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Spatial and Temporal Investment Pattern in Irrigation Development and its Impact on Indian Agriculture

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LIST OF ABBREVIATIONS

ADF	:	Augmented Dickey-Fuller
AIBP	:	Accelerated Irrigation Benefit Programme
BCM	:	Billion Cubic Meter
C&S	:	Condiments and Spices
CAD	:	Command Area Development
CGR	:	Compound Growth Rate
CGWB	:	Central Ground Water Board
CI	:	Cropping Intensity
CLA	:	Central Loan Assistance
CWC	:	Central Water Commission
F & V	:	Fruits and Vegetables
FYP	:	Five Year Plan
GDP	:	Gross Domestic Product
GSA	:	Gross Sown Area
HVACs	:	High Value Agricultural Commodities
HYV	:	High Yielding Varieties
II	:	Irrigation Intensity
IMT	:	Irrigation Management Transfer
IPC	:	Irrigation Potential Created
IPU	:	Irrigation Potential Utilized
M&M	:	Major and Medium
MoWR	:	Ministry of Water Resources
NABARD	:	National Bank for Agriculture and Rural Development
NCA	:	National Commission of Agriculture
NCIWRDP	:	National Commission for Integrated Water Resources Development Plan
NIA	:	Net Irrigated Area
NSA	:	Net Sown Area
O&M	:	Operation and Maintenance
PAC	:	Public Accounts Committee
PIM	:	Participatory Irrigation Management
RIDF	:	Rural Infrastructure Development Fund
UIP	:	Ultimate Irrigation Potential

1. Introduction

Water resources occupy a special place among other natural resources. It is fundamental for sustaining a high quality of life and economic and social development. The estimates suggest that the Earth's hydrosphere contains a huge amount of water, but 97.5 per cent is in the form of ice and permanent snow cover in polar and high mountainous regions. Out of total fresh water available, which is only 2.7 per cent of total water on the Earth, only 0.26 per cent is concentrated in lakes, reservoirs and river systems and 22.6 per cent is available as groundwater (Shiklomanov, 2000). The annual rainfall in India is 120 cm but its distribution is temporarily and spatially uneven. As entire rainfall in India occurs within the narrow span of few days, it has led to increasing reliance on groundwater as well as surface water for irrigation purposes which has historically played and will continue to play a critical role in agricultural development and overall well being of many societies around the World.

Irrigated agriculture is the dominant user of water, accounting for about 80 per cent of global and 86 per cent of developing countries' water consumption (Kumar *et al.*, 2003). Gross water demand for all users in India is expected to grow up from 750 billion cubic meter (BCM) in 2000 to 1027 BCM by 2025. The gross water demand by irrigation sector alone is estimated to be 730 BCM by 2025 (Rao, 1999). Population and income growth will boost demand for irrigation water to meet food production requirements, household and industrial water demand. Though, India has one of the largest irrigated areas in the World, its per capita or per hectare availability of water is one of the lowest (Johansson, 2002). Per capita availability of water in India has come down from 5300 cubic meter (1955) to 1967 cubic meter (1997) and it was 1588 cubic meter as on March 2010 (CWC, 2010) with a projection to further decrease and wide inter-basin variations.

Irrigation development, which in combination with high yielding varieties (HYV) contributed for the success of Green Revolution in sixties, has always been the priority area of national agricultural development strategy. Ascertaining precise contribution of irrigation is difficult (World Bank, 1998) because there are no official Indian statistical data that provide the breakdown of agricultural production under irrigated or rainfed conditions. Nevertheless, various estimates point to a contribution from irrigated agriculture to overall agricultural production of about two - thirds, and under some estimates an even higher contribution. The World Bank in its India Irrigation Sector Review in 1991 estimated irrigated agriculture's contribution to be about 55 per cent (World Bank, 1991). This matches with the Planning Commission (GOI, 1999) figure of 58 per cent of food production coming from irrigated area. Seckler and Sampath (1985) estimated that irrigation has contributed nearly sixty per cent to the growth in agricultural productivity. However, the contribution of different sources of irrigation in agricultural growth is not uniform. The area irrigated by Government canals in India since independence is increasing at the rate of 2.4 per cent, while that by wells is increasing at the rate of 3.9 per cent. (Kumar, 2005). Thus, the irrigation has been the mainstay of the agricultural development. But, due to unsustainable and inefficient development, water has become the scarcest natural resources. According to the study conducted by the International Water Management Institute, while India and China will not have major water problems on an average, there will be massive regional variations in water availability.

Over the past, huge amounts have been directly invested by the public sector in various major, medium and minor irrigation works. The biggest single malady in the irrigation sector right from the first plan has been the continued tendency to start more and more new projects resulting in thin spreading of resource and consequent time and cost overruns. The investment in any sector generates capital in the form of infrastructure, improvement in the quality of natural resources and assets, and lead to the creation of productive assets. In simple terms, 'investment' means acquiring physical assets and facilities that result in the creation of incremental income over a period of time. In the agricultural sector, investment in irrigation is generally undertaken for realizing the potential by augmenting natural resources and enhancing efficiency of existing resources. The present study diagnoses the investment pattern in irrigation sector over successive five year plans (FYPs) in different geographical regions and examines its impact on agriculture using the available data to provide a feedback for equitable and sustainable development of water resources.

2. Data and Methodology

The study is based on secondary data collected from published sources such as Financial Aspects of Irrigation Projects in India, Water and Related Statistics (2000 and 2010), Estimates of Area and Production of Major Crops in India (various issues), Agricultural Statistics at a Glance (various issues), etc. Time series data on different aspects such as investment in irrigation, land use statistics, source-wise irrigated area, ultimate irrigation potential (UIP), irrigation potential created (IPC), irrigation potential utilized (IPU), irrigated area under different crops, etc were collected for different states of India. Subsequently, the states were categorized in different geographical regions, *viz.* northern (Chandigarh, Delhi, Haryana, Himachal Pradesh, Jammu and Kashmir, Punjab, Uttar Pradesh and Uttarakhand), southern (Andhra Pradesh, Karnataka, Kerala, Pondicherry and Tamil Nadu), western (Gujarat, Madhya Pradesh, Maharashtra and Rajasthan) and eastern (Bihar, Chattisgarh, Jharkhand, Odisha, West Bengal and Assam) to provide a region-wise comparative study. Investment pattern in irrigation was analysed by examining the total expenditure in major, medium and minor projects, Accelerated Irrigation Benefit Programme (AIBP) and Command Area Development (CAD) projects over successive FYPs. Further, unit cost to create net irrigation potential was estimated over successive FYPs. Investment was expressed at constant price to make it comparable over the period of time. The study used tabular, growth and time-series regression analysis to study the existing status of water resources, investment pattern, irrigation development and its impact on agriculture over successive planning periods. The estimation procedure is given below;

Compound Growth Rate (CGR)

The compound growth rate (CGR) for the source-wise net irrigated area (NIA) and crop performance was estimated using the following formula;

$$Y_t = AB^t \quad \text{.... (1)}$$

where,

Y_t = variable under the study in t^{th} period

t = time variable (1, 2, 3……, n)

A = constant

B = (1+r) = constant, and

r = compound growth rate

After log transformation and estimation of the above function as $\ln Y_t = \ln A + t \ln B$, CGR has been estimated as;

$$r = \{\text{antilog}(\ln B) - 1\} * 100 \quad \text{... (2)}$$

Cropping Intensity (CI)

The gross sown area (GSA) was calculated as the sum of area under crops in all seasons (*kharif*, *rabi* and summer including perennials). The net sown area (NSA) was calculated as the sum of area under crops for a season.

$$Cropping\ Intensity\ (CI) = \frac{Gross\ \text{sown}\ Area}{Net\ \text{sown}\ Area} \times 100 \quad \text{... (3)}$$

Irrigation Intensity (II)

Gross irrigated area (GIA) is the sum of irrigated area under all crops in all seasons. Net irrigated area (NIA) is the irrigated area under all crops for a season.

$$Irrigation\ Intensity\ (II) = \frac{Gross\ Irrigated\ Area}{Net\ Irrigated\ Area} \times 100 \quad \text{... (4)}$$

Impact of irrigation on agriculture was examined by tabular analysis as well as by fitting time-series regression models. Yield (kg/ha) of the crops (rice, wheat, sugarcane, pulses, oilseeds) was regressed with respective crop's area under irrigation (Mha) and rainfall. Additionally, value of agricultural commodities per net sown area (` /ha) at 2004-05 prices was also regressed with irrigation and rainfall to see the overall impact of irrigation on agriculture sector. It is to be noted that for time series analysis, data series should be stationary (data fluctuate around a constant mean and variance over time). Stationarity conditions were checked using Augmented Dicky-Fuller (ADF) test in E-views 5.1 software. Irrigation and crop yield data series for all the crops were found to be trend-stationary after transforming them in logarithmic terms. Therefore, trend variable was also included in the regression analysis. In addition to making series stationary, trend variable also captures effect of technological improvement over the years. The functional form of time-series regression analysis was as follows,

$$\ln Y_t = C_1 + C_2 * \ln X_{1t} + C_3 * \ln X_{2t} + C_4 * X_{3t} \quad \ldots(5)$$

where,

Y_t = crop yield (Kg/ha) in t^{th} year
C_1 = constant/intercept
X_{1t} = irrigated area under crop (Mha) in t^{th} year
X_{2t} = rainfall (mm) in t^{th} year
X_{3t} = trend, and
C_2, C_3, C_4 = coefficients to be estimated

In case of wheat, time-series regression suffered with auto-correlation problem. To correct the problem of autocorrelation, two-step procedure was followed. In first step original series of respective wheat yield was regressed on proportion of area under irrigation. Then, variance $(\hat{\rho})$ was estimated using Durbin-Watson statistics $(\hat{\rho} \approx 1 - d/2)$. Subsequently, in the second step, $\hat{\rho}$ was used to transform the original series $(y_t - \hat{\rho} y_{t-1}$ and $x_t - \hat{\rho} X_{t-1}))$ and ordinary least square (OLS) technique was applied on transformed variables. Transformation of the variables solved the problem of autocorrelation. Additionally, Prais-Winsten transformation $\{Y_1 \sqrt{1 - \hat{\rho}^2}$ and $X_1 \sqrt{1 - \hat{\rho}^2}\}$ was applied to avoid loss of one observation due to differencing.

