Temporal Irrigation Performance Assessment in Western Maharashtra, India: Takari Lift Irrigation Scheme Case Study

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Abstract - **During the recent decades, there has been an increasing effort to transfer the management of irrigation schemes from government organizations to non-governmental organizations as decentralization gained momentum and as states started to devolve some of their functions to different groups in the society. Irrigation management in India was also affected by these developments. Since 2005, in India approximately 50% and in Maharashtra approximately 30% of the public irrigation schemes were turned over to the locally managed farmer organizations. This study was conducted in the Takari Lift Irrigation Scheme, to assess the temporal variations of agricultural, water use, environmental and financial performance indicators for the pre-transfer (1984–2000) and the post-transfer (2001–2010) periods. Results showed, after 10 years of transfer, a continued improvement in irrigation performance. The most important finding of the study was a considerable increase in output per unit of land and per unit of water after turnover. Irrigation management transfer (IMT) provided a dramatic achievement in water fee collection efficiencies and more financially self-sustaining organizations. Therefore, it can be safely concluded that the transfer process created more sustainable management for irrigation.**

Keywords: **Takari Lift Irrigation Scheme, Irrigation Management Transfer, Performance Assessment**

I. Introduction

The available surface and ground water resources are inadequate to meet the growing water demands due to rapid urbanization and increasing population. The demand for water has increased over the years, due to which the assessment of quantity and quality of water for its optimal utilization has become essential.

Two hundred eighty million hectares are irrigated worldwide, accounting for 35% of all agricultural production. Irrigated agriculture consumes about 70% of the water supply. However, it has been observed since the mid 1960s that irrigation systems are operated below their potential (Nijman, 1993). Many countries around the world are currently moving to devolve water management tasks from state agencies to participatory, autonomous, financially self-supporting water user organizations. The trend is particularly noticeable in the irrigation sector (Kukul *et.al,* 2008). The process is commonly known as irrigation management transfer (IMT). The term IMT means the relocation of responsibility and authority for irrigation management from government organizations to non-governmental water user organizations such as irrigation associations (IAs). It may include all or partial transfer of management functions and authority (Vermillion and Sagardoy, 1999). Irrigation management transfers were initiated by governments mainly due to poor management performance, insufficient financial resources for operation and maintenance costs, and very low water fee collection efficiencies from the farmers. Since the 1980s, deep financial crises and poor progress in raising economic and social welfare led to a fundamental rethinking of the role of the state. Consequently, decentralization gained momentum and states started to transfer some of their functions to different groups in the society (Anonymous, 1993). Indian agriculture and irrigation management systems have also been affected by these developments.

Under the transfer agreement, the irrigation association becomes responsible for collecting water charges according to the crops and water providing to these crops. Generally the irrigation associations (Sugar Factories) are responsible for collecting the water charges from various farmers because in this area the major crop taken is Sugarcane. The services related to the operation and maintenance of the specified irrigation facilities and for bearing the costs of providing these services are related to the government. Neither water rights nor the ownership of facilities are transferred to the IA but remain with the state. Operation responsibilities in virtually all larger schemes are not shared between SHW and IAs. Performance of irrigation systems is evaluated for a variety of management objectives. Several researchers have proposed various indicators to assess the performance of irrigation systems. Most of them focused on internal processes of irrigation schemes that relate performance to management objectives such as the area irrigated, crop patterns and distribution and delivery of water (Abernethy, 1986; Levine, 1982; Molden and Gates, 1990; Bos *et al.,* 1994; Rao, 1993). These process indicators have been developed to assess the quality of operational performance. However they do not provide information for cross-system comparison (Small and Svendsen, 1990). Molden *et al.* (1998) have proposed nine external and other comparative indicators which will allow for comparison between countries and regions, different management types and environments, and for assessment over time of the trend in performance of a specific irrigation scheme. These comparative indicators have been used by many researchers to assess the temporal and spatial variations of agricultural, water use, environmental and financial performances of irrigation systems (Sakthivadivel *et al*., 1999; Molden *et al*., 1998; Kloezen and Garce´s-Restrepo, 1998). Very few of the studies evaluated the impacts of management interventions, e.g. irrigation management transfer. Such impact assessment studies require analysis of time-series data and provide useful information for policy makers and managers when the interventions lead to projected objectives. This study was conducted to assess temporal variations of some performance criteria for pre- and post-transfer periods in the Takari Lift Irrigation Scheme.

