eighth Plan	88.22	96.64	91.87	56.65	43.35	54.40	45.60
	Annual Plan* (1997-98)	88.22	96.49	91.82	56.42	43.58	54.20	45.80
HIMACHAL PRADESH	Sixth Plan	83.33	89.74	89.43	4.88	95.12	4.55	95.45
	Seventh Plan	75.00	89.02	88.19	5.94	94.06	5.05	94.95
	Annual Plan (1990-92)	50.00	86.51	84.56	5.35	94.65	3.16	96.84
	Eighth Plan	54.55	85.00	82.93	6.80	93.20	4.47	95.53
	Annual Plan* (1997-98)	54.55	83.69	81.76	6.62	93.38	4.42	95.58
JAMMU & KASHMIR	Sixth Plan	73.20	97.03	89.59	31.22	68.78	25.51	74.49
	Seventh Plan	74.05	97.17	90.06	30.72	69.28	25.26	74.74
	Annual Plan (1990-92)	86.08	96.89	93.62	30.29	69.71	27.85	72.15
	Eighth Plan	85.06	96.32	92.77	31.53	68.47	28.91	71.09
	Annual Plan* (1997-98)	84.09	96.22	92.37	31.73	68.27	28.89	71.11
KARNATAKA	Sixth Plan	90.39	97.13	93.73	50.37	49.63	48.57	51.43
	Seventh Plan	90.44	97.20	93.88	49.11	50.89	47.31	52.69
	Annual Plan (1990-92)	86.56	97.21	92.00	48.96	51.04	46.07	53.93
	Eighth Plan	88.36	97.39	92.67	52.19	47.81	49.76	50.24
	Annual Plan* (1997-98)	88.14	97.40	92.52	52.68	47.32	50.18	49.82
KERALA	Sixth Plan	91.20	93.59	92.42	49.02	50.98	48.37	51.63
	Seventh Plan	88.31	91.22	89.89	45.61	54.39	44.81	55.19
	Annual Plan (1990-92)	88.22	93.13	90.94	44.54	55.46	43.21	56.79
	Eighth Plan	90.45	93.70	92.22	45.43	54.57	44.56	55.44
	Annual Plan* (1997-98)	90.83	93.54	92.29	46.24	53.76	45.51	54.49
MADHYA PRADESH	Sixth Plan	67.34	93.88	82.09	44.42	55.58	36.44	63.56
	Seventh Plan	69.92	94.36	83.79	43.25	56.75	36.09	63.91
	Annual Plan (1990-92)	71.10	92.76	83.36	43.38	56.62	37.00	63.00
	Eighth Plan	69.93	89.88	81.04	44.29	55.71	38.22	61.78
	Annual Plan* (1997-98)	69.86	89.40	81.01	42.94	57.06	37.03	62.97

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Table: A.3.6 Statewise And Planwise Achievement Of Irigation Potential Created,Utilised(Cumulative) ('000 hec)

1	2	3	4	5	6	7	8	9
MAHARA-STRA	Sixth Plan	43.79	91.74	69.53	46.30	53.70	29.16	70.84
	Seventh Plan	49.14	90.41	71.70	45.34	54.66	31.08	68.92
	Annual Plan (1990-92)	50.99	90.02	72.36	45.24	54.76	31.87	68.13
	Eighth Plan	55.69	89.54	73.64	46.97	53.03	35.52	64.48
	Annual Plan* (1997-98)	58.36	89.56	74.50	48.28	51.72	37.82	62.18
MANIPUR	Sixth Plan	62.50	87.18	74.68	50.63	49.37	42.37	57.63
	Seventh Plan	77.97	84.22	80.74	55.71	44.29	53.80	46.20
	Annual Plan (1990-92)	84.75	83.06	83.98	54.33	45.67	54.82	45.18
	Eighth Plan	82.54	79.83	81.22	51.22	48.78	52.05	47.95
	Annual Plan* (1997-98)	84.38	79.39	81.92	50.75	49.25	52.27	47.73
MEGHA-LAYA	Sixth Plan		91.43	91.43	0.00	100.00	0.00	100.00
	Seventh Plan		88.12	88.12	0.00	100.00	0.00	100.00
	Annual Plan (1990-92)		87.53	87.53	0.00	100.00	0.00	100.00
	Eighth Plan		86.12	86.12	0.00	100.00	0.00	100.00
	Annual Plan* (1997-98)		85.47	85.47	0.00	100.00	0.00	100.00
MIZORAM	Sixth Plan		90.63	90.63	0.00	100.00	0.00	100.00
	Seventh Plan		86.32	86.32	0.00	100.00	0.00	100.00
	Annual Plan (1990-92)		85.71	85.71	0.00	100.00	0.00	100.00
	Eighth Plan		87.69	87.69	0.00	100.00	0.00	100.00
	Annual Plan* (1997-98)		87.12	87.12	0.00	100.00	0.00	100.00
NAGALAND	Sixth Plan		92.16	92.16	0.00	100.00	0.00	100.00
	Seventh Plan		86.76	86.76	0.00	100.00	0.00	100.00
	Annual Plan (1990-92)		85.87	85.87	0.00	100.00	0.00	100.00
	Eighth Plan		85.42	85.42	0.00	100.00	0.00	100.00
	Annual Plan* (1997-98)		85.21	85.21	0.00	100.00	0.00	100.00
ORISSA	Sixth Plan	95.31	92.45	93.99	53.83	46.17	54.59	45.41
	Seventh Plan	92.48	91.64	92.09	53.98	46.02	54.20	45.80
	Annual Plan (1990-92)	94.11	90.43	92.38	53.08	46.92	54.07	45.93
	Eighth Plan	92.62	82.34	87.60	51.20	48.80	54.14	45.86
	Annual Plan* (1997-98)	89.16	85.12	87.25	52.59	47.41	53.74	46.26
PUNJAB	Sixth Plan	99.20	98.90	99.02	41.50	58.50	41.58	58.42
	Seventh Plan	98.25	98.45	98.37	41.88	58.12	41.83	58.17
	Annual Plan (1990-92)	97.55	98.41	98.05	41.84	58.16	41.62	58.38
	Eighth Plan	97.57	98.27	97.97	42.03	57.97	41.85	58.15
	Annual Plan* (1997-98)	97.98	98.26	98.14	42.05	57.95	41.98	58.02

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Table: A.3.6 Statewise And Planwise Achievement Of Irigation Potential Created,Utilised(Cumulative) ('000 hec)