3. Results and Discussion

3.1. *Water Resources in India*

The water resources potential of the country has been assessed from time to time by different agencies. These estimates range between 1443 and 1953 BCM (Appendix 1). Most of the documents (Kumar *et al.,* 2005) on water resources of India have mentioned the figures of Central Water Commission (CWC) and National Commission for Integrated Water Resources Development Plan (NCIWRDP). The latest estimate of total water resources of India as assessed by NCIWRDP is 1952.87 BCM, but this cannot be fully put to beneficial use because of topographical and other constraints. The NCIWRDP also states that the CWC has estimated the utilizable surface water in each river basin considering suitable sites/locations for diversion and for storage structures as 690.31 BCM (Table 1).

The National Water Policy has also adopted the utilizable surface flow as 690.31 BCM, as estimated by CWC.

Table 1. Basin-wise annual utilizable water resources in India

Basin	Estimated Utilizable flow excluding groundwater (BCM)	Utilizable groundwater (CGWB assessment, 1983-84) (BCM)	Total Utilizable flow (BCM)
Indus (up to border)	46.00	17.81	63.81
Ganga	250.00	172.01	422.01
Brahmaputra	24.00	20.82	46.15
Barak	-	1.33	
Godavari	76.30	44.98	121.28
Krishna	58.00	24.62	82.62
Cauvery	19.00	10.42	29.42
Pennar	6.86	5.35	12.21
East flowing rivers between Mahanadi and Pennar	13.11	11.69	24.80
East flowing rivers between Pennar And Kanyakumari	16.73	21.08	37.81
Mahanadi	49.99	18.20	68.19
Brahmani and Baitarani	18.30	7.89	26.19
Subarnarekha	6.81	2.85	9.66
Sabarmati	1.93	4.38	6.31
Mahi	3.10	4.44	7.53
West Flowing rivers of Kutch and Saurashtra including Luni	14.98	12.61	27.59
Narmada	34.50	13.00	47.50
Tapi	14.50	6.73	21.23
West flowing rivers from Tapi to Tadri including tadri	11.34	8.98	20.92
West flowing rivers from Tadri to Kanyakumari	24.27	7.74	32.01
Area of inland drainage in Rajasthan	-	1.33	1.33
Minor river basins draining into Myanmar (Burma) and Bangladesh	-	0.28	0.280
Total	690.31	418.54	1108.85

Source: Water Resources of India, Publication No. 30/88, Central Water Commission, New Delhi, 1988.

The CWC adopted the possible utilization from groundwater as 418.54 BCM, which was taken from the estimates of CGWB. Based on a large amount of data with detailed analysis, the CGWB in 1994–95 estimated the replenishable groundwater as 431.9 BCM, which is taken as the sum of the recharge of 342.4 BCM from rainfall and the additional recharge of 89.5 BCM from the canal irrigation system. The NCIWRDP has also adopted the replenishable groundwater resources as 431.9

BCM as given in CGWB report and the total utilizable groundwater resources as 396 BCM. However, according to Garg and Hassan (2007) the utilizable water resources are over-estimated in various studies, ranging from 66 to 88 per cent. In the analyses of utilizable water resources, they mentioned that the CWC had directly adopted the values of utilizable flows in river basins from the estimates of the National Commission on Agriculture (NCA) which also included the interaction of surface and groundwater in the form of regenerated groundwater flows of 450 BCM into the rivers. These flows were taken as the natural groundwater recharge due to precipitation by the NCA. CWC had ignored this fact that estimated utilizable flows were taken after excluding the groundwater; therefore, CWC added 418.54 BCM as utilizable groundwater to the estimated utilizable flows and estimated total utilizable flows as 1110 BCM. If the entire utilizable groundwater of 418.54 BCM was to be added to the utilizable surface flows, then the latter should have been reduced by 450 BCM by the CWC. Thus, CWC has over-estimated the total utilizable flows to a total of 1110 BCM. Garg and Hassan (2007) estimated the utilizable water resources would be 668 BCM. Therefore, the projected demand of even 897 BCM by the year 2050, corresponding to low demand scenario, cannot be met even after full development of utilizable water resources.

3.1.1. Surface water resources

India is blessed with vast network of river basins with varying catchment area and surface water potential. Total catchment area of about 3227 thousand square km is divided into 20 river basins with average water resources potential of 1869.35 billion cubic meters (BCM) including both surface as well as groundwater (Table 2). However, due to various constrains of topography, uneven distribution of resources over space and time, only about 1123 BCM of total potential of 1869.35 BCM can be put to beneficial uses, 690.1 BCM being due to surface water resources. Out of all river basins, Ganga-Brahmaputra-Meghna river basin is the major contributor of the total water resources potential with 34 per cent, 59.41 per cent and 39.70 per cent contribution in total catchment area, total water resources potential and total utilizable surface water resources, respectively.

For the use of water during the non-monsoon seasons, there is a need to create storage capacities in reservoirs and tanks. About 80–90 per cent of the river flows occur during four months of the monsoon season. The total storage built up in the projects completed up to 2010 is about 225 BCM in the country. The projects under construction will contribute to additional 64 BCM, while the contribution expected from projects under consideration is 107 BCM. Thus, likely storage available will be 396 BCM once the projects under construction or consideration are completed against the total water availability of 1869 BCM in the river basins of the country. It is to be noted that maximum storage lies in the Ganga Basin and major States like Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Odisha and Uttar Pradesh together account for about 70 per cent of total live storage capacity in the country.

Table 2. Water resource potential of major river basins in India

River Basin	Catchment Area (Sq. km)	Average Water Resources Potential (BCM)	Utilisable Surface Water Resources (BCM)
Indus (up to Border)	3,21,289 (9.96)	73.31 (3.92)	46.00 (6.67)
Ganga, Brahmaputra, Barak & others	10,97,588 (34.01)	1,110.62 (59.41)	274.00 (39.70)
Godavari	3,12,812 (9.69)	110.54 (5.91)	76.30 (11.06)
Krishna	2,58,948 (8.02)	78.12 (4.18)	58.00 (8.40)
Mahanadi	1,41,589 (4.39)	66.88 (3.58)	50.00 (7.25)
Narmada	98,796 (3.06)	45.64 (2.44)	34.50 (5.00)
Tapi	65145 (2.02)	14.88 (0.80)	14.50 (2.10)
West flowing rivers from Tapi to Tadri	55940 (1.73)	87.41 (4.68)	11.90 (1.72)
West flowing rivers from Tadri to Kanyakumari	56177 (1.74)	113.53 (6.07)	24.30 (3.52)
East flowing rivers between Mahanadi and Pennar	86643 (2.68)	22.52 (1.20)	13.10 (1.90)
East flowing rivers between Pennar And Kanyakumari	100139 (3.10)	16.46 (0.88)	16.50 (2.39)
West Flowing rivers of Kutch and Saurashtra including Luni	321851 (9.97)	15.1 (0.81)	15.00 (2.17)
Area of inland drainage in Rajasthan	-	0	N.A
Minor river basins draining into Myanmar (Burma) and Bangladesh	36202 (1.12)	31 (1.66)	N.A
Total	32,27,021 (100)	1,869.35 (100)	690.10 (100)

Figures within parentheses are share of respective river basin in total
Source: Water and Related Statistics, 2010 (Central Water Commission)

There exists spatial and seasonal variation in the endowment of water. More than 90 per cent of the annual run-off in peninsular rivers and more than 80 per cent in Himalayan rivers occur during June to September months. Consequently, several areas with high rainfall also experience water shortage in other seasons. Chopra and Goldar (2000) estimated the approximate available surface water irrigation by live storage capacity of all kinds in India, including that provided by run-off in the river schemes (numbering 250) to store and use about 63.5 BCM of water. The

Northern region has maximum length of surface water storage structures and thereby the available surface water (Table 3). In the Eastern region, available surface water is the lowest, though these states are regularly affected by floods during monsoon season. This shows the poor development of irrigation canals and water management capacities in these states.

Table 3. Region-wise utilizable surface water

Region	Utilisable surface water (BCM)	Available surface water (BCM)	Length of rivers and canal (km)
North	294.50	134.80	51,470
South	179.93	81.26	31,026
East	68.90	31.53	12,046
West	178.19	72.62	27,726
India	690.32	315.98	1,20,628

Source: Chopra and Goldar (2000)

3.1.2. Groundwater resources

Groundwater has played a major role in increasing food production and achieving food security in India. The importance of groundwater resources in the country can be realized by the fact that about 50 per cent of the total irrigated area is dependent on groundwater (CWC, 2000) and about 60 per cent of the irrigated food production depends on irrigation from groundwater (Shah *et al.*, 2000). Total replenishable groundwater potential in India has been estimated as 433 BCM/year out of which 399 BCM groundwater can be made available for different uses annually, keeping aside 34 BCM for natural discharge (Table 4). The annual replenishable groundwater resource is contributed by two major sources- rainfall and other sources that include canal seepage, return flow from irrigation, seepage from water bodies and artificial recharge due to water conservation structures. The overall contribution of rainfall to the country's annual replenishable groundwater resource is 67 per cent and the share of other sources taken together is 33 per cent. Further, south-west monsoon being the most prevalent contributor of rainfall in the country, about 73 per cent of country's annual replenishable groundwater recharge takes place during the *Kharif* period of cultivation. The annual groundwater draft is 231 BCM out of which 213 BCM is for irrigation use and 18 BCM for domestic and industrial use. Overall groundwater development in the country is 58 per cent and about 161 BCM groundwater can be utilized for future irrigation. Thus, groundwater can be developed further in the country as a whole. However, there exists significant regional variation in its development across different regions and states. Development of groundwater in Delhi (170 per cent), Punjab (145 per cent), Rajasthan (125 per cent), Haryana (109 per cent) and Pondichery (105 per cent) is more than its sustainable level because of over-exploitation and injudicious use. This implies that in these states, the average annual groundwater consumption is more than average annual groundwater recharge.

Among the regions, Eastern region has maximum potential of groundwater resources (130 BCM/year) followed by Northern region (115 BCM/year). Uttar Pradesh ranks first among the all the states in terms of annual replenishable groundwater resources and contributes about 66 per cent (76 BCM/year) of groundwater resources of Northern region. In Western, Southern and Eastern regions, Madhya Pradesh, Andhra Pradesh and West Bengal have highest groundwater potential, respectively. It is to be noted that groundwater development in the groundwater abundant Eastern region is least (27 per cent) because of poor groundwater utilisation and unfavourable geological conditions for its development. Thus, Eastern region has a greater scope to harness the potential of this precious natural resource. Highest groundwater development is in the Northern region followed by Western region of the country.

Table 4. Region-wise groundwater resources availability, utilization and stage of development in India.