II. Materials And Methods

A. The Takari Plain Irrigated Area

The Takari plain is located in the Yerala Basin. The Yearla Basin is located within the Western Maharashtra, India Latitude 16° 55' to 17° 28' N and Longitude 74° 20' to 74° 40' E. falling in part survey of India topographical sheet no 47 K – 5, 6, 7, 8, 10, 11, 12, 47 L - 9 on the scale 1:50,000 it covers total area of 3035 km^2 includes two districts (Satara and Sangli) in Maharashtra The tributaries of the Yerala River have been filled with eroded silt and sediment by erosion. For this reason, river sand is very much useful for the construction of various structures. These conditions create a problem of groundwater and biodiversity near the bank of the river. Generally soils are light textured. Typical soil textures in area of the nine tertiary canals under study are clay loam, sandy loam, gravelly loam and silty loam. According to climatic data for Yerala for the period 1985–2009, the average annual air temperature is 25.8ºC, the minimum monthly average air temperature in January is 8º C, and the maximum monthly average air temperature in July is 26.9ºC. The average annual rainfall increases from 1200 mm in the western side to 450 mm in the east side. Geology of the area is dominantly covered by basaltic rock. The area has suffered a lot by tectonic movement in the past as evidenced by varying fold, fault and lineament association with hills located in the western side of study area (Fig. 1).

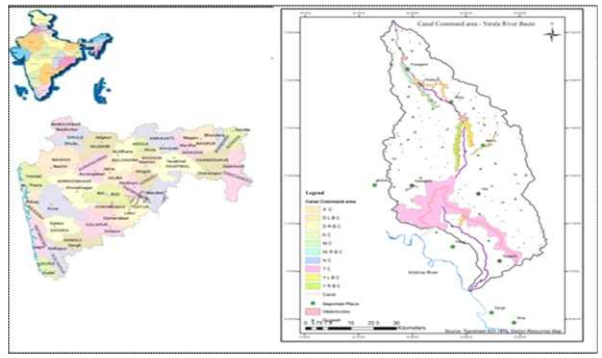

Fig. 1 Index map of Yerala
watershed with Takari Lift Irrigation command area

The Takari Lift Irrigation Scheme (TLIS) delivers irrigation water only during the peak crop water requirement period. Water requirements for the rest of the irrigation season are partially met by rainfall and small amount of water in the river flows that are fed by the river's tributaries. The TLIS supplies a steady amount of water to the system by pumping water from Krishna River, taking into account farmer demands. Farmers use this water to irrigate crops, especially sugarcane, as well as other crops like Gram, Wheat and Vegetables. Therefore, water delivery does not cause any major disagreements among farmers. The system irrigates 4000 ha. Approximately But total command area comes under this scheme is 30921 ha. So that there is large scope to improve the water distribution system. There are twenty-five secondary canals in the TLIS. This study investigated the TLIS main canal (Length 81.55 Kms). Total main canal length is 144 kms. The secondary canals are not in good conditions to pass the water through them. There are two points in the system at which flow or water level control is possible: (i) the main regulator at the TLIS Pumping Station- 1 & 2 of the main canal, (ii) KT weirs is constructed in the main canal stream. Control operations are carried out in between TLISD and the village irrigation committees (VICs). Although water level can be measured with staff gauges at secondary and tertiaries, but at this stage it is not done regularly. Water is diverted into fields using farm outlets, in the case of trapezoidal canals, pumping from main canal stream and siphon tubes. Water allocation to main canals is fixed by the Takari Lift Irrigation Scheme Department (TLISD) according to the cropping pattern and the canals' irrigation area. Total water available for pumping in TLIS about 9 TMC but at this stage only 3 TMC water is lifted. The TLISD is responsible for water delivery from the main canal to secondary canals, and therefore, for the rotation program.

