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Full Length Research Paper

Integrating Socio-Environmental Benchmarks for Sustainable Irrigation Management

Sanjay Sitaram Phadnis[1]* and Mukul Kulshrestha[2]

[1]Research Scholar, MANIT-Bhopal, and Executive Engineer, MP, Water Resources Department, Bhopal, India.
[2]Department of Civil Engineering, National Institute of Technology, MANIT Bhopal, Madhya Pradesh, India.

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It is a proven fact that the quantity and quality of available water resources have been recognized as limiting factors in development of most of the arid and semi-arid regions. The function of the conveyance and distribution systems and services should be providing sufficient water in a timely manner so that it can be used efficiently for crop production. Reliability, flexibility and efficiency are the keywords for a modernization plan. Optimal use of available surface and groundwater, in any canal command area would result in their better utilization by maximizing the benefits from the crop production and the environmentally sustainable development and management of water resources in an integrated and participatory approach. Irrigation sector is the highest water consumer; therefore it is a sector where performance assessment is necessary to ensure optimum utilization of water. The major system deficiencies are low canal carrying capacity, over utilizations of water in rabi irrigation, flooding irrigation practices, low yield per unit irrigated area, low-cost recovery in the Samrat Ashok Sagar irrigation project. This paper presents a need of benchmarking of major irrigation projects for socially and environmentally sustainable development in India based on integrated and participatory approach.

Key words: Benchmarking, participatory approach, environmentally sustainable development, water management.

INTRODUCTION

Improvement of irrigation efficiency can improve equity in water distribution and minimize the gap between potential crop water requirements and actual water use. Farmers need to use lesser water or lower input in investment while obtaining higher production and leaving more water to maintain the ecological cycle and environment of river basin (Fongasmuth and Okudira, 2006). Through the accelerated transfer program of Government owned irrigation projects which started in 1993, the responsibility for management, operation and maintenance of irrigation systems has mainly been transferred to users. Participatory irrigation management (PIM) has been established for three main reasons: user participation, self-control of the irrigation management and reducing financial load on government (Hasan and Hakan, 2003).

PIM refers to the involvement of irrigation users in all aspects and all levels of irrigation operation and management. System performance monitoring, evaluation and diagnostic analysis are keys to appreciate the improvement or inefficiency in our irrigation projects and benchmarking is a valuable tool for this (Phanish, 2002). The essence of the benchmarking process is to provide organizations with the ability to compare their performance in relation to similar organizations or similar processes (IPTRID Report, 2000). It will help project authority to take adequate measures for identified problems to bridge the gap in order to ensure the optimum utilization of water in the project (INCID, 2006).

The national water policy brought adopted in 1987 and subsequently revised in April, 2002 has also recommended for conducting evaluation studies of water resources projects periodically (National Water Policy, 2002). In the case of benchmarking of irrigation systems, performance of an irrigation project can easily be compared with its best past performance and performance of other irrigation projects in the group. In

*Corresponding author. E-mail: lo_mani@yahoo.co.in. Tel: 91-755-2778406. Fax: 91-755-2551900.

this way, it provides wider scope for performance comparison and performance improvement. Experience has shown that there are certain conditions which prevent the optimal development of schemes e.g. it is impossible to provide satisfactory service to individual farmers, because of the poor and deteriorated infrastructure, and vague and inadequate operation and maintenance procedures. The situation is further complicated because of interference of large number of water users with varying extents of landholdings and having different socio economic interests. To remedy this situation, involvement of farmers and their participation in the management of the system along with irrigation department staff is now recognized as imperative management. PIM facilitates the farmers to come together and work, as a group with the concerned irrigation authorities so that, they, as a group may be able to serve individual farmers' needs better (Phadnis et al., 2008). Therefore there is a need to develop a strategy for equitable and optimal utilization of canal irrigation water for better productivity through community participation. Nowadays it is widely accepted that promoting community participation through water users association can be the best strategy for long term sustainability of irrigated agriculture.