Particulars	North	West	South	East	India
Annual Replenishable Groundwater resources	115	98	83	130	433
Net Annual groundwater Availability	105	92	76	120	399
Annual Groundwater Draft	92	57	46	36	231
Irrigation	87	52	42	31	213
Domestic and industrial uses	5	4	4	4	18
Groundwater Availability for future irrigation	11	32	31	82	161
Stage of Groundwater Development	76	65	59	27	58

3.1.3. Ultimate irrigation potential (UIP)

Ultimate irrigation potential (UIP) as defined by Ministry of Water Resources (MoWR) is the gross irrigated area that theoretically could be irrigated if all available land and water resources would be used for irrigation. Total UIP of the country stands at around 139.89 million hectare (Mha) without inter-basin sharing and 175 Mha with inter-basin sharing (Table 5). The UIP from minor irrigation stands 22.96 Mha higher than major and medium irrigation potential in India. Further, in minor irrigation, groundwater accounts for 78.7 per cent of total minor UIP making it most important source of irrigation. Among the regions, Northern region contribute highest (30.52 per cent) share in the total UIP followed by Western region. Northern region also contribute highest share in total UIP of major and medium surface water, total UIP of minor irrigation (total) and total UIP of minor irrigation (groundwater). However, in UIP of minor irrigation (surface water), Eastern region contributed highest share (30.45 per cent). Andhra Pradesh ranks first among the states (Appendix 2). The abundant water resources of Eastern region is not accessible to farmers at the right time and place because of poor infrastructure and groundwater development making it high potential but poor performing region of the country. Thus, better irrigation infrastructure and groundwater development would open scope for diversification of crops as well as enterprises through multiple uses of water and integrated water management to increase the income of the farmers. Uttar Pradesh ranks first in total UIP from all types of schemes among all the states followed by Madhya Pradesh. Uttar Pradesh is the major state in UIP of major and medium irrigation as well as UIP of minor irrigation from groundwater. It is to be noted that total UIP of all types of schemes except minor surface water is least in Southern region of the country.

Table 5. Region-wise Ultimate Irrigation Potential (UIP)

Region	Major and medium surface water	Minor irrigation			Grand Total
		Surface water	Groundwater	Total	
North	18800 (32.16)	1935 (11.16)	21954 (34.25)	23889 (29.34)	42689 (30.52)
West	14765 (25.25)	4283 (24.70)	17436 (27.20)	21719 (26.67)	36484 (26.08)
South	10000 (17.10)	5200 (29.99)	10245 (15.98)	15445 (18.97)	25445 (18.19)
East	14517 (24.83)	5279 (30.45)	13861 (21.63)	19140 (23.51)	33657 (24.06)
India	58465 (100)	17337 (100)	64092 (100)	81429 (100)	139894 (100)

Figures within parentheses are share of respective region in total UIP
Total may not tally because non_availability of data for some States

It is to be noted that, many researchers have questioned UIP estimates. Seasonal imbalance in flow of rivers, geographic incongruity between regions with undeveloped water potential and those with irrigable lands; increasing competition for land and water from non irrigation sector, and possible over - assessment due to non - conjunctive assessment of surface and groundwater are some of the factors leading to probable over-assessment (World Bank, 1998). The inter-linked nature of groundwater and surface water is not recognized in India. Exploitation of one affects the potential development of the other, yet each is measured independently (World Bank, 1991). Also, for many of the states, irrigation potential created (IPC) has been observed to be higher than UIP (Dhawan, 1993). The figures for UIP are not based on any river basin wide planning or survey and, thus are adhoc figures based on sites identified for various sizes of dams and similar adhoc estimates of groundwater development potential based on water balance formula (Thakkar, 1999). Therefore, assessment of UIP needs to be reviewed keeping above mentioned facts in view.

3.2. Investment pattern in irrigation

3.2.1. Public investment in irrigation sector

To create irrigation infrastructure in the country, the Government invests in various major, medium and minor irrigation projects. Additionally, investment is done to remove the deficiencies of created potential and for optimal utilization of water resources through Centrally Sponsored Schemes such as Command Area Development and Water Management (CADWM) Programme, Accelerated Irrigation Benefit Programme (AIBP), etc. With the considerable Government support, though the absolute financial expenditure (planned) on irrigation development has increased from ` 6,839.9/- crores during first FYP to ` 55,488.9/- crores during tenth FYP at 1993-94 prices, the share of irrigation expenditure in total planned budget has rather decreased from 23 per cent to 9 per cent (CWC, 2010) during the same period indicating increasing demand towards other sectors of the economy. However, in the recent years, trend is again shifting upward (Fig. 1). Among the projects, total expenditure was highest in major and medium irrigation projects followed by minor and CAD projects constituting about 79 per cent, 17 per cent and 4 per cent of total irrigation expenditure during tenth FYP (Fig. 2). Major and medium irrigation projects utilized ` 44,105/- crore rupees during the tenth FYP. On the other hand, minor irrigation projects and CAD programmes spent ` 9,336/- crore and ` 2,047/- crore, respectively.

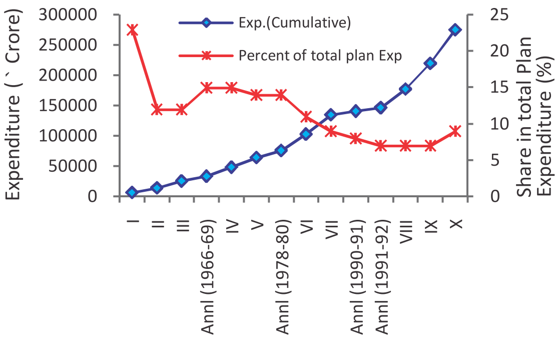

Figure 1. Plan-wise financial expenditure (planned) on irrigation and its share in total plan expenditure

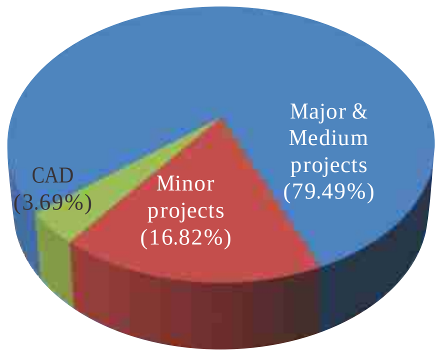

Figure 2. The share of different projects in total financial expenditure (at 1993-94 prices) in India during X FYP

The cost of creation of one hectare of irrigation through major and medium projects has increased substantially from ` 26,000/- during first FYP to ` 1,13,439/- during tenth FYP at constant (1993-94) prices (Table 6). At current prices, major and medium projects spent ` 2,11,405/- to create one hectare of irrigation potential in the country during tenth FYP. Similar increasing trend was observed in per hectare cost of creation of irrigation through minor irrigation projects during the same period (Table 7). Minor irrigation projects spent ` 43,125/- at current prices and `23,141/- at constant (1993-94) prices to create one hectare of irrigation potential during tenth FYP. The Planning Commission also accepts that the cost of creation of one hectare of irrigation through major and medium projects have gone upto atleast 365 per cent since the early planning periods.

Table 6. Plan-wise financial expenditure incurred in major and medium irrigation projects

Period	Expenditure (` crore)		IPC (000, ha) (cumula-tive)	IPC (000, ha) (during)	Irrigation intensity (%)*	Net IPC (000 ha)	Exp. (`/Net IPC)	
	At 1993-94 prices	At current price					At 1993-94 prices	At current price
Pre plan	---	---	9705	---	---	---	---	---
I (1951-56)	5824	376	12191	2486	111	2240	26000	1679
II (1956-61)	5278	380	14334	2143	114	1874	28167	2028
III (1961-66)	6560	576	16565	2231	115	1934	33916	2978
Annual (1966-69)	3376	430	18095	1530	122	1254	26909	3426
IV (1969-74)	7784	1242	20703	2608	123	2126	36618	5844
V (1974-78)	9887	2516	24717	4014	125	3216	30742	7824
Annual (1978-80)	7192	2079	26612	1895	127	1488	48331	13968
VI (1980-85)	17330	7369	27695	1083	128	845	205019	87174
VII (1985-90)	18990	11107	29920	2225	131	1695	111997	65541
Annual (1990-92)	6941	5459	30741	821	131	626	110946	87254
VIII (1992-97)	19568	21669	32957	2216	133	1665	117556	130181
IX (1997-2002)	33494	49290	36981	4024	136	2951	113508	167038
(2002 -2007)	44106	82195	42350	5369	138	3888	113439	211405

*irrigation intensity is the ratio of gross irrigated area and net irrigated area expressed in percent and is used to estimate net IPC from IPC

A substantial increase has taken place in the per hectare cost of creation of irrigation potential from the Sixth Plan onwards which is mainly due to introduction of the extension and distribution system upto 5-8 hectare block, the cost of rehabilitation and resettlement, environmental & Forest aspects, inclusion of the cost of catchment area treatment, inclusion of drainage system in the command of irrigation projects, increase in establishment costs, etc (GOI, 1999). Part of the reason for the increase in the cost is that too many projects are taken up to in the successive FYPs without emphasizing the completion of on-going projects. The biggest single malady in the major & medium irrigation sector right from the First Plan has been the continued tendency to start more and more new projects resulting in wanton proliferation of projects, thin spreading of resources and consequent time and cost overruns. Though all the Plans, without exception, declared their intention to give priority to complete the ongoing schemes, the addition of new schemes continued unabated (Dhawan, 1993).

Table 7 . Plan-wise financial expenditure incurred in minor irrigation projects

Period	Expenditure (` crore)		IPC (000,ha) (cumula-tive)	IPC (000,ha) (during)	Irrigation intensity (%)*	Net IPC (000 ha)	Exp. (`/Net IPC)	
	At 1993-94 prices	At current price					At 1993-94 prices	At current price
Pre plan	---	---	12901	---	---	---	---	---
I (1951-56)	1016	66	14060	1159	111	1044	9727	628
II (1956-61)	2244	162	14731	671	114	587	38252	2754
III (1961-66)	5028	442	17000	2269	115	1967	25559	2244
Annual (1966-69)	4367	556	19020	2020	122	1656	26367	3357
IV (1969-74)	7314	1167	23400	4380	123	3570	20487	3270
V (1974-78)	5604	1426	27300	3900	125	3125	17935	4565
Annual (1978-80)	3379	977	30000	2700	127	2120	15937	4606
VI (1980-85)	8036	3417	37520	7520	128	5869	13691	5821
VII (1985-90)	10583	6193	46605	9085	131	6920	15293	8950
Annual (1990-92)	3828	3006	50348	3743	131	2852	13422	10539
VIII (1992-97)	9457	10472	62479	12131	133	9112	10378	11493
IX (1997-2002)	7677	11297	75414	12935	136	9485	8093	11910
X (2002 -2007)	9336	17398	80985	5571	138	4034	23141	43125

*irrigation intensity is the ratio of gross irrigated area and net irrigated area expressed in percent and is used to estimate net IPC from IPC

Among the regions, public investment in irrigation was highest in Western region for all types (major, medium and minor) of irrigation projects during tenth FYP (Table 8). However, irrigation potential created through major & medium and minor projects was highest in Eastern and Northern region, respectively during the same period indicating inter-regional differences in physical performance of irrigation projects. Financial performance of irrigation projects also varied across different regions as evident from differential per hectare cost of creation of irrigation potential. For major and medium projects, cost of creation of irrigation varied from ` 87,265/- in Eastern region to ` 3,17,078/- at current prices in Southern region during tenth FYP. Cost of creation of irrigation through minor irrigation projects was lowest (` 22,377/-) in Northern region and highest ( ` 83,419/-) in Western region. In the recent years, greater emphasis is being given by the Government to complete the on-going projects rather to start new projects. With this view, Government of India launched Accelerated Irrigation Benefit Programme (AIBM) to complete on-going irrigation projects on which substantial progress had been made.