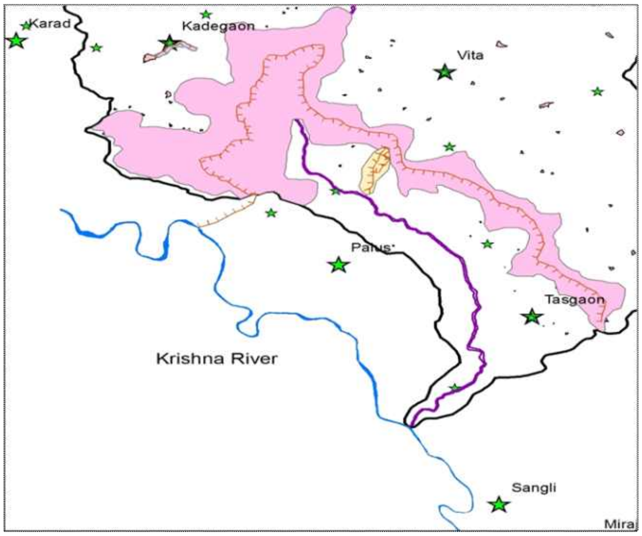

Fig. 2 Takari Lift Irrigation Scheme in details

Since the system is not handed over to the VICs so that no plan has been developed for water delivery at the secondary and tertiary level. Arrangements are made in this way: Currently there is no standard method to supply the water through canal. Distribution is carried out by set rotation approximately 15 days in a month except rainy season. When a farmer feels the land has sufficient water, the farm outlet or siphon tube is closed and water passes to the next farmer down the canal. Water charges are reassessed annually by the TLISD according to crop type and land area, and payments are collected from the farmers by the Sugar factories and VICs. Because water supplied to secondaries is not measured, VICs have no way of knowing how much water has been supplied, and are thus incapable of ensuring completely adequate and equitable delivery. Moreover, as in the whole of Western Maharashtra, crop production planning is not practiced on the Takari plain, and farmers follow the tradition of planting crops with a high water requirement – principally sugarcane, and also jawar, gram, wheat and vegetables and fruits – without regard to the availability of irrigation water. Production costs are a main factor in this tradition. In addition, factors such as concern that irrigation water may not be available at the desired time, and lack of knowledge of the detrimental effects of excessive irrigation, encourage farmers to over-irrigate. Therefore, farmers at the tail of the system generally claim that those at the head of the system use excess water.

B. Performance Assessment

The Takari Lift Irrigation Scheme was evaluated for several performance indicators for both pre-transfer (1984–2000) and post-transfer (2001–2010) periods. The performance indicators used in assessment are given

TABLE I GENERAL INFORMATION OF THE TAKARI LIS

Sl. No.	Details	Takari Main Canal
1	Command area (ha)	30921
2	Main Crop (%)	60
3	Length of Irrigation canals (km)	81.55
4	Number of Villages	34
5	Number of members	2000 appx.

1. Agricultural Performance Indicators

Five external indicators, which have been developed by Molden et al. (1998), and the irrigation ratio (Bos et al., 1994) were used for assessment of irrigated agricultural performances.

$$\text{Output per unit command area (\$/ha)} = \frac{Production\ (SGVP)}{Common\ Area} \quad (1)$$

$$\text{Output per unit cropped area (\$/ha)} = \frac{\text{Production(SGVP)}}{\text{Irrigated cropped area}} \quad (2)$$

$$\text{Output per unit irrigation supply (\$/m}^3\text{)} = \frac{\text{Production(SGVP)}}{\text{Irrigation water supply}} \quad (3)$$

$$\text{Output per unit water consumed (\$/m}^3\text{)} = \frac{\text{Production(SGVP)}}{\text{Volume of water consumed by ET}} \quad (4)$$

$$\text{Irrigation ratio (\%)} = 100 * \frac{\text{Irrigated cropped area}}{\text{Command area}} \quad (5)$$

where production is the output of the irrigated area in terms of net or gross value of production measured at local prices (Rs); Command area is the design area to be irrigated ha); Irrigated cropped area is the sum of the areas under crops or the actually cropped area during the time period of analysis (ha); Irrigation water supply is the volume of surface irrigation water diverted to command area (m^3); volume of water consumed by ET is the actual evapotranspiration of crops (m^3). The Standardized Gross Value of Production (SGVP) was used for temporal comparison of agricultural production. SGVP was calculated as follows (Molden *et al.,* 1998)

$$SGVP\ (\$) = P_w \sum_i A_i Y_i \frac{P_i}{P_b}\ ,\quad i\ for\ crops \quad (6)$$

where A_i, is the area cropped with crop i (ha); Y_i, is the yield of crop i (ton/ha); P_i, is the local price of crop i (Rs./ton); P_b, is the local price of the base crop (Rs./ton); P_w, is the value of the base crop traded at world prices ($/ton).

Sugarcane was considered as the base crop, since it was grown approximately in 60% of the irrigated area in the Takari Lift Irrigation Scheme, in both the pre- and post-transfer periods. As for the world prices of sugarcane, Liverpool Index A prices were taken into consideration. In order to eliminate the inflation effect, local prices were corrected by wholesale price index (base year 1984).