1	2	3	4	5	6	7	8	9
RAJASTHAN	Sixth Plan	90.60	97.48	94.30	46.28	53.72	44.47	55.53
	Seventh Plan	90.96	97.36	94.43	45.81	54.19	44.13	55.87
	Annual Plan (1990-92)	94.40	96.98	95.80	45.56	54.44	44.89	55.11
	Eighth Plan	91.82	96.62	94.38	46.72	53.28	45.45	54.55
	Annual Plan* (1997-98)	91.28	96.59	94.13	46.31	53.69	44.91	55.09
SIKKIM	Sixth Plan		71.43	71.43	0.00	100.00	0.00	100.00
	Seventh Plan		77.94	77.94	0.00	100.00	0.00	100.00
	Annual Plan (1990-92)		77.03	77.03	0.00	100.00	0.00	100.00
	Eighth Plan		78.38	78.38	0.00	100.00	0.00	100.00
	Annual Plan* (1997-98)		79.19	79.19	0.00	100.00	0.00	100.00
TAMIL NADU	Sixth Plan	100.47	99.64	100.00	43.46	56.54	43.66	56.34
	Seventh Plan	99.81	99.56	99.66	42.78	57.22	42.84	57.16
	Annual Plan (1990-92)	99.74	99.74	99.74	42.30	57.70	42.29	57.71
	Eighth Plan	99.94	98.93	99.35	41.48	58.52	41.73	58.27
	Annual Plan* (1997-98)	99.81	99.68	99.73	41.37	58.63	41.41	58.59
TRIPURA	Sixth Plan		86.21	86.21	0.00	100.00	0.00	100.00
	Seventh Plan	100.00	90.06	90.30	2.42	97.58	2.68	97.32
	Annual Plan (1990-92)	100.00	90.16	90.38	2.24	97.76	2.48	97.52
	Eighth Plan	100.00	91.92	92.08	1.98	98.02	2.15	97.85
	Annual Plan* (1997-98)	150.00	91.75	92.90	1.97	98.03	3.18	96.82
UTTAR PRADESH	Sixth Plan	88.75	91.31	90.44	33.91	66.09	33.27	66.73
	Seventh Plan	85.57	91.23	89.61	28.60	71.40	27.31	72.69
	Annual Plan (1990-92)	84.68	91.89	89.98	26.51	73.49	24.94	75.06
	Eighth Plan	86.78	90.81	89.88	23.23	76.77	22.43	77.57
	Annual Plan* (1997-98)	86.89	90.93	89.99	23.35	76.65	22.55	77.45
WEST BENGAL	Sixth Plan	90.21	94.01	92.45	41.05	58.95	40.05	59.95
	Seventh Plan	91.00	82.87	85.48	32.16	67.84	34.23	65.77
	Annual Plan (1990-92)	92.98	83.32	86.49	32.80	67.20	35.26	64.74
	Eighth Plan	92.31	81.61	84.94	31.11	68.89	33.81	66.19
	Annual Plan* (1997-98)	92.35	81.09	84.56	30.80	69.20	33.64	66.36

Source: Same as Table-A.3.1

Table: A.3.7 M & M Projects included in CADP

Year of Inclusion	Projects Included	Projects Excluded	On-going (cumulative)	CCA (Mha)
1974-75	60		60	15
1979-80	16		76	16.23
1983-84	28		104	18.38
1984-85		3	101	18.31
1985-86	31		132	18.87
1987-88	4		136	18.99
1988-89		6	130	17.95
1990-91	26	1	155	20.13
1991-92	4		159	20.25
1992-93	8		167	20.39
1993-94	16		183	20.62
1994-95	6		189	20.73
1995-96	4		193	21.16
1996-97	11	1	203	21.85
1997-98	14		217	22.05
1998-99	10		227	22.16
1999-2000	1		228	22.16
2000-2001	26	18	236	22.72
Total	265	29	236	22.72

Source: Report of the Working Group on Command Area Development for 10th Five-Year Plan. Planning Commission. Government of India. 2001

Table: A.3.8 Compound Growth Rate of FC, FD, LL, WB Between the VII Plan and VIII Plan

State	FC	FD	LL	WB
Andhra Pradesh	0.35	0.00	1.62	4.81
Assam	14.17	9.14		29.92
Bihar	0.86		0.00	1.99
Goa	41.22			
Gujarat	2.25	4.03	0.07	8.12
Haryana	33.81		5.10	19.60
Himachal Pradesh	30.66			
Jammu & Kashmir	14.78	49.89	8.09	39.66
Karnataka	2.61	19.20	2.79	15.85
Kerala				70.50
Madhya Pradesh	3.53	9.59	0.00	10.41
Maharastra	4.62	8.46	0.28	6.05
Manipur	31.16	15.58	64.79	
Meghalaya				0.00
Orissa	7.45		20.08	61.12
Rajasthan	8.43	2.96	1.85	19.61
Tamil Nadu	18.94	0.00		84.60
Tripura		0.00		
Uttar Pradesh	3.93		0.00	29.14
West Bengal	20.42	0.00	0.00	
D&N Haveli				
Daman & Diu				
Total	4.41	8.97	1.58	22.04

Source: Government of India. Ninth Five Year Plan. Planning Commission, New Delhi. 1998

Table-A.3.9 Principle Component Analysis

Total Variance Explained

Component	Initial Eigenvalues Total	% of Variance	Cumulative %	Extraction Sums of Squared Loadings Total	% of Variance	Cumulative %
1	1.722	43.060	43.060	1.722	43.060	43.060
2	1.133	28.336	71.396	1.133	28.336	71.396
3	.751	18.772	90.168			
4	.393	9.832	100.000			

Extraction Method: Principal Component Analysis.

Component Matrix

Variable	Component 1
FC	.730
FD	.531
LL	.850
WB	.431

Extraction Method: Principal Component Analysis.

Source: Same as Table-A.3.1

Table: A.3.10 CADP Schemes for Reclamation of Waterlogged Areas in M & M Projects

State	Waterlogged area in the State as whole as per Working Group (1991) (Lakh ha)	CAD Projects covered under sanctioned reclamation schemes	No. of Schemes approved for reclamation under CAD Projects	Area Proposed to be reclaimed (ha) from Colum-4 schemes	Coverage of Waterlogged area of CADP/State	Sanctioned Cost (Rs. Lakh)
1	2	3	4	5	6	7
Bihar	6.2	2	55	10793	1.74	165.36
Gujarat	1.73	1	7	1290	0.75	136.7
J & K	0.01	2	4	1500		283.87
Karnataka	0.24	3	15	926	3.77	116.56
Kerala	0.12	13	265	11600		2315.4
Madhya Pradesh	0.73	1	6	1437	1.96	172.44
Maharastra	0.15	3	4	196	1.28	19.3
Orissa	1.96	2	15	1133	0.58	124.14
Uttar Pradesh	4.3	2	12	5321	1.24	645.23
Total	15.44	29	383	34196		3979