PIM refers to the involvement of irrigation users in all aspects and all levels of irrigation management. "All aspects" includes the initial planning and design of new irrigation projects or modernization of existing projects, as well as the construction, supervision, financing, decision rules, operation, maintenance, monitoring, and evaluation of the system. In India, PIM is introduced by various state governments to reduce their financial demands with ensuring sustainability of irrigation systems. Many states like Madhya Pradesh, Rajasthan and Andhra Pradesh have passed PIM Act. Goa has also passed command area development act in 1997 in line of PIM act. Presently Madhya Pradesh, Rajasthan, Andhra Pradesh, Uttar Pradesh, Gujarat, Bihar, Maharashtra, Tamil Nadu, Orissa etc are planning to strengthen water users associations.

Several unforeseen environmental problems emerge under irrigation system (Lele and Joglekar, 2008). A reliable service allows efficient irrigation management within the constraints of the system. Moreover, if the irrigation delivery is flexible, the farmer can adapt the irrigation schedules to optimum cropping strategies and strategies that can be adjusted as the crop progresses. Therefore, both reliability and flexibility lead to higher irrigation efficiency and crop yield (Playan et al., 2006*).* It is imperative for water managers to perform continuous monitoring by adopting benchmarking process in the study area (INCID, 2006).

The objective of this paper is:

(1) To study scheme under irrigation and drainage sector this is transferred to water users association for operation and maintenance based on participatory methods.

(2) To understand role of water users associations (WUA) to promote and secure distribution of water, knowledge of adequate maintenance of the irrigation system for efficient and economical utilization of water so as to optimize agricultural production to protect the environment

(3) To ensure ecological balance inculcating a sense of ownership of the irrigation system in accordance with the water budget and the operational plan.

METHODOLOGY

The main objective of this paper is to understand application and importance of participatory methods for socially and environ-mentally sustainable development in major irrigation and drainage sector and need of benchmarking in present situation. The material for the study consisted of ongoing Samrat Ashok Sagar Project to manage water resources for the benefit of its users. The water users, namely farmers and other beneficiaries have been involved in the project as organized associations that is, WUA (Figure 1).

To select the indicators, emphasis was given to opt "Guideline for benchmarking of irrigation and drainage sector issued by Indian national committee for irrigation and drainage constituted by central water commission, government of India (INCID, 2002)". It is also noted from previous studies that a key issue within the irrigation and drainage sector is the uniqueness of each irrigation and drainage scheme. After the study of several reports and research papers it is observed that there are many variables which influence the performance of irrigation and drainage schemes, making comparative performance difficult. Based on this, data was collected for selected indicators in the study area. The evaluation was done in a simple excel sheet.

It is evaluated through many studies that the benchmarking performance indicators provide the knowledge base for irrigators to assess their own irrigation efficiency, to compare themselves to other irrigators or with their past performance, and to make adjustments to their practices in order to improve their efficiency. The main objective of this study is to benchmark the irrigation water use in irrigation and drainage project for selected indicators. The indicators used are mainly those recommended by Indian nation committee for irrigation and drainage in 2006.

RESULTS AND DISCUSSION

The basic requirement for irrigation is availability of water in reservoir. The water availability in the reservoir has been considered on the basis of survey conducted by government of India, regional remote sensing service centre, Indian space research organization, Jodhpur, for central water commission, New Delhi in October, 2004. As evident from Figure 2, the capacity of reservoir was found 186 Mcum as against original capacity of 226 Mcum, which is again a matter of concern and may be due to heavy siltation rate (Sharma, 2004).

Conveyance losses in study area shown in Figure 3 are much higher than losses taken in account at the time of project preparation that is, for earthen canal -1.83 cumecs/msqm of wetted perimeter and for lined canal - 0.61 cumecs/msqm of wetted perimeter. Seepage and operational losses from distribution systems are