2. Water Use Performance Indicators

Relative irrigation supply was identified for water use performance assessment (Levine, 1982). Relative irrigation supply relates supply to demand and it is defined as:

$$\text{Relative irrigation supply} = \frac{\text{Irrigation water supply}}{\text{Irrigation demand}} \quad (7)$$

where Irrigation water supply is the volume of surface irrigation water diverted to command area (m^3); Irrigation demand is the net irrigation water requirements of crops for ET in cropped area (m^3).

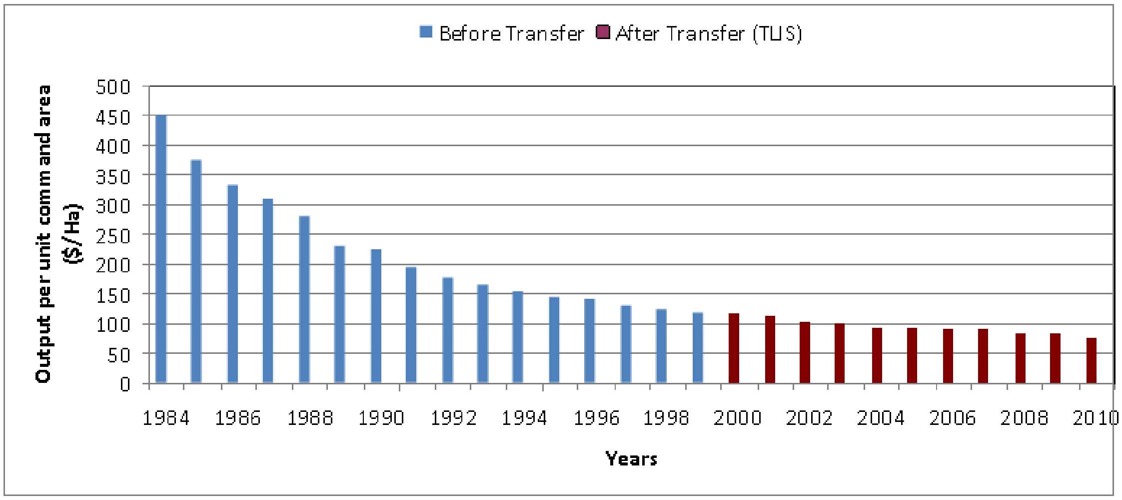

Fig. 3 Output per unit command area of the Takari Lift Irrigation Scheme for the pre- and post-transfer periods

3. Environmental Performance Indicator

Sustainability of the irrigation area was taken into consideration as an environmental performance criterion.

$$\text{Sustainability of irrigation area} = \frac{\text{Current irrigable area}}{\text{IInitial irrigable area}} \quad (8)$$

where Current irrigable area is the current command irrigation area (ha); Initial irrigable area is the design area to be irrigated or the projected command area (ha).

4. Financial Performance Indicators

Two indicators, used for financial assessment, are given below:

$$\text{Water fee collection efficiency (\%)} = 100 * \frac{\text{Irrigation fees collected}}{\text{Irrigation fees due}} \quad (9)$$

where Irrigation fees collected are the total irrigation fees collected from water users (VICs) and major fee collected from Sugar industries.

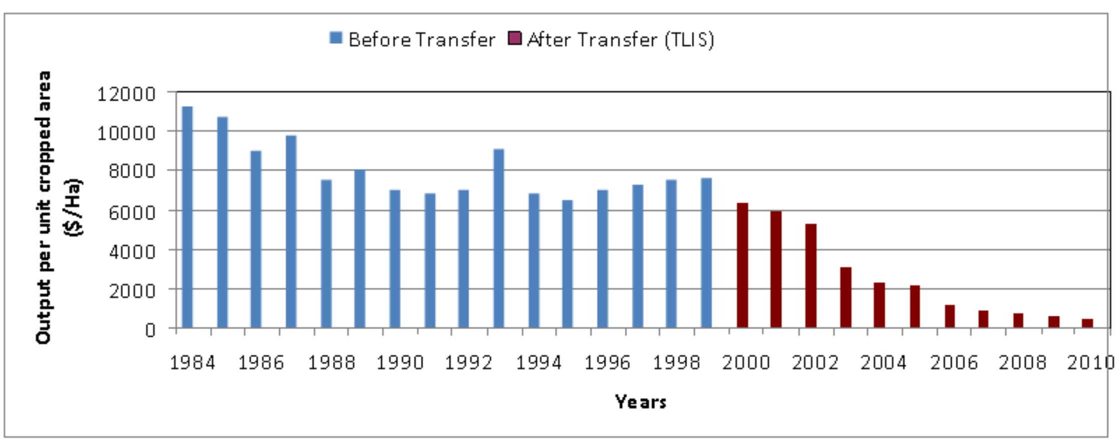

Fig. 4 Output per unit cropped area of the Takari Lift Irrigation Scheme for the pre- and post-transfer periods