Source: Same as Table-A.3.7

Table: A.3.11 Area Submerged by Different Dams in India

Name of Dam	Area (thousand ha)	Name of Dam	Area (thousand ha)
Pandoh	0.13	Vani Vilasa Sagar	8.66
Kanholi	0.27	Warna	8.76
Palkhed	0.56	Krishnaraja Sagar	9.01
Jalaput	0.59	Shertunji	9.20
Ozarkhand	0.68	Isapur	9.40
Waghad	1.27	Jakham	10.15
Bennithora	1.66	Maithon	10.47
Karanjwan	1.82	Yeldari	10.88
Kanher	1.86	Paihan	11.87
Sidheshwar	1.99	Koyna	12.00
Harangi	2.03	Matatila	12.93
Dham	2.41	Mahi Bajaj Sagar	14.34
Vir	2.43	Hidkal	14.52
Bhatsa	2.56	Kadana	16.60
Konar	2.69	Balimela	17.52
Bhatghar	2.78	Bhakra	17.69
Periyar	2.91	Rana Pratap Sagar	19.58
Bagh	3.90	Tawa	19.82
Mula	4.99	Nagarjunasagar	28.48
Nimba	5.08	Nizam Sagar	30.16
Tehri	5.20	Tungabhadra	35.88
Idukki	5.78	Majalgaon	36.95
Ibadoh	6.02	Gohira	41.97
Kabini	6.35	Rihand	46.80
Tilaya	6.44	Sriram Sagar	55.97
Dimbhe	7.35	Ukai	60.13
Kayadhu	7.53	Srisailam	61.20
Kamthi Kheri	7.75	Pong	62.87
Totladoh	8.27	Gandhi Sagar	68.00
Hemavathy	8.50	Hirakud	75.00
Panchet Hill	8.61	Almatti	79.02
		Total	2028.24

Source: Evaluating Large Dams in India, Economic and Political Weekly, Satyajit K. Singh, March 17, 1990

Table: A.3.12 Number of Villages and Population Displaced for Different Dams in India

Name of Dam	Villages Displaced	Population Displaced
Kamthi Kheri	7	889
Ozarkhad	3	1354
Bagh	16	1374
Karanjwan	1	1600
Palkhed	1	1716
Ibadeh	19	2258
Bennithora	6	3000
Kanher	29	7080
Kayadhu	35	8857
Kabibi	20	11250
Hemavathy	46	11600
Nagarjunsagar	18	13227
Krishnaraja Sagar	25	15000
Isapur	26	15589
Dhimbe	69	18000
Hirakud	249	18000
Dham	35	19735
Almatti	228	20000
Mahibajaj Sagar	109	27325
Warna	37	29300
Koyna	100	30000
Gohira	130	31000
Hidkal	44	31133
Bhima	80	35069
Bhakra	375	36000
Tehri	92	46000
Narayanpur	93	48125
Gandhi Sagar	228	51514
Ukai	170	52000
Srisailam	65	52049
Rihand	108	55000
BALIMOLA	91	60000
Majalgaon	65	65296
Nizam Sagar	40	67445
Sriram Sagar	64	75090
Ukai	170	80000
Tilaya		13455
Maithon		28030
Panchet Hill		41461
Tungabhadra		54452
Pong		80000
Kangsabati Kumari		125000
Total		1385273

Source: Same as Table - A.3.11

Table: A.4.1 Percentage of Financial Expenditure on Different Projects

Plan	Major and Medium	Minor (State)	Minor (Institutional)	Minor (Total)	Command Area Development
First Plan (1951-56)	85.15	14.85	0.00	14.85	0.00
Second Plan (1956-61)	70.17	26.26	3.57	29.83	0.00
Third Plan (1961-66)	56.61	32.05	11.34	43.39	0.00
Annual Plan (1966-69)	43.60	32.59	23.81	56.40	0.00
Fourth Plan (1969-74)	51.56	21.01	27.43	48.44	0.00
Fifth Plan (1974-78)	61.52	15.34	19.53	34.87	3.61
Annual Plan (1978-80)	63.55	15.17	14.69	29.86	6.56
Sixth Plan (1980-85)	63.92	17.17	12.47	29.64	6.44
Seventh Plan (1985-90)	59.25	16.71	16.33	33.03	7.72
Annual Plan (1990-91)	59.77	18.42	15.33	33.75	6.48
Annual Plan (1991-92)	60.39	18.05	14.41	32.47	7.14
Eighth Plan (1992-97)	63.95	18.24	12.13	30.37	5.67

*Anticipated figure
Source: Water and Related Statistics, CWC

Table: A.4.2 Compound Growth Rate of Planwise Financial Expenditure on Irrigation in India at Constant Prices (1980-81=100)

Plan	Major and Medium	Minor (State)	Minor (Institutional)	Minor (Total)	Command Area Development	Major & Medium, Minor & CAD	Total Plan Expenditure in All Sectors
First and Second Plan	-1.97	14.20		17.16		1.90	16.40
Second Plan and Third Plan	3.94	12.91	36.70	16.94		8.50	8.00
Third Plan and Fourth Plan	2.47	-1.66	15.78	5.11		3.67	0.45
Fourth Plan and Sixth Plan	7.55	3.55	-1.83	0.86		5.46	9.07
Sixth Plan and Seventh Plan	1.81	2.81	9.10	5.64	7.19	3.37	7.75
Seventh Plan and Eighth Plan	0.67	0.84	-4.56	-1.61	-4.71	-0.42	
First Plan and Eighth Plan	3.03	4.28			3.76		5.58

Source: Same as Table-A.4.1

Table: A.4.3 Capital Expenditure in Major and Medium Irrigation as a Percentage of Total Capital Expenditure

State	1980-83	1987-90	1995-98
Andhra Pradesh	52.37	59.97	45.99
Assam	13.04	10.67	9.13
Bihar	45.24	50.33	44.27
Goa		19.76	21.36
Gujarat	52.33	49.37	60.04
Haryana	41.70	37.85	40.51
Karnataka	59.82	61.06	65.81
Kerala	36.00	30.05	22.40
Madhya Pradesh	44.62	41.06	26.58
Maharashtra	53.52	50.19	42.72
Orissa	61.13	36.09	49.37
Punjab	51.56	53.48	68.22
Rajasthan	40.38	29.21	17.84
Tamil Nadu	19.39	20.73	3.89
Uttar Pradesh	37.28	27.68	27.57
West Bengal	20.38	13.79	9.40

Source: State Finance Accounts

Table: A.4.4 Growth Rate of Capital Expenditure in Major and Medium Irrigation and Total Capital Expenditure