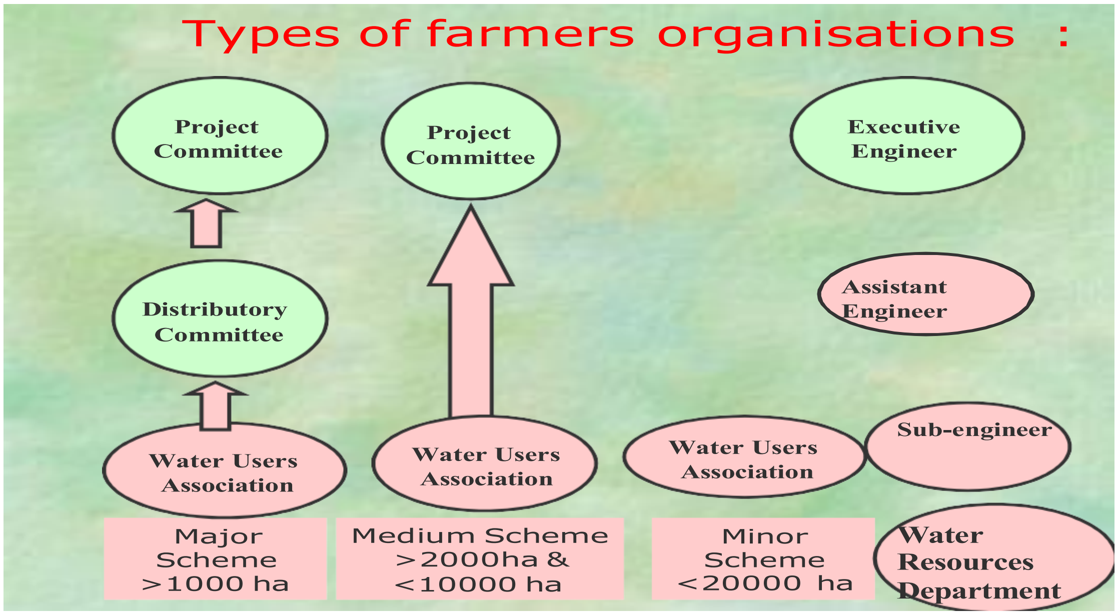

Figure 1. Water Users Associations in Madhya Pradesh.

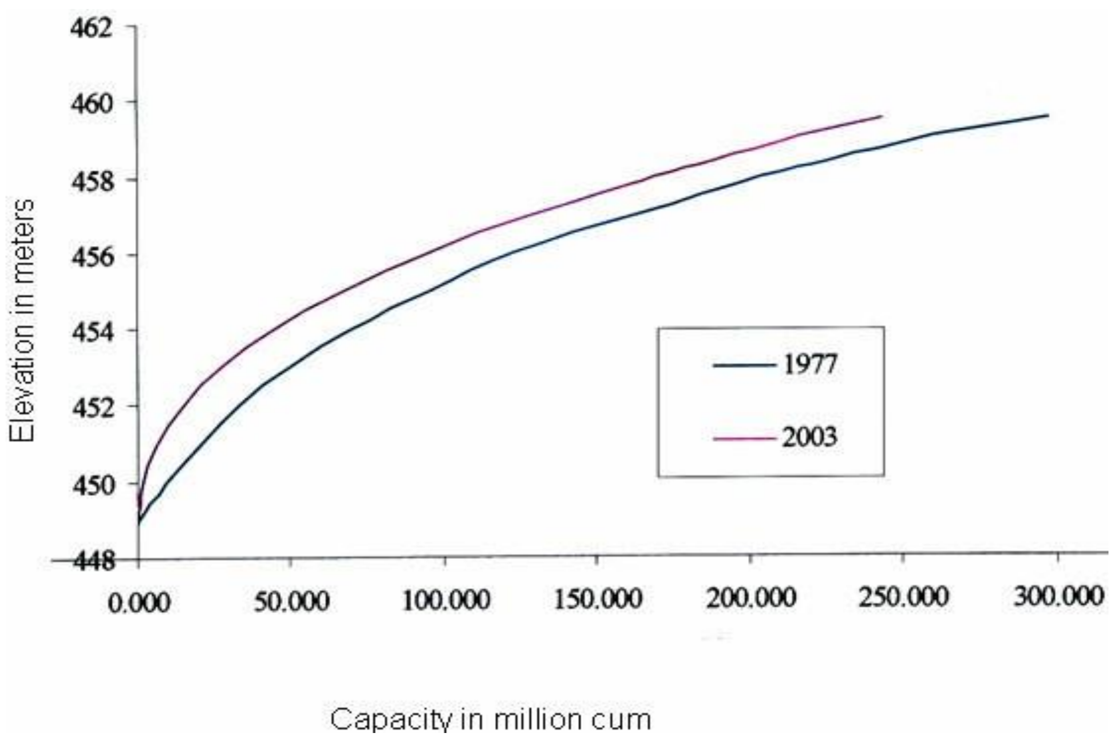

Figure 2. Elevation capacity curve for year 1997 and 2003 (Source: Sharma, 2004).