TABLE II AVERAGE VALUES OF PRE-TRANSFER (1984-2000) AND POST-TRANSFER (2001-2010) PERIOD PERFORMANCE INDICATORS FOR THE TAKARI LIS

Sl. No.	Indicators	Pre-transfer Period	Post-Transfer Period
1	Output per unit command ($/ha)	221	94.79
2	Output per unit cropped ($/ha)	8037	2637
3	Output per unit irrigation supply	0.22	0.043
4	Output per unit water consumed ($/m³)	0.43	0.08
5	Irrigation ratio (%)	2.67	7.08
6	Relative irrigation supply	0.231	0.134
7	Sustainability of Irrigated area	1.14	0.99
8	Water fee collection efficiency (%)	-	83.3

III. RESULTS AND DISCUSSION

A. Output Per Unit Command and Cropped Land

These indicators provide the basis for comparison of irrigated agriculture performance and they relate output to unit land (Molden *et al.,* 1998). Before transfer, the output values per unit command area varies between $ 118 and 448 per hectare (Fig. 3), with an average value of $ 221/ha (Table II). After transfer, the output values per unit command range between $ 116 and 77 for TLIS. Before transfer, the output values per unit cropped land change from $ 7603 to 11215 per hectare (Fig. 4), and the average output is $ 8037. After transfer of the irrigation scheme, output values per unit cropped area varies between $ 448 and 6408 for TLIS.

Variations in the output values per unit land might be attributed to the change in crop pattern and the yield per unit area of crops grown. Other factors affecting the variation are prices of local and internationally traded base crops (Molden *et al.,* 1998).

Cropping patterns remained almost is not the same throughout the investigation years. Lower values were attained in the years with low cropping intensities and low yields per unit area. On the other hand, lower cropping intensities and yields per unit area were generally due to years with water shortage with long periods between 1990 and 1995. The economic crises and high rates of devaluation of the Indian currency in 1992 and 1994 are another explanation of the lower output values per unit command and cropped area. Similarly, the economic crisis and very high devaluation in 2001 are also the main reasons for lower values of the output per unit land in the post-transfer period. Despite wide annual fluctuations, post-transfer values of output per unit command and cropped area imply an increasing trend. This could be mainly explained by the steady increase in yields per unit area for sugarcane and other crops that have been reported by the IAs in the Yerala Basin irrigation schemes.

B. Output Per Unit Irrigation Supply and Water Consumption

The above comparative performance indicators relate outputs from irrigated agriculture to the inputs of water. The output per unit irrigation supply in Fig. 5 shows variations of $ 0.13–0.39/m^3, with a mean value of $ 0.22 before turnover. After transfer, the output values range between $ 0.02 and 0.079 with an average of 0.043 for TLIS. The output values per unit water consumption show very similar trends (Fig. 5).

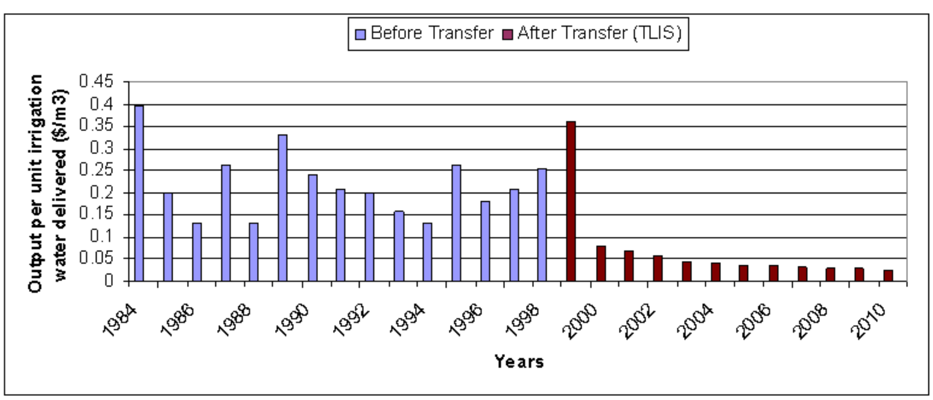

Fig. 5 Output per unit irrigation water delivered of the Takari Lift Irrigation Scheme for the pre- and post-transfer periods