	Between 1980-83 & 1987-90			Between 1987-90 and 1995-98			Between 1980-83 and 1995-98		
State	M&M	Total	Difference	M&M	Total	Difference	M&M	Total	Difference
Andhra Pradesh	4.19	2.19	-2.00	0.38	3.77	3.39	2.14	3.03	0.89
Assam	4.33	7.38	3.04	-6.74	-4.92	1.83	-1.73	0.64	2.36
Bihar	4.75	3.17	-1.58	-11.85	-10.42	1.42	-4.46	-4.32	0.14
Goa			0.00	-1.06	-2.01	-0.96			0.00
Gujarat	0.74	1.59	0.84	9.93	7.28	-2.66	5.54	4.58	-0.96
Haryana	-8.97	-7.71	1.27	8.70	7.78	-0.92	0.06	0.25	0.19
Karnataka	0.29	-0.01	-0.29	11.04	10.01	-1.03	5.89	5.21	-0.67
Kerala	-3.09	-0.56	2.53	2.53	6.37	3.84	-0.13	3.08	3.21
Madhya Pradesh	4.18	5.43	1.24	-5.95	-0.70	5.25	-1.35	2.12	3.46
Maharashtra	3.44	4.40	0.96	4.89	7.03	2.13	4.21	5.79	1.58
Orissa	-2.09	5.57	7.66	2.10	-1.82	-3.92	0.13	1.56	1.44
Punjab	1.28	0.75	-0.53	8.95	5.68	-3.26	5.30	3.35	-1.95
Rajasthan	-2.57	2.04	4.61	4.27	10.91	6.63	1.02	6.68	5.66
Tamil Nadu	0.84	-0.12	-0.96	-9.09	12.05	21.14	-4.58	6.20	10.78
Uttar Pradesh	-0.27	4.06	4.33	-4.48	-4.43	0.05	-2.54	-0.56	1.98
West Bengal	1.86	7.71	5.85	2.26	7.28	5.02	2.07	7.48	5.41
Total	1.48	3.24	1.76	2.26	3.45	1.19	1.90	3.35	1.46

Source: Same as Table-A.4.3

Table: A.4.5 Statewise Capital Cost Of Irrigation Development Per Unit Of Potential Created (Rs 10 thousand/hectare in 1985-86 prices) And Compound Growth Rate (CGR) Between 1985-88 And 1993-96

State		E1/P	E2/P	E3/P	State		E1/P	E2/P	E3/P
Andhra Pradesh	1985-88	12.42	16.48	21.71	Madhya Pradesh	1985-88	6.36	8.43	11.11
	1993-96	63.49	84.20	110.96		1993-96	3.98	5.28	6.96
	CGR	22.62	22.62	22.62		CGR	-5.69	-5.69	-5.69
Assam	1985-88	3.95	5.24	6.91	Maharastra	1985-88	9.68	12.84	16.91
	1993-96	3.63	4.81	6.34		1993-96	11.38	15.10	19.89
	CGR	-1.07	-1.07	-1.07		CGR	2.05	2.05	2.05
Bihar	1985-88	7.73	10.26	13.51	Manipur	1985-88	3.87	5.13	6.76
	1997-98	37.96	50.35	66.35		1997-98	23.63	31.34	41.30
	CGR					CGR			
Gujarat	1985-88	9.03	11.97	15.78	Orissa	1985-88	20.04	26.58	35.02
	1993-96	19.74	26.18	34.50		1993-96	5.40	7.16	9.44
	CGR	10.27	10.27	10.27		CGR	-15.12	-15.12	-15.12
Haryana	1985-88	5.89	7.81	10.29	Punjab	1985-88	4.14	5.49	7.23
	1993-96	10.99	14.58	19.21		1993-96	1.22	1.61	2.12
	CGR	8.11	8.11	8.11		CGR	-14.19	-14.19	-14.19
Himachal Pradesh	1985-88	6.69	8.88	11.70	Rajasthan	1985-88	5.35	7.10	9.36
	1993-96	5.40	7.17	9.44		1993-96	3.51	4.65	6.13
	CGR	-2.64	-2.64	-2.64		CGR	-5.16	-5.16	-5.16
Jammu & Kashmir	1985-88	20.07	26.61	35.07	Tamil Nadu	1985-88	5.32	7.06	9.30
	1993-96	35.51	47.10	62.06		1997-98	27.56	36.55	48.16
	CGR	7.40	7.40	7.40		CGR			
Karnataka	1985-88	3.81	5.05	6.66	Uttar Pradesh	1985-88	5.52	7.32	9.65
	1993-96	7.64	10.13	13.35		1993-96	6.24	8.28	10.91
	CGR	9.09	9.09	9.09		CGR	1.54	1.54	1.54
Kerala	1985-88	16.37	21.72	28.62	West Bengal	1985-88	7.87	10.44	13.76
	1993-96	6.04	8.01	10.56		1993-96	4.38	5.81	7.66
	CGR	-11.72	-11.72	-11.72		CGR	-7.06	-7.06	-7.06
India	1985-88	7.13	9.46	12.46					
	1993-96	8.00	10.61	13.99					
	CGR	1.45	1.45	1.45					

Notes: P=potential created, Ei= expenditure at social rate of discount, 5% when i=1, 7.5% when i=2, 10% when i=3

Source: Government of India, Ninth Five Year Plan, Planning Commission, New Delhi, 1998 & State Finance Accounts

Table: A.4.6 Growth Rate of Capital Expenditure in Major and Medium Irrigation Between 1985-88 and 1993-96 and Capital Expenditure on M&M as a Percentage of Total Capital Expenditure of the State

State	Growth Rate	Share at1985-88	Share at 1993-96
Andhra Pradesh	2.07	56.48	30.37
Assam	-2.73	9.32	9.43
Bihar	-14.33	49.63	48.09
Goa	18.11	16.66	23.06
Gujarat	5.56	44.74	49.72
Haryana	-11.60	65.41	27.61
Karnataka	10.31	54.19	57.98
Kerala	0.48	28.23	25.82
Madhya Pradesh	-6.54	49.49	37.04
Maharashtra	6.13	45.66	36.05
Orissa	-5.32	41.09	31.06
Punjab	12.24	67.28	54.57
Rajasthan	4.38	34.28	26.60
Tamil Nadu	-3.39	27.90	11.83
Uttar Pradesh	-9.47	30.32	24.38
West Bengal	0.42	21.22	11.11
Total	0.34	41.71	33.81

Source: Same as Table-A.4.3

Table: A.4.7 Statewise Constant Growth Rate of Capital and Revenue Expenditure between 1980-81 and 1997-98