Table 8. Zone-wise financial expenditure on irrigation projects during tenth five year plan

Zone	Financial Expenditure (` Crore)		IPC (000 ha) (during)		Irrigation intensity (%)	Net IPC (000 ha) (during)		Financial Expenditure (`/Net IPC)	
	M&M	Minor	M&M	Minor		M&M	Minor	M&M	Minor
North	9542	3063	1342	2139	156	858	1369	111153	22377
West	26075	5155	1534	734	119	1292	618	201894	83419
South	24731	3632	940	1160	121	780	962	317078	37742
East	10214	3966	1735	1455	148	1170	981	87265	40419

M & M: major and medium irrigation projects

3.2.2. Accelerated irrigation benefit programme (AIBP)

Accelerated irrigation benefit programme (AIBP) was launched in the year 1996-97 to create additional irrigation potential and for accelerating the implementation of on-going irrigation/multi-purpose projects on which substantial progress had been made and, which are beyond the resource capability of State Government; and, for other major and medium irrigation projects which are in advance stage of construction and could yield benefits of irrigation in next four agricultural seasons. Only those projects are considered under the programme, which have the investment clearance of the Planning Commission. The projects which are already receiving assistance from domestic agencies such as NABARD, etc. are not eligible for assistance under this programme. However, the components of such projects which are not covered under such assistance by NABARD are considered for inclusion under the AIBP. Projects benefitting tribal/drought prone areas are given due preference provided they are otherwise eligible. Projects with larger irrigated area per unit of additional investment are preferred. Initially minor irrigation projects were not eligible for assistance under AIBP because NABARD was financing such schemes under the Rural Infrastructure Development Fund (RIDF). But, since 1999-2000, surface minor irrigation projects (both new and on-going) of special category states (North-Eastern states, hilly states of Sikkim, Uttarakhand, Jammu & Kashmir, Himachal Pradesh and Korapur, Bolangir and Kalahandi districts Odisha) are also included under AIBP Central Loan Assistance (CLA).

Central Loan Assistance (CLA) to the states is given on matching basis and is released in two installments of 50 per cent each. The second installment is released after the states have incurred expenditure equal to the sum of the CLA already released to them and the share of the state. The CLA under the programme is released on the recommendation of Ministry of Water Resources in the form of loan at the rate of interest prescribed by the Ministry of Finance from time to time. The Projects covered under the AIBP are monitored by Central Water Commission with the help of its regional offices situated all over the country and the releases of funds are based upon their reports. Since, April 2004, grant component has also been introduced like any other Central Government Scheme. As per the existing

AIBP criteria effective from December 2006, grant amounting to 25 per cent of the project cost for major and medium irrigation projects in non-special category states and 90 per cent of the project cost for major/medium/minor irrigation projects in special category states (including Koraput, Bolangir and Kalahandi Districts of Odisha) are provided to the selected projects. The minor irrigation schemes in non-special category states falling in drought prone/tribal areas are treated at par with special category states and are provided 90 per cent grant of the project cost. Major and medium projects providing irrigation benefits to drought prone/tribal area and flood prone area are also eligible for 90 per cent grant of the project cost.

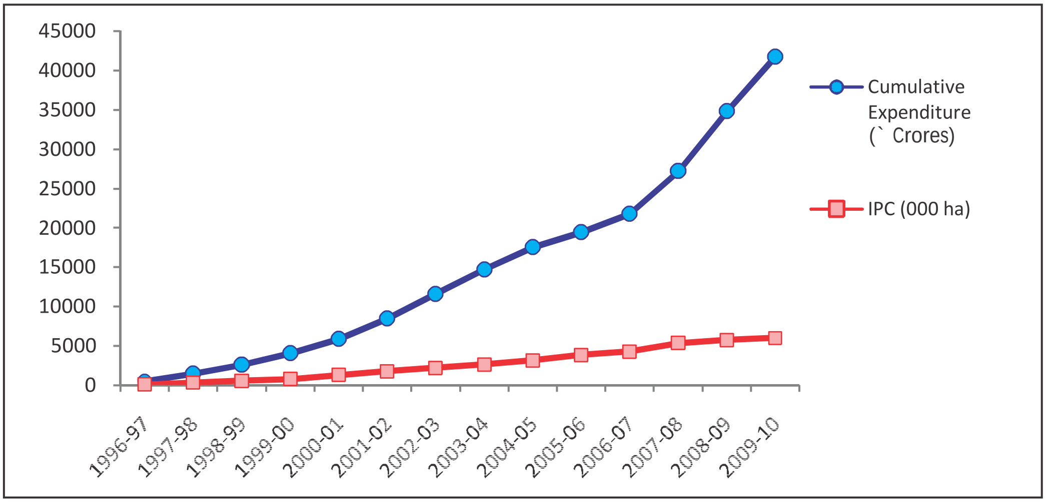

Figure 3. Cumulative expenditure incurred and irrigation potential created under AIBP

Since the inception AIBP, CLA/grants has increased from ` 500/- crores in 1996-97 to ` 41,930/- crores in 2009-10 (Figure 3) and consequently, irrigation potential created (IPC) under AIBP has increased from 75 thousand hectare in 1996-97 to 5.9 million hectare in 2009-10. CLA/grants has been provided to 268 major/medium irrigation projects and 9,908 surface minor irrigation schemes and after commencement of this programme, 109 major/medium projects and 6,584 surface minor irrigation schemes have been reported to be completed so far. Among the regions, Western region constituted highest share in total expenditure incurred (43 per cent) as well as total IPC (41 per cent) at the end of 2009-10 (Table 9). Western region was followed by Southern region with 23 per cent share in total expenditure. It is to be noted that Western as well as Southern region could constitute less share in total IPC as compared to their expenditure shares. On the other hand, share of Northern and Eastern regions on total IPC was higher than their share in total expenditure indicating relatively better performance than Western and Southern regions.

Table 9. Region-wise cumulative expenditure incurred and IPC created under AIBP upto 2009-10

Particulars	North	South	East	West	India
Cumulative expenditure (` Crore)	5,844 (14)	9,712 (23)	6,390 (15)	17,915 (43)	41,730 (100)
Irrigation Potential Created (000 ha)	1,399 (23)	1,109 (19)	965 (16)	2,451 (41)	5,990 (100)

Figures within parenthesis are share (%) of respective region in the country
Total may not tally due to unavailability of data for few states

3.2.3. Financial aspect of irrigation projects

Water rates for supplying irrigation are normally fixed considering the annual cost of providing irrigation that consists of three elements: operation and maintenance (O&M) expenses, depreciation and interest of the capital invested. But a wide diversity of opinion exists regarding fixation of the rates. National Water Policy, 1987 envisaged the water rates should cover annual O&M charges and a part of the fixed cost. National Water Policy, 2002 stipulates that water charges should cover at least O&M cost of providing the service initially and a part of capital cost subsequently. It also prescribes subsidy to the poorer sections of the society in very abstract terms. Vaidyanathan committee (1992) recommended full recovery of O&M cost plus 1% capital cost during the initial phases. 2nd Irrigation Commission (1972) recommended that water rate should cover the working expenses and interest on capital. The 5th Finance Commission recommended a return of 2.5% of capital investment over and above the O&M cost; however, the 6th and 7th Finance Commission lowered the return from 2.5% to 1% of capital investment. The 8th and 9th Finance Commission emphasized on recovery of O&M cost while 10th Finance Commission recommended recovery of full O&M costs plus 1% capital costs. Commission on pricing irrigation water (1992) mentioned recovery of O&M cost plus 1% capital cost plus a % of depreciation cost. The 11th Finance Commission fixed ` 450 per ha for utilised potential and Rs 150 per ha for unutilised potential. Central Water Commission proposed for 12th Finance Commission to recommend the water rate of ` 600 per ha for major & medium and ` 400 per ha for minor projects in case of utilised potential; ` 200 per ha for major & medium and Rs. 100 per ha for minor projects in case of unutilised potential.

Successive finance commissions since fifth one have insisted of not only the recovery of full operation and maintenance expenditures but also a proportion of the interest on irrigation investment (Planning Commission, Government of India, 1992). The irrigation being a state subject, the pricing and cost recovery of irrigation water is referred to the states for enforcement. As per the State Water Policy, the cost of operation and management will be fully recovered from the beneficiaries. Water Rates & Cost Recovery Committee has been formed to fix and review water charges. The Committee recommends the water charges to Water Resource Board for approval.

Table 10. The share of gross receipt from irrigation projects in total working expenditure

(Per cent)

Plan	North	West	South	East	India
Major and Medium Irrigation Projects					
Annual (1990-92)	10.49	6.85	8.84	13.06	8.61
Eighth	14.97	7.90	9.35	17.51	10.26
Ninth	12.62	6.48	1.99	15.52	6.94
Tenth	14.31	25.71	2.86	23.92	14.49
Minor Irrigation Projects					
Annual (1990-92)	3.45	9.32	5.10	3.24	4.85
Eighth	4.91	10.31	5.77	2.68	5.73
Ninth	6.03	7.55	3.06	1.91	4.78
Tenth	3.44	14.80	3.88	4.64	6.07

However, examination of the share of gross revenue in total working expenditure of irrigation projects revealed a pessimistic situation. The share of gross receipt in total working expenditure was 14.49 per cent and 6.07 per cent for major & medium and minor irrigation projects, respectively during tenth FYP in India (Table 10). The resultant unviability of irrigation projects exerts a big pressure on Government exchequer and sets a limit on the investment. This necessitates restructuring of institutional setup involved in execution of irrigation projects to make them viable and self-reliant. Among the regions, recovery of working expenditure was highest in Western region of the country for both major & medium and minor irrigation projects during tenth FYP. Southern region with highest investment per net irrigated area witnessed lowest recovery of working expenditure (2.86 per cent) for major and medium irrigation projects during tenth FYP. Higher investment per hectare with low recovery makes the projects unsustainable. Thus, efficient and viable execution of irrigation projects is equally important as increase in the magnitude of the investment to make the projects sustainable. Further, over the FYPs, the share of gross receipt in total working expenditure was found to be fluctuating across different regions as well as in the country as a whole indicating fluctuating and unstable financial condition of irrigation projects.