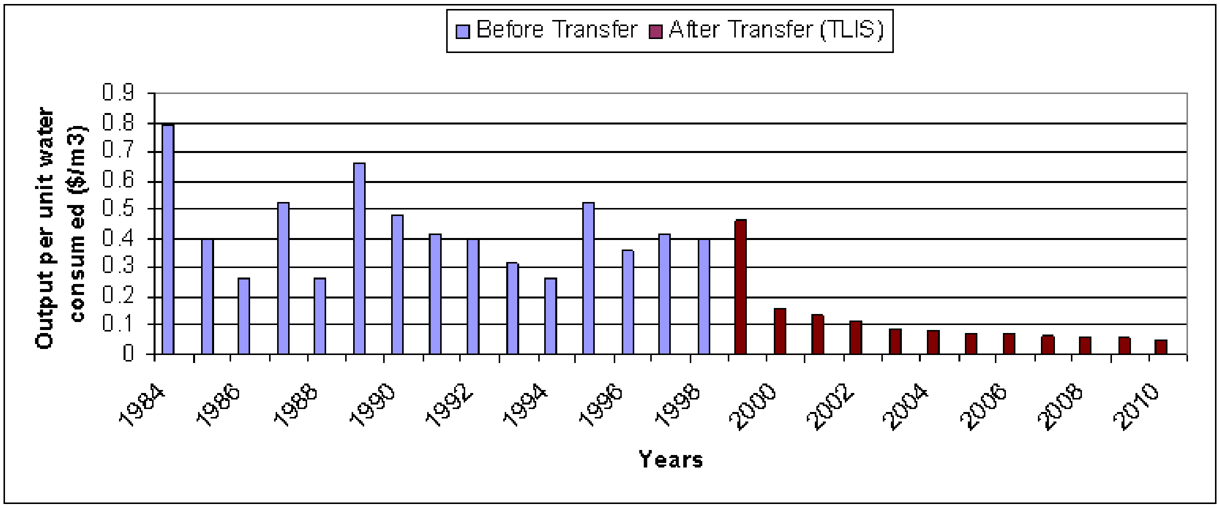

Fig. 6 Output per unit water consumed of the Takari Lift Irrigation Scheme for the pre- and post-transfer periods

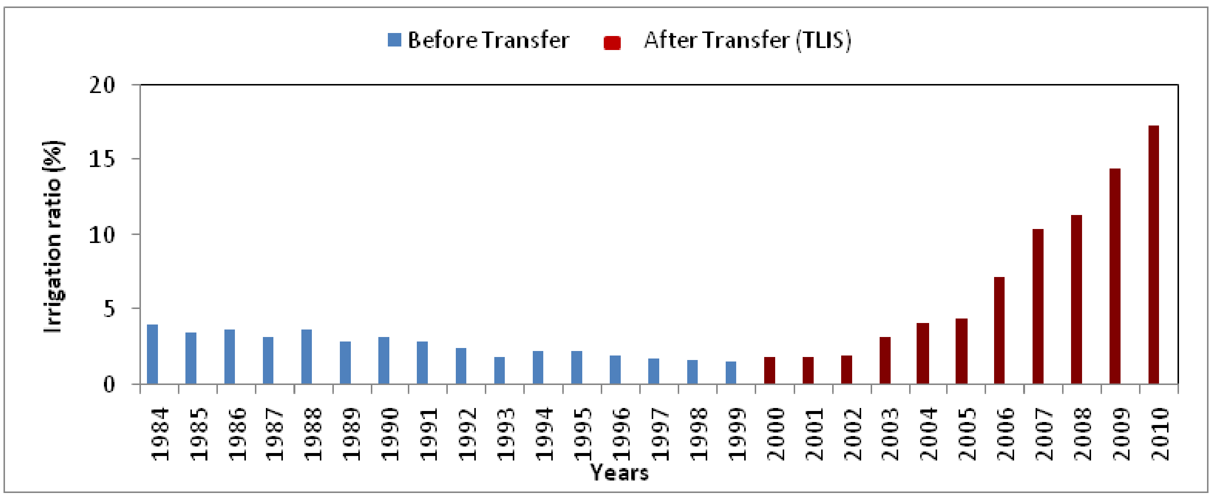

Fig. 7 Irrigation ratio of the Takari Lift Irrigation Scheme for the pre- and post-transfer periods