	Capital Expenditure					Revenue Expenditure				
State	b	Sig	R^2	g	Growth	b	sig	R^2	g	Growth
Andhra Pradesh	0.02	0.01	0.37	0.02	2.14	0.07	0.00	0.74	0.08	7.51
Assam	-0.01	0.77	0.01	-0.01	-0.85	0.03	0.04	0.23	0.03	2.54
Bihar	-0.06	0.00	0.53	-0.06	-6.23	0.01	0.03	0.25	0.01	1.35
Gujarat	0.05	0.00	0.47	0.05	4.92	0.06	0.02	0.31	0.06	6.05
Haryana	-0.02	0.28	0.07	-0.02	-2.31	0.05	0.00	0.65	0.05	4.92
Karnataka	0.06	0.00	0.79	0.07	6.51	0.04	0.00	0.95	0.05	4.57
Kerala	-0.01	0.24	0.08	-0.01	-0.89	0.05	0.02	0.28	0.05	4.66
Madhya Pradesh	-0.02	0.04	0.25	-0.02	-2.15	0.08	0.00	0.91	0.08	8.35
Maharashtra	0.04	0.00	0.60	0.04	3.59	0.08	0.00	0.96	0.09	8.53
Orissa	-0.01	0.21	0.10	-0.01	-1.42	0.07	0.00	0.76	0.07	6.89
Punjab	0.04	0.25	0.08	0.04	4.14	0.04	0.00	0.76	0.04	3.96
Rajasthan	0.01	0.08	0.18	0.01	1.39	0.04	0.00	0.85	0.04	4.16
Tamil Nadu	-0.04	0.05	0.22	-0.04	-4.23					
Uttar Pradesh	-0.05	0.00	0.51	-0.05	-4.59	0.06	0.00	0.80	0.06	6.20
West Bengal	0.02	0.15	0.13	0.02	1.91	0.03	0.00	0.71	0.03	3.24

Source: Same as Table-A.4.3

Table: A.4.8 State wise Revenue Expenditure On Major And Medium Irrigation, Minor Irrigation And Command Area Development Programme as a Percentage Of Total Revenue Expenditure

	Major and Medium Irrigation					Minor Irrigation					Command Area Development				
State	1980-81	1985-86	1990-91	1995-96	1998-99	1980-81	1985-86	1990-91	1995-96	1998-99	1980-81	1985-86	1990-91	1995-96	1998-99
Andhra Pradesh	7.40	5.32	6.49	6.64	6.49	1.07	1.51	0.89	0.57	0.33	0.45	0.25	0.05	0.05	0.03
Assam	0.13	0.13	0.12	0.08	0.18	1.14	0.67	0.72	0.31	0.61	0.00	0.00	0.00	0.00	0.00
Bihar	2.27	1.92	1.26	1.02	1.45	1.17	1.68	1.94	1.24	1.13	0.67	0.53	0.34	0.25	0.10
Goa			0.67	0.42	0.45			0.45	0.35	0.45			0.40	0.15	0.17
Gujarat	7.62	9.79	1.23	8.35	8.40	1.99	1.64	1.20	1.41	1.09	0.63	0.65	0.36	0.25	0.17
Haryana	9.27	7.13	5.78	4.24	3.72	0.26	0.13	1.31	0.17	0.06	0.66	0.47	0.62	0.68	0.48
Karnataka	5.93	4.84	4.23	4.03	3.90	1.98	0.93	0.98	0.53	0.51	0.60	1.19	0.63	0.29	0.18
Kerala	0.86	0.76	0.84	0.60	0.45	1.14	0.63	0.75	0.88	0.67	0.02	0.10	0.57	0.36	0.23
Madhya Pradesh	1.00	1.64	1.69	1.87	1.84	3.17	1.24	0.77	0.45	0.27	0.65	0.46	0.29	0.49	0.16
Maharashtra	4.60	5.18	5.82	6.18	5.81	1.02	0.95	1.09	1.38	0.98	0.13	0.57	0.40	0.20	0.11
Orissa	1.40	0.56	0.76	0.96	0.86	3.43	1.78	1.34	1.32	1.16	0.84	0.27	0.20	0.18	0.20
Punjab	4.17	4.96	3.47	2.40	2.22	0.67	1.44	0.78	0.40	0.34	0.00	0.00	0.00	0.00	0.00
Rajasthan	7.52	7.41	4.39	4.03	4.58	0.81	1.73	1.25	0.64	0.58	1.33	1.26	0.68	0.92	0.71
Tamil Nadu	0.00	1.92	0.00	0.06	0.06	0.01	0.01	0.01	0.01	0.01	4.23	2.29	1.90	1.59	1.91
Uttar Pradesh	4.42	3.76	4.02	3.48	2.70	3.88	3.52	2.49	3.47	2.38	1.48	0.59	0.38	0.28	0.17
West Bengal	1.35	1.28	1.11	0.99	0.99	2.08	1.62	1.53	1.30	1.46	0.41	0.03	0.03	0.02	0.02

Source: Same as Table-A.4.3

Table: A.4.9 State wise And Year wise Percentage Recovery Of Working Expenses Through Gross Receipts In Irrigation And Multipurpose River Valley Projects

State	1975-76	1980-81	1985-86	1990-91	1995-96
Andhra Pradesh	16.9	7	36.9	14	13.3
Bihar	94.4	63.2	29.3	11.2	36.9
Gujarat	94.3	34.4	25.8	6	5.1
Haryana	77.9	64.4	46.8	15.5	9.5
Jammu & Kashmir	2	1.8	8	3	14
Karnataka	129.2	7.6	6.8	10	4.9
Kerala	69.6	49.5	24.9	9	7.7
Madhya Pradesh	539.9	45.5	41.8	19.7	21.3
Maharastra	134.4	93.8	48.9	3.6	7.3
Orissa	86.4	46.8	134.9	26.8	24.7
Punjab	113.4	73.8	48.3	16.2	27
Rajasthan	104.9	55.9	19.3	10.7	6.4
Tamil Nadu	9.9	15.6	6.8	2.6	2.5
Uttar Pradesh	184.9	134.4	169.8	9	17
West Bengal	46.8	11	7.3	2.7	2.7
All India	91.1	45.8	46	9	10.4

Source: Water and Related Statistics, CWC

Table: A.4.10 Compound growth rate of Per Unit of Gross Receipts, Working Expenses between 1987-90 and 1993-96 (at 1987-88==100)