3.3 Impact of Investment in Irrigation

3.3.1 Contribution of Indian agriculture in national Income

The performance of Indian agriculture across different regions over the FYPs was examined by the gross domestic product (GDP) from agriculture and its share in total GDP (Table 11). In India, real GDP from agriculture has increased from ` 23,968 billion in sixth FYP to ` 44,643 billion in tenth FYP indicating better performance of Indian agriculture over the year.

Table 11. Plan wise and region-wise GDP from agriculture (` billion) and its share in total GDP at factor cost at 1999-00 prices

Plan	North		South		East		West		India	
	GDP_Ag	Share*	GDP_Ag	Share*	GDP_Ag	Share*	GDP_Ag	Share*	GDP_Ag	Share*
Sixth	6,355	40	6,157	32	5,159	40	5,412	28	23,968	34
Seventh	7,498	36	6,800	29	6,273	39	5,828	24	27,403	30
Annual (1990-92)	8,694	34	7,841	27	6,499	35	6,694	22	30,790	28
Eighth	9,590	31	8,452	25	7,839	31	9,337	23	34,950	27
Ninth	10,887	27	9,307	20	8,681	26	9,665	18	40,476	23
Tenth	12,373	22	10,217	16	9,648	21	12,658	17	44,643	18

*share of GDP from Agriculture in total GDP (per cent)

Assured irrigation in synergy with the other technological and policy factors is the critical factor for the better performance of Indian agriculture over the years. However, the share of agriculture in total GDP has declined consistently from 34 per cent in sixth FYP to 18 per cent in tenth FYP. This indicated that other sectors performed better as compared to agriculture. Similar declining trend in the share of agriculture in GDP was witnessed in all the regions. The share of agriculture in total GDP was highest in Northern region followed by Eastern region during the tenth FYP. Southern region has lowest share of agriculture in total GDP. Thus, among the regions, agriculture has largest contributor in the total income in Northern and Eastern regions.

3.3.2 Irrigation potential created and utilized

Irrigation potential created (IPC) as defined by Ministry of Water Resources (MoWR) is the total gross area proposed to be irrigated under different crops during a year by a scheme. Irrigation potential utilized (IPU) is the gross area actually irrigated during reference year out of the gross proposed area to be irrigated by the scheme during the year (MoWR).

Total IPC from major, medium and minor irrigation projects in India has increased from 22 Mha during pre-plan period to 123.33 Mha upto tenth FYP (Table 12) because of public as well as private investment in irrigation. More than fifty per cent (66.87 Mha) of the total IPC in India was contributed by minor irrigation (ground water) followed by major and medium irrigation projects (42.35 Mha). Utilization of the total irrigation potential (IPC) was about 90-95

Table 12. Plan-wise cumulative irrigation potential created and utilized in India

(000, ha)

Period	Major & Medium Irrigation Surface Water		Minor Irrigation: Surface Water		Minor Irrigation: Ground Water		Minor Irrigation: Surface & Ground Water		Total (Major, Medium & Minor Irrigation)		Per cent utilization
	IPC	IPU	IPC	IPU	IPC	IPU	IPC	IPU	IPC	IPU	
Pre-Plan (1951)	9705	9705	6401	6401	6500	6500	12901	12901	22606	22606	100.00
First Plan (1951-56)	12191	10985	6430	6430	7630	7630	14060	14060	26251	25045	95.41
Second Plan (1956-61)	14334	13052	6454	6454	8277	8277	14731	14731	29065	27783	95.59
Third Plan (1961-66)	16565	15175	6480	6480	10520	10520	17000	17000	33565	32175	95.86
Annual Plan (1966-69)	18095	16751	6512	6512	12508	12508	19020	19020	37115	35771	96.38
Fourth Plan (1969-74)	20703	18688	6962	6962	16438	16438	23400	23400	44103	42088	95.43
Fifth Plan (1974-78)	24717	21163	7500	7500	19800	19800	27300	27300	52017	48463	93.17
Annual Plan (1978-80)	26612	22645	8000	8000	22000	22000	30000	30000	56612	52645	92.99
Sixth Plan (1980-85)	27695	23574	9697	9010	27823	26238	37520	35248	65215	58822	87.1
Seventh Plan (1985-90)	29920	25467	10986	9968	35619	33152	46605	43120	76525	68587	89.63
Annual Plan (1990-92)	30741	26315	11456	10289	38892	36249	50348	46538	81089	72853	89.84
Eighth Plan (1992-97)	32957	28440	12189	8201	50290	40088	62479	48289	95436	76729	80.39
Ninth Plan (1997-02)@	36981	30972	12269	7175	63145	45658	75414	52833	112395	83805	74.56
Tenth Plan (2002-07)	42350	34420	14116	8341	66870	48363	80985	56704	123335	91124	73.90

Source : Central Water Commission (P&P Directorate), MOWR. (Minor Irrigation Division)

Note: @ Figures for minor irrigation are based on 3rd Minor Irrigation Census (2000-01)

Upto the Annual Plan 1978-80, the potential creation and its utilization for minor irrigation are shown as same. In this context, it is to be mentioned that as per procedure upto Fifth Plan, the utilization of potential was reckoned as 100% of potential created. However, the Public Accounts Committee (PAC) in its 141st Report (1982-83) did not accept the above practice. Subsequently, the Working Group on Minor Irrigation for the formulation of Seventh Plan recommended that during the Sixth Plan the utilization figure might be reported as per existing practice but the base line for the year 1984-85 should be worked out both for potential created and utilized. Accordingly, after consultation with the States the Planning Commission fixed the base figure for 1984-85 for potential created and utilized as 37.52 m.ha and 35.25 m.ha., respectively (GOI, 1999).

in the subsequent FYPs upto annual plans (1978-80). Subsequently, utilization of the irrigation potential started declining with 73.90 per cent utilization at the end of tenth FYP. As per the latest estimates, the gap between irrigation potential created and utilized is anticipated to be about 32 M ha (about 26 per cent). The increasing gap between IPC and IPU over the years indicated inefficiency in the water resource utilization. Among the regions, utilization of the IPC varied from 65.52 per cent in Eastern region to 82.38 per cent in Northern region (Table 13). Less than hundred per cent utilization of IPC indicated inefficient water use and lead to wastage of precious resources on the one hand, and loss of opportunity to increase the agricultural production and subsequently the income of the rural producer, on the other. Among the states, utilization of irrigation potential created varied from about 60 per cent in Madhya Pradesh to 93 per cent in Punjab (Appendix 3). It is to be noted that these figures do not give a correct picture of utilization of irrigation potential, mainly because of following reasons (GOI, 1999);

1. A lag of few years between the introduction of irrigation and its full utilisation (which is less in case of Minor Irrigation) is obvious due to time required for the construction of the distribution system as well as for switching over from rainfed agriculture to irrigated agriculture involving major changes in agricultural techniques which the farmers take time to master.

2. The criteria/norms for reporting creation of irrigation potential and its utilisation adopted by the states are not uniform. For example, Maharashtra gives the utilisation as achieved and irrigated, while Uttar Pradesh gives the maximum area irrigated since inception during any *rabi* and *kharif* period.

3. The potential area which can be irrigated in a system depends on several variables including availability of distribution networks, the volume and seasonal pattern of water availability, conveyance losses, distribution and application on fields, the extent to which the conjunctive use is developed and the actual crop pattern on ground. There is considerable evidence to show that the crop pattern actually adopted by the farmers are often much more water intensive than assumed and this is one important reason why actual area irrigated is smaller than designed potential (Vaidyanathan, 1999). In so far as the assumptions in respect of these parameters underlined in the project design are not actually realised in full, there is bound to be divergence between actual area irrigated and the potential created.

Table 13. Zone-wise irrigation development at the end of tenth five year plan

(000, ha)

Zone	IPC	IPU	% of IPU to IPC
North	45078.82	37133.9	82.38
West	33523.45	22570.40	67.33
South	22098.84	16582.30	75.04
East	21825.93	14301.20	65.52
India	123335.60	91124.10	73.88

IPC: Irrigation potential created, IPU: irrigation potential utilized
Total may not tally because non-availability of data for some States

For the country as a whole, about 88 per cent of the UIP has already been developed by different major, medium and minor irrigation schemes, which limits further expansion of irrigation infrastructure at large scale. Thus, improving the utilization of already created irrigation infrastructure by removing existing operational and maintenance inefficiencies will contribute positively for agricultural growth in the country.

3.3.3 Source –wise net irrigated area in India

Net irrigated area (NIA) in India has increased from 21.77 Mha in first FYP to 59 Mha in tenth FYP because of improving irrigation infrastructure over the years with the compound growth rate (CGR) of 2.08 per cent per annum (Table 14). However, a structural shift has been observed in the relative contribution of different sources of irrigation in NIA over the years.

Table 14. Source-wise in NIA in successive FYPs in India

(000, ha)

Plan	Canal	Tank	Tube well	Other wells	Net Irrigated Area
First Plan	8971	3894	115	6638	21777
Second Plan	9816	4596	135	6862	23558
Third Plan	10907	4606	913	6989	25876
Annual Plans (1966-69)	11461	4281	2302	7401	27703
Fourth Plan	12924	3885	4788	7530	31445
Fifth Plan	13936	3830	7125	7711	34999
Annual Plans (1978-80)	14962	3709	8733	8414	38292
Sixth Plan	16092	3210	10625	8488	40802
Seventh Plan	16529	2780	13030	8997	44035
Annual Plans (1990-92)	17622	2968	14713	10653	48945
Eighth Plan	17320	2979	17322	11447	52630
Ninth Plan	16597	2515	21788	12124	56342
Tenth Plan	15502	1926	24226	11848	59073
CGR (1950-2007)	1.26	-1.40	8.01	1.30	2.08

Canal was the major source of irrigation during the first FYP irrigating about 41 per cent of the total NIA followed by other-wells and tanks with their respective share of 30 per cent and 18 per cent. The tube-wells constituted marginal share in the NIA during first FYP (Fig. 4). Subsequently, irrigated area under tube-wells has increased at the rate of 8 per cent per annum during 1950 to 2007. Manifestation of this was the increase in the share of tube-wells in NIA from less than 1 per cent during first FYP to about 41 per cent during tenth FYP.