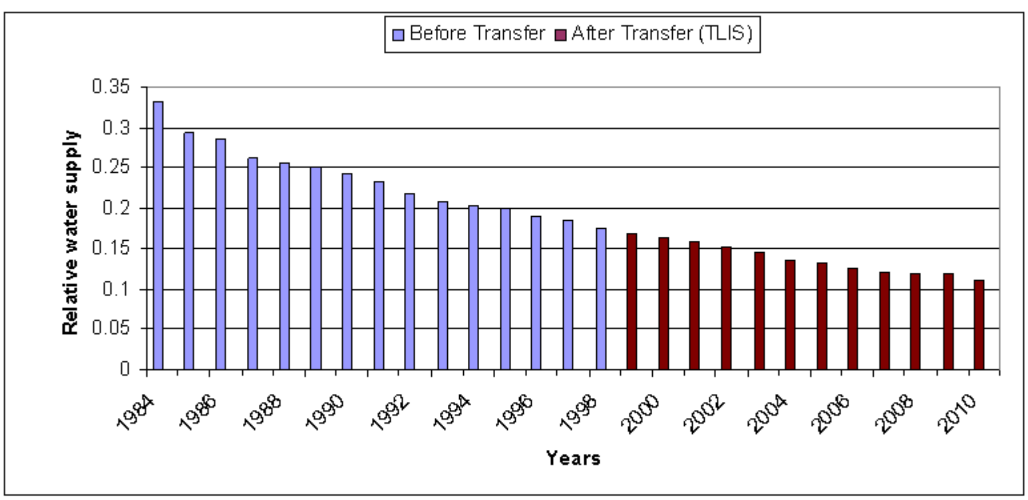

Fig. 8 Relative water supply of the Takari Lift Irrigation Scheme for the pre- and post-transfer periods

In the Takari lift Irrigation Scheme the main crops grown are sugarcane, grapes, vegetables and jawar crops. The results of the Takari lift irrigation Scheme are similar to the findings of this study.

C. Irrigation Ratio

The term irrigation ratio refers to what extent the irrigable land is being actually irrigated. Table II shows that the mean irrigation ratio is 2.67% at the pre-transfer period. After transfer mean ratios are determined as 7.08% for TLIS. The post-transfer irrigation period displays a slight increase and generally more stabilized ratios (Fig. 7). Lower irrigation ratios are attained between 1993 and 1999, at the pre-transfer period. During this period severe drought adversely affected water resources and agriculture in the Yerala Basin and consequently, irrigation ratios considerably decreased. The other possible reasons for the low irrigation ratios were increased input prices and destabilized market conditions, which have been influenced by the economic crises in India in the beginning of the 1990s.

D. Relative Irrigation Supply

The relative irrigation supply indicates how well irrigation supply matches with the demand. Relative irrigation supply is the inverse of the irrigation efficiency and it is an indicator of water use performance of an irrigation scheme. A value lower than one implies that less irrigation water is allocated to the scheme than demanded. It has been stated that the relative irrigation supply higher than 2.5 is an indicator of inappropriate water management (Levine, 1982). The relative irrigation supply is determined between 0.17 and 0.33 at the pre-transfer period (Fig. 8). After transfer, the values range between 0.11 and 0.16 for TLIS. The average values of relative irrigation supply are almost less than one i.e. not close to the optimum water management conditions during the post-transfer period (Table II). Lower irrigation supply values during pre-transfer period were again due to the prolonged drought and scarcity of available water resources at the end of 1980s and the first half of 1990s.

E. Sustainability of Irrigation Area

Sustainability of irrigation area is an environmental performance criteria indicating the variations in the size of irrigated land considering the initial or projected area of the scheme. Sustainability of irrigation area monitors the loss of irrigated area due to negative environmental conditions resulting from salinization, drainage problems and misuse of agricultural lands by urban and industrial development. Fig. 9 shows that the sustainability of irrigated area is found approximately 1.0 for both the pre- and post-transfer periods. This figure reveals that the irrigation areas remained almost the same and no evidence was detected pertaining to the negative environmental impacts as a consequence of misuse of agricultural lands during the investigation period.