State	Gross Receipts/Potential Utilised	Working Expenses Including Interest/Potential Utilised
Andhra Pradesh	22.61	1.13
Bihar	7.76	-5.08
Gujarat	-1.28	-2.86
Haryana	-1.61	7.66
Jammu & Kashmir	16.31	9.14
Karnataka	-11.68	0.22
Kerala	-11.02	-7.88
Madhya Pradesh	-3.51	3.29
Maharastra	7.81	1.28
Orissa	-7.66	5.34
Punjab	-1.35	-1.88
Rajasthan	-3.18	5.02
Tamil Nadu	6.67	0.58
Uttar Pradesh	13.40	-0.35
West Bengal	-2.02	-0.48
Total	5.65	1.91

Source: Same as Table-A.4.9

Table: A.4.11 Average Working Expenses and Gross Receipts Per Hectare of Potential Utilized of Irrigation and Multipurpose River Valley Projects during 1987-90 and 1993-96 (1987-88=100)

State	Year	Gross Receipts/Potential Utilized	Working Expenses Including Interest (W.E)/Potential Utilized
Andhra Pradesh	1987-90	48.34	1019.64
	1993-96	164.26	1090.57
	Difference	115.92	70.93
Bihar	1987-90	27.38	206.7
	1993-96	42.86	151.16
	Difference	15.48	-55.54
Gujarat	1987-90	185.11	3344.43
	1993-96	171.36	2810.01
	Difference	-13.75	-534.42
Haryana	1987-90	63.18	508.92
	1993-96	57.31	792.4
	Difference	-5.87	283.48
Jammu & Kashmir	1987-90	6.97	157.99
	1993-96	17.26	266.97
	Difference	10.29	108.98
Karnataka	1987-90	108.41	1042.89
	1993-96	51.46	1056.84
	Difference	-56.95	13.95
Kerala	1987-90	45.26	509.31
	1993-96	22.46	311.32
	Difference	-22.8	-197.99
Madhya Pradesh	1987-90	114.62	389.7
	1993-96	92.52	473.16
	Difference	-22.1	83.46
Maharastra	1987-90	217.72	3742.33
	1993-96	341.79	4038.4
	Difference	124.07	296.07
Orissa	1987-90	43.41	112.54
	1993-96	26.91	153.77
	Difference	-16.5	41.23
Punjab	1987-90	62.79	270.76
	1993-96	57.88	241.57
	Difference	-4.91	-29.19
Rajasthan	1987-90	70.01	628.59
	1993-96	57.66	843.1
	Difference	-12.35	214.51
Tamil Nadu	1987-90	8.4	428.78
	1993-96	12.38	443.85
	Difference	3.98	15.07
Uttar Pradesh	1987-90	44.51	485.29
	1993-96	94.66	475.07
	Difference	50.15	-10.22
West Bengal	1987-90	12.18	337.5
	1993-96	10.78	327.94
	Difference	-1.4	-9.56
Total	1987-90	39.34	440.99
	1993-96	54.69	494.05
	Difference	15.35	53.06

Source: Same as Table-A.4.9

Table: A.4.12 Percentage of Operation and Maintenance Expenditure going for Establishment and Works

State	Year	Establishment	Works	Works/Establishment
Bihar	1986-87	61.33	38.67	0.63
Bihar	1987-88	56.76	43.24	0.76
Bihar	1988-89	56.70	43.30	0.76
Bihar	1989-90	62.34	37.66	0.60
Bihar	1990-91	66.64	33.36	0.50
Haryana	1986-87	52.28	47.72	0.91
Haryana	1987-88	60.22	39.78	0.66
Haryana	1988-89	63.43	36.57	0.58
Haryana	1989-90	69.55	30.45	0.44
Haryana	1990-91	66.62	33.38	0.50
Madhya Pradesh	1986-87	25.02	74.98	3.00
Madhya Pradesh	1987-88	24.98	75.02	3.00
Madhya Pradesh	1988-89	25.00	75.00	3.00
Madhya Pradesh	1989-90	25.02	74.98	3.00
Maharastra	1986-87	30.76	69.24	2.25
Maharastra	1987-88	29.71	70.29	2.37
Maharastra	1988-89	54.89	45.11	0.82
Maharastra	1989-90	55.28	44.72	0.81
Punjab	1986-87	68.48	31.52	0.46
Punjab	1987-88	68.95	31.05	0.45
Punjab	1988-89	72.91	27.09	0.37
Punjab	1989-90	75.14	24.86	0.33
Punjab	1990-91	76.96	23.04	0.30
Uttar Pradesh	1986-87	19.10	80.90	4.24
Uttar Pradesh	1987-88	54.31	45.69	0.84
Uttar Pradesh	1988-89	38.04	61.96	1.63
Uttar Pradesh	1989-90	46.68	53.32	1.14
West Bengal	1986-87	40.98	59.02	1.44
West Bengal	1987-88	43.34	56.66	1.31
West Bengal	1988-89	44.34	55.66	1.26
West Bengal	1989-90	49.15	50.85	1.03
West Bengal	1990-91	52.80	47.20	0.89

Source: Government of India, 1992. Report of the Commission on Pricing Irrigation Water, Planning Commission, New Delhi.

Table: A.4.13 Basic Data On Irrigation Needs, Irrigated Area, And Water Rates Under Major And Medium Projects In Selected States (1991)

	Gujarat			Karnataka			Madhya Pradesh		
	1	2	3	1	2	3	1	2	3
Paddy	91	110	82.4	78	87	431	100	59	4.7
Coarse Cereals	18	40	67.8	30	19	271	15	37	0.31
Wheat	75	10	144.2	83	54	45	63	62	668
Pulses	23	10	16.7	29	37	35	49	42	182
Sugarcane	278	830	36.2	251	370	112	169	297	39
Oilseeds	60	100	157.9	30	59	205	24	54	58
Cotton	107	100	150.3	96	99	82	40	59	34
	Orissa			Punjab			Uttar Pradesh		
	1	2	3	1	2	3	1	2	3
Paddy	85	40	1012	123	48	635	87	98	789
Coarse Cereals	41	21	16	20	30	89	26	68	289
Wheat	38	32	38	51	29	1138	52	98	319
Pulses	25	11	77	16	24	34	42	66	304
Sugarcane	122	100	26	160	68	31	172	168	394
Oilseeds	69	26	55	44	32	52	17	68	119
Cotton				59	33	218	59	35	9

1. Irrigation depth in cm
2. Water rate on major and medium irrigation works (Rs. per ha)
3. Gross Irrigated area (000 ha)

Source: Same as Table-A.4.12

Table: A.4.14 Working Expenses And Gross Receipts Per Hectare Of Potential Utilization Of Irrigation And Multipurpose River Valley Projects And Range Of Water Rates

(Rs/hectare)