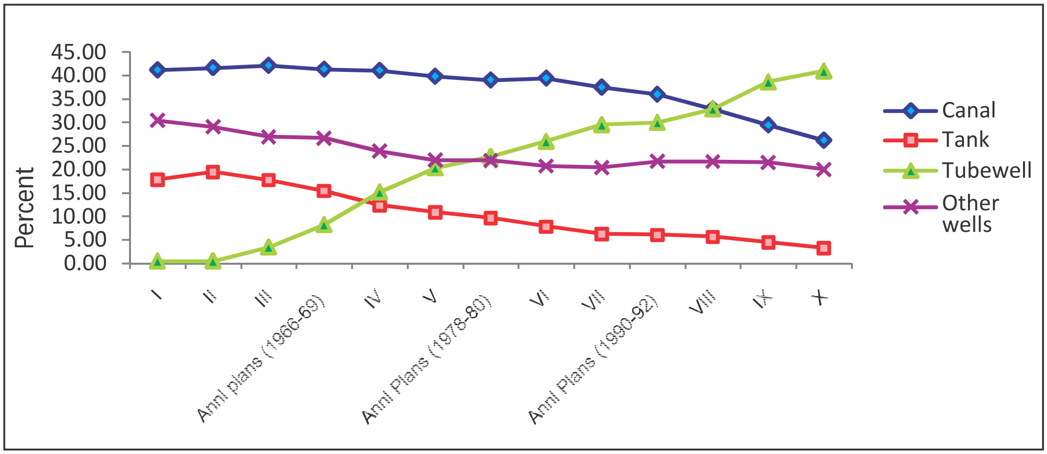

Figure 4. The share (%) of different sources in net irrigation area in India in successive FYPs

On the other hand, the share of canal in NIA has declined from about 41 per cent in first FYP to about 26 per cent in tenth FYP, although the absolute area under canal irrigation has increased with the growth of 1.26 per cent per annum. The deceleration in the growth of area under canal in the recent years despite increased investment is mainly because of three reasons (Raju, 2004). First, the relatively easier potential had already been utilized, and further development was more difficult, with the result that there was inevitably a decline in the rate of growth of the area under irrigation. Secondly, the investment cost of the irrigation projects that were taken up from the seventh plan onwards were much higher, and a given order of investment could create only a lower order of irrigation potential than was possible in earlier plan periods. Thirdly, budgetary allocations could not be made in adequate measure for the large number of major and medium irrigation projects taken up, and this inevitably resulted in the slower completion of projects and therefore the slower creation of irrigation potential. There is every possibility that the growth of canal-irrigated area may decelerate further in future for these reasons. Further, inefficient and unequal distribution of canal water in farmers' field results into a shift from canal to tube-well as a source of irrigation which is comparatively more reliable and efficient than canal.

The irrigation efficiency of groundwater is 70-80 per cent as compared to 25-45 per cent in case of canal water (Sharma, 2009). The significant growth in groundwater irrigation is primarily because of private investment as revealed by the third minor irrigation census (http://wrmin.nic.in/micensus/mi3census) conducted during 2000-01. About 80 per cent dug-wells and 60 per cent tube-wells were constructed investing farmers' own saving, while only 4 per cent dug-wells and 14 per cent tube-wells were constructed using bank/other loans and 23 per cent tube-wells were government funded. However, it is to be noted that excessive reliance and over-exploitation of groundwater has raised several sustainability issues of this precious resource in many pockets of India.

Tanks, with the long history and special significance to small and marginal farmers especially in Southern India, witnessed poor performance with negative growth (-1.4 per cent) due to the weak institutional arrangements, property rights structures and breakdown of the local authority system (Marothia, 1992 and 1993; Vaidyanathan, 1997). It has been observed that in a period of 10 years, tanks get normal supply during first to third years, deficit supply during fourth to eighth year and fail completely during ninth and tenth year (Palanisami, 2000). Thus, tube-well explosion, especially in the North-Western states during early seventies and later period, over-stripped other sources of irrigation raising sustainability issues on groundwater resources (Kumar *et al.,* 2003).

3.3.4 Changing land use pattern

The reporting area for the country is 305.7 Mha, which is about 93 per cent of the total geographical area. Over successive FYPs, net sown area (NSA) in India has increased from 125.95 Mha in first FYP to 139.54 Mha in tenth FYP with almost insignificant growth rate (Table 15). It is to be noted that NSA followed an increasing trend upto eight FYP and subsequently headed downwards because of increasing urbanization and conversion of agricultural land for non-agricultural purposes. However, the gross sown area (GSA) in India has increased consistently from about 140 Mha in first FYP to 189.84 Mha in tenth FYP with the growth of 0.58 per cent per year. Consistent increase in GSA led to improvement in the cropping intensity over the planning periods from 111 per cent in first FYP to 136 per cent in tenth FYP.

One of the reasons for improvement in cropping intensity was assured irrigation supply through various irrigation projects. This is reflected through significant increase in the net as well gross irrigated area of the country with the growth of 2.08 and 2.52 per cent per annum, respectively during 1950-2007. Comparatively higher growth in NIA and GIA led to their increasing share in NSA and GSA, respectively over different FYPs. At the end of tenth FYP, about 42 per cent of the

GSA as well as NSA was irrigated. Irrigation intensity also witnessed increasing trend during the period under consideration.

Table 15. Plan-wise land use pattern in India

(Million ha)

Plan	Net sown area (NSA)	Gross sown area (GSA)	Net irrigated area (NIA)	Gross irrigated area (GIA)	% of NIA to NSA	% of GIA to GSA	Cropping intensity (%)	Irrigation intensity (%)
First	125.95	140.01	21.57	23.93	17.13	17.09	111	111
Second	131.58	150.51	23.56	26.94	17.91	17.90	114	114
Third	136.51	156.89	25.88	29.85	18.96	19.03	115	115
Annual (1966-69)	138.14	160.21	27.70	33.79	20.05	21.09	116	122
Fourth	139.66	165.05	31.45	38.58	22.52	23.37	118	123
Fifth	140.06	168.76	35.00	43.68	24.99	25.88	121	125
Annual (1978-80)	140.94	172.20	38.29	48.76	27.17	28.32	122	127
Sixth	141.18	175.60	40.80	52.28	28.90	29.77	124	128
Seventh	139.76	178.03	44.03	57.81	31.50	32.47	127	131
Annual (1990-92)	142.32	183.99	48.83	64.08	34.31	34.83	129	131
Eighth	142.61	187.48	52.62	70.05	36.90	37.36	132	133
Ninth	141.64	189.70	56.06	76.46	39.58	40.31	134	136
Tenth	139.54	189.84	58.81	81.20	42.15	42.77	136	138
CGR (1950-2007)	0.18	0.58	2.08	2.52				

Cropping intensity, irrigation intensity and share of NIA and GIA in NSA and GSA, respectively witnessed increasing trend in all the regions of the country over successive FYPs reflecting overall improvement in irrigation status and consequently, agriculture. However, rate of improvement in above indicators was not found to be uniform across different regions indicating inter-regional disparity between irrigation and agriculture sector (Table 16). Northern region ranked first among the regions in terms of cropping intensity, irrigation intensity and share of NIA and GIA in NSA and GSA, respectively during tenth FYP. More than double share of NIA and GIA in NSA and GSA, respectively in Northern region as compared to other regions indicated better development of irrigation in the region. Irrigation intensity and share of NIA and GIA in NSA in GSA, respectively was lowest in

Western region in tenth FYP reflecting poor development of irrigation in the region.

Table 16. Zone wise land use pattern in different FYPs

(per cent)

Particulars	Sixth Plan	Seventh Plan	Annual Plans (1990-92)	Eighth Plan	Ninth Plan	Tenth Plan
North						
CI	148	152	155	156	157	161
II	133	149	152	156	156	156
% of GIA in GSA	54.20	61.90	65.50	71.00	74.70	79.00
% of NIA in NSA	60.20	63.10	66.80	71.20	75.20	81.40
South						
CI	115	116	118	120	121	121
II	128	125	124	126	126	120
% of GIA in GSA	30.14	30.66	32.56	33.90	36.70	35.22
% of NIA in NSA	27.14	28.44	31.12	32.31	35.24	35.42
East						
CI	139	147	147	142	141	144
II	132	141	121	123	147	148
% of GIA in GSA	25.05	31.17	30.31	31.70	36.53	36.46
% of NIA in NSA	26.32	32.42	36.64	36.55	34.95	35.46
West						
CI	114	114	117	119	132	125
II	119	118	116	116	116	119
% of GIA in GSA	16.15	17.74	20.09	23.43	25.10	27.88
% of NIA in NSA	15.50	17.19	20.38	24.12	28.56	29.44

CI: cropping Intensity, II: irrigation intensity

3.3.5 Crop-wise land use pattern, yield and irrigated area under different crops over successive FYPs in India

Cropping pattern was examined by estimating share of a particular crop in GSA over successive FYPs in India (Table 17). Cereals constituted more than fifty per cent share in GSA with 98.77 Mha area under its cultivation in India during tenth FYP. Rice and wheat together constituted around 70 per cent of the total area under cereals with 42.84 Mha and 26.78 Mha area under their cultivation, respectively. Thus, rice is the major crop contributing 22.61 per cent share in GSA in India followed by wheat. It is to be noted that over the FYPs, total area under cereals has declined from about 71 per cent in first FYP to 52 per cent in tenth FYP. Pulses followed same declining pattern over the FYPs. On the other hand, oilseeds, sugarcane, fruits and vegetables and condiments and spices registered increasing share in GSA over the FYPs. Declining share of foodgrains (cereals and pulses) and increasing share of water intensive and high value crops showed the increasing diversification of Indian agriculture towards these crops. Further, among the cereals, increasing share of rice and wheat in GSA over FYPs indicated shift from coarse cereals to fine cereals such as rice and wheat. As rice and wheat along with