F. Water Fee Collection Efficiency

Water fee collection efficiency values are calculated between the years 2000 and 2010 covering both the public and irrigation association managed periods (Fig. 10). It is clear that the efficiency is considerably low, 83.3% in average, during the after transfer period (Table II). This can be attributed to the lack of sanctions for non-payers and to very low interest rates charged to the late payment of irrigation fees. Higher fee collection efficiencies have also been reported for transferred irrigation schemes in western Maharashtra, India.

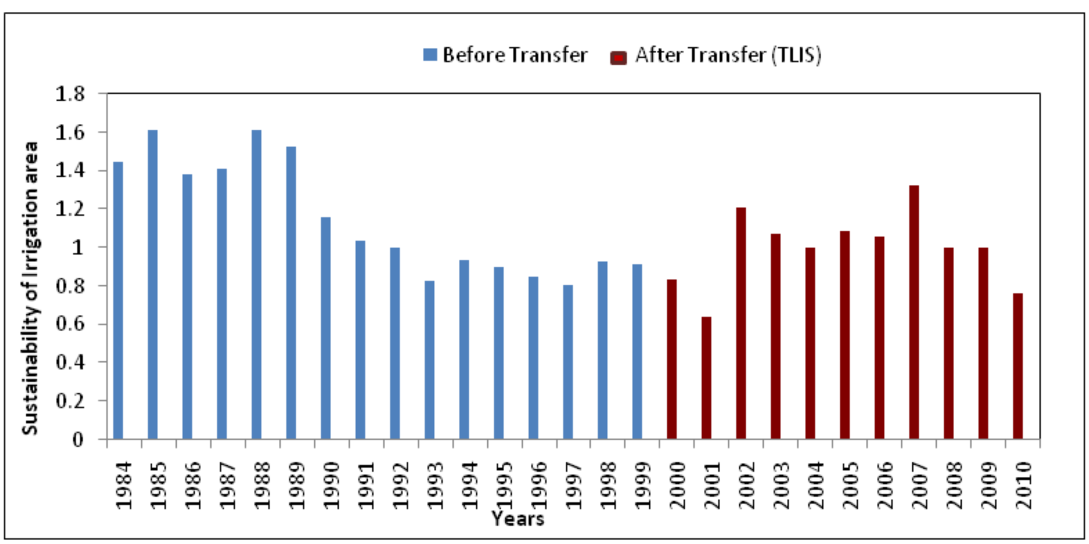

Fig. 9 Sustainability of irrigation area of the Takari Lift Irrigation Scheme for the pre- and post-transfer periods

IV. Conclusion

Availability of reliable pre- and post-transfer time-series data of the several agricultural, water use, environmental and financial performance indicators in the Takari Lift Irrigation Scheme in India can serve as useful tools to analyze the impacts of the management turnover process. The indicators were computed for a total period of 26 years: the pre-transfer period from 1984 to 1999, and the post-transfer period from 2000 to 2010. The most important finding of the time-series analyses is the considerable increase in outputs per unit of land and per unit of water after turnover. Improvements in agricultural performance could be attributed to the steady increase in the yield per unit area of the main crops i.e. sugarcane and jawar, with the introduction of new highly yielding varieties and more suitable application of cultural practices. Other reasons of improved agricultural performances are consistently higher irrigation ratios and more stabilized economic and climatic conditions during the post-transfer period. The relative irrigation supply values indicated improvements in operational performance of irrigation scheme and better water management during the post-transfer period.

Researchers emphasized that these benefits could be attributed in part to favorable market conditions for sugarcane and jawar, but also to more appropriate level of service so that growers were not constrained by uncertainties in water deliveries. Sixteen years after the transfer, no significant evidence has been found pertaining to adverse environmental conditions derived from various parameters in the irrigation schemes. Other apparent improvements in irrigation management transfer are considerable increases in financial self-sufficiency and water fee collection efficiency. Main driver for the accelerated irrigation management transfer in India was the national budgetary crises, political interference and very low financial self-sufficiency owing to rapid increase in personnel, energy and maintenance costs in the early 1990s. The most important impact of turnover in the Takari Lift Irrigation Scheme is the financially self-sufficient management of IAs. It is also clear that the transfer contributed to the government's objective of curtailing subsidies and making irrigation management financially self-sustaining. The results of this temporal assessment are useful for policy makers and managers at all levels who make long-term strategic decisions along with researchers applying benchmarking and doing comparative performance studies.

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