			Water Rates		
States	Working Expenses	Gross Receipts	Minimum	Maximum	Simple Average
Andhra Pradesh	2378	316	148.27	1235.55	691.91
Bihar	342	126	74.13	296.53	185.33
Gujarat	5900	300	25	830	427.5
Haryana	1237	114	23.96	119.6	71.78
Jammu & Kashmir	480	67	1.53	289.12	145.325
Karnataka	2436	120	19.77	556	287.885
Kerala	672	52	17	99	58
Madhya Pradesh	1075	229	14.83	296.53	155.68
Maharastra	7960	577	50	800	425
Orissa	323	80	14	463	238.5
Punjab	559	125	14.83	98.84	56.835
Rajasthan	1747	111	19.77	143.32	81.545
Tamil Nadu	982	24	18.53	61.78	40.155
Uttar Pradesh	1015	173	20	474	247
West Bengal	617	20	37.06	123	80.03
All India	1665	173			

Source: Same as Table-A.4.9

Table-A.4.15 Regression result of Gross Recovery Per Hectare on Working Expenditure and Water Rate Per Hectare

Regress GR = a + b WE + c SA

Source	SS	df	MS
Model	243570.577	2	121785.288
Residual	52414.3567	12	4367.86305
Total	295984.933	14	21141.781

Number of obs = 15
F(2, 12) = 27.88
Prob > F = 0.0000
R-squared = 0.8229
Adj R-squared = 0.7934
Root MSE = 66.09

GR	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
WE	.0452392	.0100026	4.523	0.001	.0234454	.067033
SA	.248363	.1202414	2.066	0.061	-.0136204	.5103465
_cons	25.79606	26.88552	0.959	0.356	-32.78246	84.37458

. hettest
Cook-Weisberg test for heteroscedasticity using fitted values of GR
Ho: Constant variance
chi2(1) = 1.84
Prob > chi2 = 0.1751

Regress GR = a + b WE + c MI

Source	SS	df	MS
Model	244162.439	2	122081.22
Residual	51822.4943	12	4318.54119
Total	295984.933	14	21141.781

Number of obs = 15
F(2. 12) = 28.27
Prob > F = 0.0000
R-squared = 0.8249
Adj R-squared = 0.7957
Root MSE = 65.716

GR	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
WE	.0542563	.0081316	6.672	0.000	.036539	.0719736
MI	1.041213	.4934589	2.110	0.057	-.033942	2.116367
_cons	27.37467	26.21965	1.044	0.317	-29.75304	84.50237

. hettest
Cook-Weisberg test for heteroscedasticity using fitted values of GR
Ho: Constant variance
chi2(1) = 0.01
Prob > chi2 = 0.9063

Regress GR = a + b WE + c MA

Source	SS	df	MS
Model	242268.232	2	121134.116
Residual	53716.7009	12	4476.39174
Total	295984.933	14	21141.781

Number of obs = 15
F(2. 12) = 27.06
Prob > F = 0.0000
R-squared = 0.8185
Adj R-squared = 0.7883
Root MSE = 66.906

GR	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
WE	.0449112	.0103635	4.334	0.001	.022331	.0674915
MA	.1317105	.0669343	1.968	0.073	-.0141269	.2775478
_cons	27.57618	27.02368	1.020	0.328	-31.30336	86.45572

. hettest
Cook-Weisberg test for heteroscedasticity using fitted values of GR
Ho: Constant variance
chi2(1) = 2.11
Prob > chi2 = 0.1463

Table: A.4.16 Correlation Coefficients Between Cannel Irrigated Area For Broad Size-class of Operational Holding and Size of Operational Holding (1991-92)

State	All Season	Kharif Season	Rabi Season
Andhra Pradesh	-0.21562	-0.21151	-0.32141
Arunachal Pradesh	-0.23893	-0.21368	-0.37857
Assam	-0.0518	-0.35311	-0.33495
Bihar	-0.1799	-0.07752	-0.21876
Gujarat	-0.03944	0.095052	0.010823
Haryana	0.964886	-0.0086	0.920727
Himachal Pradesh	-0.66469	-0.66701	-0.71113
Jammu & Kashmir	-0.35845	-0.35142	-0.36204
Karnataka	0.410704	0.250833	0.418397
Kerala	-0.63466	-0.57463	-0.68861
Madhya Pradesh	0.314364	0.232449	0.239832
Maharastra	0.274739	0.450239	0.483927
Orissa	-0.44699	-0.48428	-0.48944
Punjab	0.50969	0.502771	0.50861
Rajasthan	0.996578	0.986135	0.966625
Sikkim	-0.01115	0.121794	-0.47886
Tamil Nadu	-0.48515	-0.55558	-0.6881
Tripura	-0.62176	-0.4191	-0.51818
Uttar Pradesh	-0.30957	-0.3808	-0.35235
West Bengal	-0.44978	-0.52235	-0.75104
India	0.486296	0.060195	0.420367

Source: National Sample Survey. 48th Round

Table: A.4.17 Ranks and Spearman's Rank Correlation Coefficient between GR/hec (1990-93) and Rank of Correlation Coefficient Between Canal Irrigated Area for Different Farm Sizes and Size of Farm (1991-92)

		All Season	Kharif Season	Rabi Season
State	**RGR (1990-93)**	**RCAS**	**RCAS**	**RCAS**
Andhra Pradesh	11	7	7	7
Bihar	5	8	8	8
Gujarat	14	9	10	9
Haryana	9	14	9	14
Jammu & Kashmir	3	5	6	5
Karnataka	13	12	12	11
Kerala	4	1	1	2
Madhya Pradesh	12	11	11	10
Maharastra	15	10	13	12
Orissa	6	4	4	4
Punjab	7	13	14	13
Rajasthan	10	15	15	15
Tamil Nadu	1	2	2	3
Uttar Pradesh	8	6	5	6
West Bengal	2	3	3	1
Correlation Coefficient Between GR/hec and RCAS		0.668	0.725	0.689
Significance		0.007	0.002	0.004

Note: RCAS = Rank of Correlation Coefficient Between Canal Irrigated Area For Different Farm Sizes and Size of Farm
RGR = Rank of GR/hectare
Source: Same as Table-A.4.16

Table: A.5.1 Summery Table About Major and Medium Irrigation Water Resource Management