Table 17. Plan-wise area under crops and cropping pattern in India

Plan	Rice		Wheat		Cereals		Pulses		Oilseeds		Sugarcane		F & V		C& S	
	TA	CP	TA	CP	TA	CP	TA	CP	TA	CP	TA	CP	TA	CP	TA	CP
First	30.78	21.77	10.87	7.67	99.61	70.85	21.94	15.50	11.62	8.22	1.75	1.24	2.17	1.54	1.29	0.91
Second	33.16	22.03	12.86	8.54	89.90	59.73	23.94	15.91	12.88	8.56	2.16	1.44	2.52	1.67	1.44	0.96
Third	35.57	22.67	13.33	8.50	93.28	59.46	24.01	15.30	14.02	8.94	2.48	1.58	2.95	1.88	1.55	0.99
Annual plans (1966-69)	35.68	22.27	14.44	9.01	96.54	60.26	22.31	13.93	14.38	8.97	2.31	1.44	3.46	2.16	1.67	1.04
Fourth	37.49	22.72	18.30	11.09	101.04	61.22	22.80	13.81	14.90	9.03	2.63	1.59	3.66	2.22	1.78	1.08
Fifth	38.98	23.10	20.11	11.91	102.06	60.48	23.72	14.05	15.25	9.04	3.09	1.83	4.19	2.48	1.91	1.13
Annual plans (1978-80)	40.03	23.25	22.32	12.96	104.28	60.56	23.15	13.44	15.43	8.96	3.10	1.80	4.70	2.73	2.14	1.24
Sixth	40.42	23.01	23.15	13.18	105.03	59.81	23.24	13.23	17.34	9.87	3.28	1.87	5.21	2.97	2.16	1.23
Seventh	41.03	23.05	23.42	13.16	103.16	57.96	23.18	13.02	20.98	11.78	3.38	1.90	6.14	3.45	2.36	1.33
Annual Plans (1990-92)	42.67	23.20	23.77	12.92	101.51	55.17	23.67	12.86	25.46	13.85	3.90	2.12	7.63	4.15	2.41	1.31
Eighth	42.73	22.79	25.29	13.49	100.75	53.74	22.94	12.24	26.58	14.18	3.97	2.12	8.68	4.63	2.36	1.26
Ninth	44.61	23.52	26.76	14.10	83.22	43.88	21.97	11.58	24.41	12.86	4.19	2.21	9.80	5.17	2.79	1.47
Tenth	42.84	22.61	26.78	14.07	98.77	52.01	22.66	11.90	25.62	13.45	4.42	2.28	11.95	6.15	3.53	1.98
CGR (1950-2007)	**0.66**		**1.85**		**-0.24**		**-0.02**		**1.69**		**1.72**		**3.36**		**1.68**	

CGR: compound growth rate in respective category during 1950-2007

TA: Total area under respective crop (Million ha)

CP: cropping pattern (share of a crop's area in gross sown area)

F & V : Fruits and Vegetables

C & S : Condiments and spices

Table 18. Plan-wise irrigated area under different crops in India

(Per cent)

Plan	Rice		Wheat		Cereals		Pulses		Oilseeds		Sugarcane		F & V		C& S	
	IA*	Yield#	IA	Yield	IA	Yield	IA	Yield	IA	Yield	IA	Yield	IA	Yield	IA	Yield
First	33.40	8.74	35.21	7.08	17.74	5.67	9.15	4.68	1.20	4.66	67.75	327.70	11.71	-	6.17	-
Second	36.15	9.14	31.77	7.58	21.60	6.15	8.27	4.82	3.18	5.03	67.00	375.25	18.21	-	22.00	-
Third	37.15	9.86	35.98	8.31	22.83	7.01	8.87	4.87	3.56	4.87	69.72	440.50	18.43	-	27.34	-
Annual plans (1966-69)	38.31	9.90	47.06	10.53	25.38	7.14	9.76	4.67	4.96	4.77	74.11	434.12	22.01	-	27.80	-
Fourth	38.25	11.06	55.12	12.68	27.99	9.11	8.58	4.91	7.48	5.28	74.32	495.70	29.56	-	33.72	-
Fifth	39.03	12.01	63.38	13.57	31.54	9.90	7.65	4.84	8.81	5.60	77.80	501.12	33.79	-	37.77	-
Annual plans (1978-80)	42.22	12.46	67.13	14.95	34.27	10.73	8.31	4.70	11.76	5.40	77.51	512.71	37.47	-	39.82	-
Sixth	42.13	13.50	72.18	16.83	35.53	11.53	8.20	4.86	16.54	6.20	81.58	523.14	36.79	-	38.93	-
Seventh	44.51	15.85	77.48	20.16	38.77	14.05	9.37	5.39	20.20	6.74	85.77	518.89	37.50	-	44.56	-
Annual Plans (1990-92)	46.45	17.45	82.18	22.66	42.18	15.59	10.63	5.54	24.73	7.62	89.99	517.76	34.33	102.13	47.36	9.48
Eighth	50.07	18.44	85.63	24.33	46.15	16.78	12.41	5.73	25.86	8.43	93.04	531.41	34.61	116.73	59.33	10.32
Ninth	54.58	19.26	87.53	26.65	61.65	18.79	13.04	5.98	25.87	8.42	99.78	541.63	46.82	130.36	59.07	11.84
Tenth	55.42	21.02	91.08	26.50	52.50	19.33	15.39	5.93	29.13	9.91	99.57	542.07	49.09	128.54	52.89	13.41
CGR (1950-2007)	**1.65**	**2.32**	**4.10**	**2.49**	**2.27**	**2.51**	**0.96**	**0.74**	**8.24**	**1.93**	**2.58**	**1.00**	**6.56**	**1.03**	**5.70**	**2.50**

CGR: compound growth rate in respective category during 1950-2007

* share of irrigated area under respective crop

Yield: Quintals/ha

For rice, wheat, cereals, pulses, oilseeds and sugarcane, CGR is estimated for the period 1969-2007. For fruits & vegetables (F&V) and condiments and spices (C&S), CGR is estimated for the period 1990-2007.

the high value crops such as fruits, vegetables, sugarcane, spices, etc required assured irrigation for their cultivation, their increasing share in GSA indicated improvement in irrigation facilities over different planning periods. Thus, assured irrigation emerged as an important factor for increasing diversification of Indian agriculture along with various other economic, policy and technological factors. Among the crops, fruits and vegetables witnessed maximum growth (3.36 per cent per annum) in their area during 1950 to 2007.

Further, 99.57 and 91.08 per cent area under sugarcane and wheat, respectively had access to irrigation during tenth FYP in India (Table 18). Irrigated area under sugarcane has increased from 67 per cent in first FYP to 99.57 per cent in tenth FYP with the annual growth of 2.58 per cent. Similarly, irrigated area under wheat increased from 35.21 per cent in first FYP to 91.08 per cent in tenth FYP with the annual growth of 4.1 per cent. More than half of the total area under fruits and vegetables, condiments and spices, cereals and rice was under irrigation during tenth FYP. Pulses and oilseed, which are primarily grown under rainfed conditions, occupied minimum area under irrigation. However, oilseeds witnessed maximum growth in irrigated area under them during 1950 to 2007 because of technological and policy boosts provided by government to increase the oilseeds production.

3.3.6. Impact of irrigation development on crop yield in India

Irrigation is the one of the most important factor affecting yield and contributes about sixty per cent to the growth in agricultural productivity (Seckler and Sampath, 1985). Yield and irrigated area under respective crop followed similar trend over different FYPs (Table 18). It was found that irrigated area under crops, particularly water intensive crops (rice, wheat, sugarcane, fruits and vegetables) and the respective yield has increased in the same direction. Results of the time series regression analysis also showed irrigation a significant factor affecting crop yield positively though with varying degree except pulses. For pulses, irrigation was not found to be a significant factor because they are primarily grown under rainfed and residual moisture conditions. Rainfall was found to be significant factor affecting yield of pulses positively. Rainfall was also significantly affecting yield of all the crops except sugarcane and wheat which are mainly grown in irrigated conditions. About 94 and 91 per cent of the sugarcane and wheat are grown under irrigated conditions in India, respectively. For oilseeds, irrigated area has increased from less than one per cent during 1950s to 27 per cent in 2008 and was found significant in combination with rainfall and trend variable. Trend variable represents technological improvement and was found to be significant and positive for all the crops. Overall, agricultural productivity, expressed in terms of value of agricultural commodities (`) per net

Table 19. Impact of irrigation on crop yield (time series regression)

Parameters	Rice	Wheat	Sugarcane	Pulses	Oilseeds	Agricultural **Productivity (`/Ha)**
Constant	1.803* (0.961)	2.482*** (0.124)	10.319*** (0.116)	2.006 (1.239)	4.918*** (0.188)	6.043*** (0.594)
Irrigated area	0.550** (0.231)	0.506*** (0.127)	0.208** (0.099)	0.024 (0.128)	0.084* (0.049)	0.332** (0.134)
Rainfall	0.494*** (0.143)	-0.027 (0.035)	0.001 (0.000)	0.564*** (0.176)	0.001*** (0.000)	0.270*** (0.086)
Trend	0.011*** (0.004)	0.005*** (0.002)	0.009*** (0.002)	0.007** (0.002)	0.014*** (0.002)	0.018*** (0.003)
R^2	0.959	0.868	0.929	0.708	0.921	0.990
D-W statistics	1.34	1.95	1.55	1.81	2.21	1.52
D_L-D_u (1%)	1.20-1.47	1.20-1.47	1.10-1.44	1.14-1.45	1.12-1.45	1.20-1.47
Time period	1965-2008	1965-2008	1965-2008	1970-2008	1971-2008	1965-2008

Dependent variable: Yield (kg/ha) of respective crop. For Agril. Productivity, unit is Rs/ha
Variable are expressed in logarithmic term to make the series stationary
In case of wheat, variable are transformed using D-W statistics to correct autocorrelation problem

sown area at 2004-05 prices, was positively affected by irrigation, rainfall and technological improvements. It is to be noted that estimated coefficients represent elasticity of the crop yield with respect to respective variable because variables are expressed in logarithmic terms (Cobb-Douglas production function) except in case of wheat, where model was run with transformed variables to make the series stationary.

3.4. Challenges for sustainable irrigation development in India

In spite of large investments, the performance of many irrigation and drainage systems is significantly below potential due to variety of shortcomings. These include inadequate design, use of inappropriate technology, system layouts that do not adequately reflect existing conditions, inappropriate governance arrangements, and poor management practices. The most obvious manifestations of these shortcomings in irrigation are unreliable main system water supply, water wastage and poor maintenance practices. Irrigation can also cause certain environmental problems, in the areas of drainage and stalinisation, habitat change, and human health. Over-irrigation and injudicious planning of roads, canals and other rural infrastructure blocking the natural drainage ways also cause many of the drainage problems, especially in irrigated areas. Some of the challenges for the sustainable irrigation development in India are as follows;

3.4.1 Unsustainable groundwater development

Irrigation development in private domain using groundwater was not found to be sustainable in many pockets of the country. Over-dependence on groundwater neglecting the recharge mechanism resulted not only groundwater depletion but also other harmful consequences like salinity in the state of Punjab, Haryana and Western Rajasthan; fluoride contamination in North Gujarat and Southern Rajasthan, arsenic contamination in West Bengal and ingress of saline water into the aquifers in coastal areas (Kumar *et al.*, 2003). A more recent assessment by NASA showed that during 2002 to 2008, three states (Punjab, Haryana and Rajasthan) together lost about 109 km^3 of water due to decline in water table to the extent of 0.33 metres per annum (Rodell *et al.*, 2009). On the basis of groundwater development and its recharge, Central Ground Water Board (CGWB, 2010) observed that about 15 per cent of the total assessed administrative units (5723) are over-exploited with Andhra Pradesh, Delhi, Gujarat, Haryana, Karnataka, Punjab, Rajasthan and Tamil Nadu having significantly higher number of over-exploited units. Government policies of providing free/subsidizes electricity and pumps in many states are adding fuel to water crisis. Reduced farm profitability via increasing pumping cost, deceleration in productivity of irrigation water (Kumar *et al. 2003)* and equity issues (Nagaraj *et al.*, 2003) in groundwater distribution are also being raised by the scholars. The crux of the groundwater challenge in India is that there is extreme over exploitation of the resource in some parts of the country coexisting with relatively low levels of extraction in others. Thus, the stage of groundwater development in Punjab (145%), Rajasthan (125%) and Haryana (109%) have reached unsustainable levels, while Tamil Nadu (85%), Gujarat (76%) and UP (75%) are fast approaching that threshold (Shankar *et al.*, 2011). The water abundant Eastern states, where groundwater development is low, offer a great scope for unleashing unprecedented agrarian boom through sustainable groundwater development.