State	Percentage Irrigated of Net Cropped Area (1995-96)	Percentage Irrigated of Gross Cropped Area (1995-96)	Percentage of Creation of Ultimate Irrigation Potential (upto Eighth Plan) in Major & Medium Irrigation	Potential Utilisation as a Percentage of Potential Creation (upto Eighth Plan)	Compound Growth Rate of Potential Creation Per Year Between 1985-88 and 1993-96	Compound Growth Rate of Capital Expenditure Between 1985-88 and 1993-96	Capital Cost of Irrigation Development (per Unit of Potential Created) in 1993-96 (EI/P)*	Compound Growth Rate of Capital Cost (column 8) between 1985-88 and 1993-96	Percentage Recovery of Working Expenses Through Gross Receipts (1995-96)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Andhra Pradesh	38.76	40.67	60.9	94.21	-29.5956	2.07	63.49	22.62	13.3
Arunachal Pradesh	19.46	14.75			0.450576				
Assam	20.72	14.53	20.31	70.05	-25.2371	-2.73	3.63	-1.07	
Bihar	50.27	45.72	43.12	82.91	-14.7643	-14.33	37.96**		36.9
Gujarat	31.16	36.25	45	88.89	-16.9387	5.56	19.74	10.27	5.1
Haryana	76.99	76.87	69.3	88.22	-7.25429	-11.6	10.99	8.11	9.5
Himachal Pradesh	17.78	18.31	22	54.55	-0.98548		5.4	-2.64	
Jammu &Kashmir	52.59	41.01	69.6	85.06	-6.89525		35.51	7.4	14
Karnataka	22.09	23.79	66.64	88.36	-5.17624	10.31	7.64	9.09	4.9
Kerala	15.1	15.2	51.3	90.45	-6.30277	0.48	6.04	-11.72	7.7
Madhya Pradesh	30.01	24.67	38.63	69.93	-16.3274	-6.54	3.98	-5.96	21.3
Maharastra	14.33	14.77	57	55.69	-4.21064	6.13	11.38	2.05	7.3
Manipur	46.43	41.21	46.67	82.54	3.051291		23.63**		
Meghalaya	21.84	18.22	0		-9.05371				
Mizoram	6.42	8.26			-4.20456				
Nagaland	29.38	31.58	0		-20.3837				

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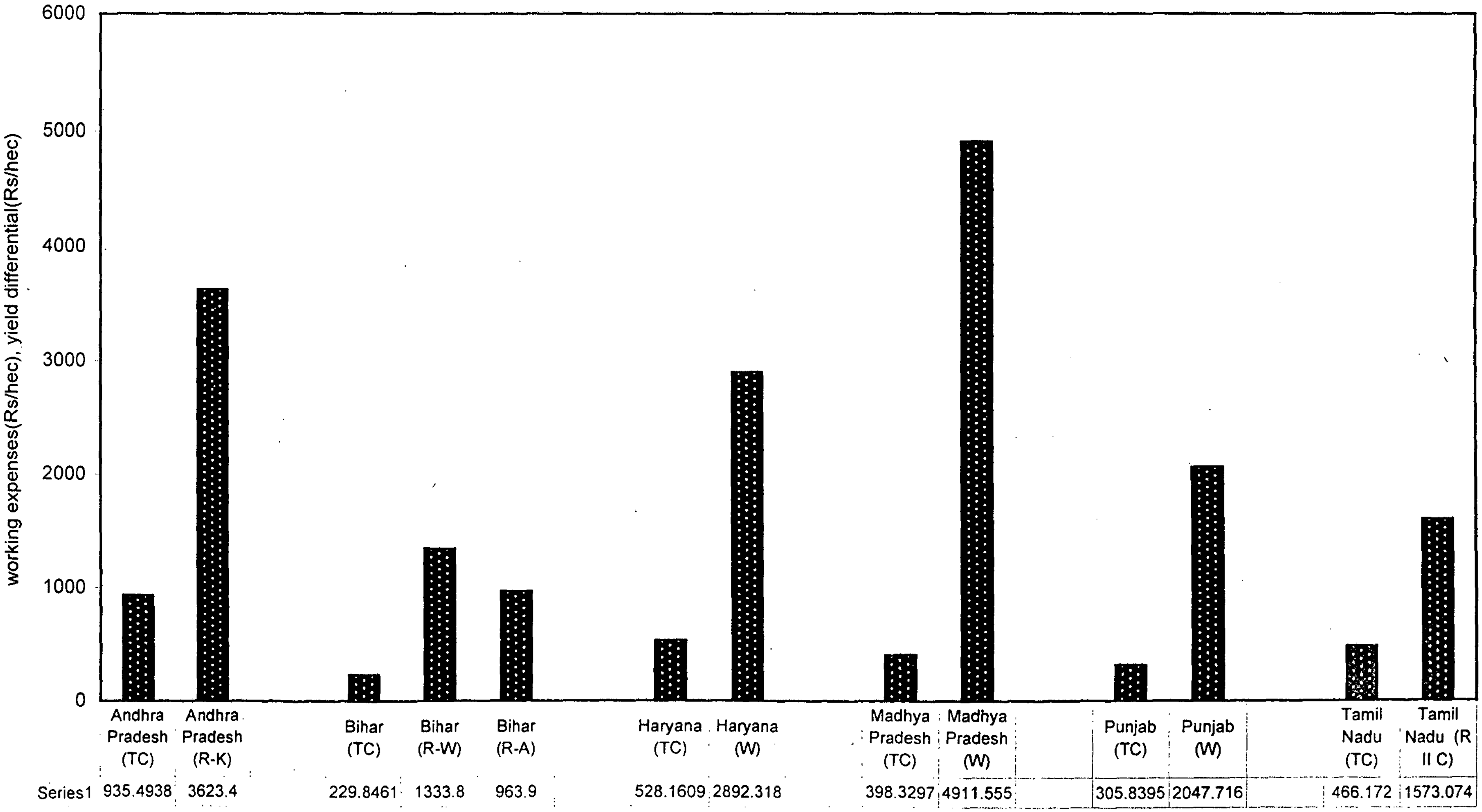
Orissa	33.66	27.22	43.28	92.62	-8.12143	-5.32	5.4	-15.12	24.7
Punjab	92.95	95.16	83.77	97.57	-4.51245	12.24	1.22	-14.19	27
Rajasthan	31.57	32.34	82.69	91.82	-21.4674	4.38	3.51	-5.16	6.4
Sikkim	16.84	11.27	0		-5.76966				
Tamil Nadu	49.14	50.79	103.07	99.94	-29.343	-3.39	27.56**		2.5
Tripura	12.64	14.08	2	100	-18.043				
Uttar Pradesh	67.1	65.8	56.34	86.78	1.763227	-9.47	6.24	1.54	17
West Bengal	34.99	27.76	62.3	92.31	6.849573	0.42	4.38	-7.06	2.7
Total	37.6	38.3	56.37	86.18	-2.41546		8	1.45	10.4

Chart

Figure-1 Comparison Between Total Cost and Gain From Canal Irrigation (1992-93)



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