3.4.2 Low level of water use efficiency

Water use efficiency is presently estimated to be only 35 to 40 per cent for canal irrigation and about 60 per cent for groundwater irrigation schemes. On the basis of 1991 census, our country's per capita water availability per year was estimated at 2214 cubic metres against the global average of 9231 cubic metres. Irrigation, being the major water user, its share in the total demand is bound to decrease from the present 83 per cent to 74 per cent due to more pressing and competing demands from other sectors by 2025 A.D. and as such, the question of improving the present level of water use efficiency in general and for irrigation in particular assumes a great significance in perspective water resource planning. It is estimated that with 10 per cent increase in the present level of water use efficiency in irrigation projects, an additional 14 million hectare area can be brought under irrigation from the existing irrigation capacities which would involve a very moderate investment as compared to the investment that would be required for creating equivalent potential through new schemes (Swaminathan, 2006).

Switching from traditional irrigation technologies (furrow, border and flood irrigation), which involve water delivery to plants through gravitation usually resulting in substantial water losses and limiting uniformity in water distribution, to modern irrigation technologies, particularly drip and sprinkler, increases water use efficiency. These technologies have opened up opportunities to cultivate soils with low water-holding capacity (sandy and rock soils) and low quality lands and steep slopes. The cost for installing drip irrigation varies from ` 20,000 to 25,000 per ha for wide spaced crops like coconut, mango etc. to ` 50,000 to 70,000 per ha for closely spaced crops like sugarcane, cotton, vegetables, etc. It is observed that the pay back period is about one year for most of the crops and the benefit cost ratio varies from 2 to 5.26. It is worked out that ` 30,000 per ha will be the investment with micro sprinkler and rain gun irrigation with improved management technologies and in all the cases the system is viable for more than 10 years under good maintenance. The payback period is 2-3 years only indicating the viability of the investment (Swaminathan, 2006). These technologies has also enabled regions facing limited water supplies to shift from low value crops (eg. cereals) to high value crops such as fruits, vegetables and oilseeds.

3.4.3 Waterlogging with rise in water table in canal commands

In many canal command areas, injudicious use of irrigation water, poor maintenance and drainage infrastructure have resulted in rising water tables and waterlogged conditions leading to reduction in crop productivity and soil fertility in many canal commands. The water table rise ranged from 0.26-1.2 m in different commands studied. Once the water table rises to shallow depths, the land loses productivity due to unfavourable conditions. About 8.4 Mha of land of the country is degraded due to soil salinity and waterlogging problems.

3.4.4 Dwindling financial performance of irrigation projects

The financial aspects of irrigation projects were found to be dwindling since their inception raising a question mark on future investment in the light of poor return from the investment. The estimated share of gross receipt in total working expenditure, using the data given by CWC (2010), varied between 6-14 per cent only in different projects with inter-regional variability during tenth FYP, keep aside return from capital expenditure. The unstable financial condition of irrigation projects indicates agency problem and calls for the institutional restructuring in execution of irrigation projects. Keeping this in view, a paradigm shift in the policies for irrigation development and management has been happening during the past two decades through participatory irrigation management (PIM) and irrigation management transfer (IMT) approach. The centralized control and management responsibility of the irrigation resources are being transferred to the local farmer groups or water users associations (WUAs) for better management. About 13.16 M ha of irrigated land has been covered under 56539 numbers of WUAs in the country.

3.4.5 Increasing food demand and changing consumption pattern

Due to increasing income, growing urbanization and changing life style, composition of food basket is changing rapidly away from cereals towards high value agricultural commodities (HVACs) such as fruits, vegetables, milk, non-vegetarian products, etc. Although the per capita consumption of foodgrains has declined over the years, its total demand has been projected to increase due to increase in population and indirect demand from seed, feed and waste. Requirement of cereals and pulses for household consumption and other uses in 2020-21 is expected to be 280.6 million tones (Chand, 2007). The demand of fruits, vegetables, milk and non-vegetables, which are more water intensive, will grow more rapidly than cereals (Alagh, 2011). The amount of water required to produce a unit of animal origin products (milk, chicken, mutton, eggs, etc) i.e. water footprints, is much higher than plant origin products (cereals, pulses, oilseeds, etc). Increasing production of these HVACs to fulfill the growing demand will put pressure on available water resources which is a critical input in their production. This demands for the strengthening the irrigation for the sustainable production of these commodities.

4 Conclusions

Irrigation remains the key element in enhancing the agricultural productivity in the country in synergy with other inputs. The irrigation sector has always been the priority in the successive FYPs and taken as a driver for the agricultural growth. Consequently, massive financial resources have been infused in this sector. The public investment is made for different major, medium, minor irrigation projects, CAD and AIBP programmes to create irrigation potential in the country. Therefore, irrigation potential across the country has increased manifolds in the successive FYPs. Among the different sources of irrigation, groundwater has emerged as a dominant source in the recent years because of its reliability and efficiency over canal irrigation. However, injudicious utilization of groundwater has raised several issues on sustainability of these precious natural resources. Several states in Northern and Southern part of the country witnessed over-exploitation of the groundwater, while the Eastern part is under-utilizing its groundwater because of poor infrastructure and unfavourable geological conditions. Overall, there exists a potential to develop groundwater further as only about 58 per cent of groundwater has been developed till date.

The cost of creation of one hectare of irrigation infrastructure has increased manifolds over successive FYPs mainly due to introduction of the extension and distribution system upto 5-8 hectare block, the cost of rehabilitation and resettlement, environmental & Forest aspects, inclusion of the cost of catchment area treatment, inclusion of drainage system in the command of irrigation projects, increase in establishment costs, etc. There also exists inter-regional variation in per hectare irrigation investment due to differential topographical conditions and wage rates. Further, irrigation projects were not found to be viable and gross revenue could not cover even working expenditure of the irrigation projects. Thus, the efficiency in the execution of the irrigation projects and institutional set up need to be strengthen to improve the return from the investment. Participatory Irrigation Management (PIM) through formation of Water User Associations is the one of the steps taken by the Central and State Governments in this direction.

The impact of the irrigation development on the agriculture was found to be positive as shown by the increasing cropping intensity, irrigation intensity, changing cropping pattern towards water intensive high value crops and improving crop yield vis-à-vis irrigation infrastructure over the FYPs. Significant positive impact of irrigation on crop yield also suggested a great scope to enhance crop yield through suitable water management practices. However, there exists inter-regional disparity in irrigation development and the performance of the above indicators, which necessitates location specific policy reforms for the sustainable, holistic and unbiased development of all parts of the country.

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Appendix

Appendix 1. Estimates of water resources in India

Agency	Estimate (BCM)	Deviation from 1869 (BCM)
First Irrigation commission (1902-03)	1443	-23%
Dr. A.N. Khosla	1673	-10%
Central Water and Power Commission (1954-66)	1881	+0.6%
National Commission on Agriculture	1850	-1%
Central Water Commission (1988)	1880	+0.6%
Central Water Commission (1993)	1869	-
National Commission for Integrated Water Resources Development Plan (NCIWRDP)	1952.87	+4.49%

Appendix 2. State wise ultimate irrigation potential (UIP)

(000, ha)

State	Major and medium surface water	Minor irrigation			Grand Total
		Surface water	Groundwater	Total	
Uttar Pradesh	12500	1200	16799	17999	30499
Bihar	6500	1900	4947	6847	13347
Madhya Pradesh	6000	2200	9732	11932	17932
Andhra Pradesh	5000	2300	3960	6260	11260
Maharashtra	4100	1200	3652	4852	8952
Odisha	3600	1000	4203	5203	8803
Gujarat	3000	347	2756	3103	6103
Haryana	3000	50	1462	1512	4512
Punjab	3000	50	2917	2967	5967
Rajasthan	2750	600	1778	2378	5128
Karnataka	2500	900	2574	3474	5974
West Bengal	2300	1300	3318	4618	6918
Tamil Nadu	1500	1200	2832	4032	5532
Kerala	1000	800	879	1679	2679
Assam	970	1000	900	1900	2870
Jammu & Kashmir	250	400	708	1108	1358
Manipur	135	100	369	469	604
Tripura	100	100	81	181	281
Goa	62	25	29	54	116
Himachal Pradesh	50	235	68	303	353
Meghalaya	20	85	63	148	168
Sikkim	20	50	-	50	70
Nagaland	10	75	5	80	90
Arunachal Pradesh	0	150	18	168	168
Mizoram	0	70	5	75	75
India	58465	17337	64092	81429	139894

Total may not tally because non-availability of data for some States

Appendix 3. State wise UIP, IPC and IPU at the end of X five year plan

(000, ha)

State	IPC	IPU	% of IPC to IPU
Haryana	4669	4221	90
Himachal Pradesh	263	215	82
Jammu & Kashmir	770	617	80
Punjab	9130	8505	93
Uttar Pradesh	29222	22849	78
Uttarakhand	1024	727	71
Goa	56	42	75
Gujarat	7229	4601	64
Madhya Pradesh	7639	4618	60
Maharashtra	9364	6492	69
Rajasthan	9236	6818	74
Andhra Pradesh	9700	7307	75
Karnataka	4543	3659	81
Kerala	2030	1624	80
Tamil Nadu	5826	3993	69
Bihar	8128	4977	61
Chhattisgarh	2786	1706	61
Jharkhand	1026	731	71
Odisha	3745	2708	72
West Bengal	5352	3629	68
Assam	790	551	70
India	123263	91086	74