continuing problems for designers and managers of irrigation districts and for water users. The designer must provide sufficient capacity in the canals to allow for these losses, and the managers must divert extra water into parts of the system to assure ample flow to the lower reaches of all laterals. The water users must provide for ample storage to offset seepage losses. The managers also have to deal with more complex legal and technical problems that arise if seepage losses cause high water tables in fields adjacent to the canal (Worstell, 1978). The

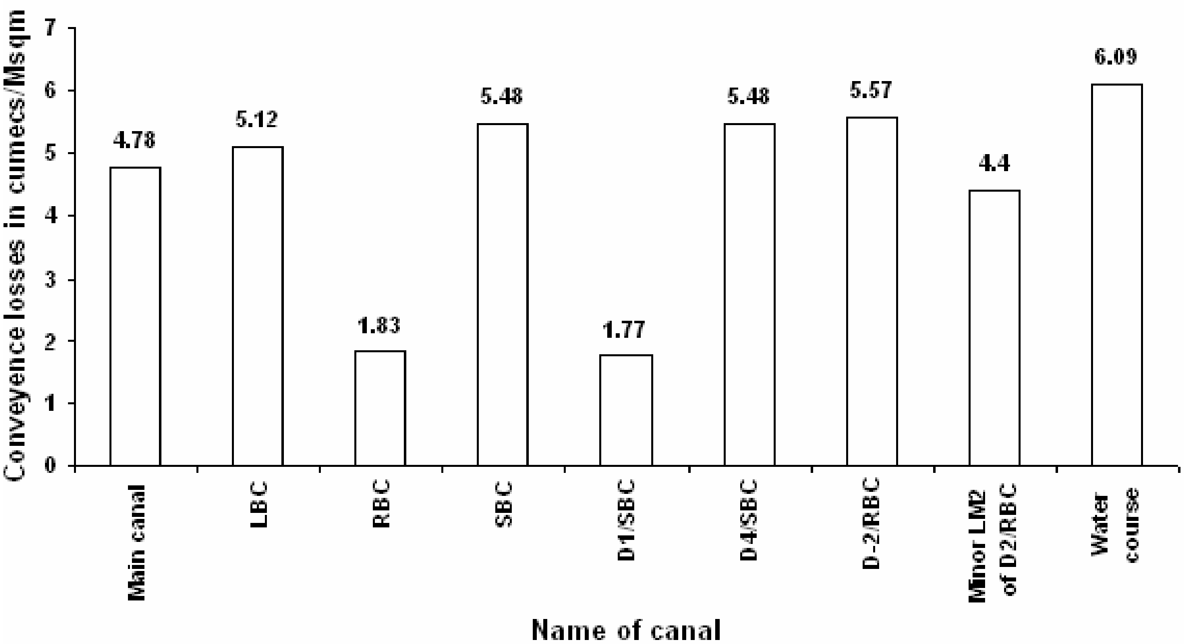

Figure 3. Conveyance losses observed in study area.

reason for such losses are heavy filling reaches, low banks, damages in lining, highly permeable canal reaches, poor conditions of masonry structures, leakage from gates, out lets and absence of command area development works that is, watercourse and field channel. Therefore some remedial action to minimize these losses is necessary and preferably all filling reaches should be lined. Apart from this, it is desirable to find out whether outer slopes are maintained and phreatic lines are not exposed in heavy filling reaches. Seepage and operational losses from distribution systems are continuing problems for designers and managers of irrigation districts and for water users (Worstell, 1976).

In this study, four broad indicators are used such as system performance, Production, financial and environmental.

System operation performance indicators

It has been observed that Rabi is developed in the command area except in limited area where potential is not created due to incomplete infrastructure or litigations etc. In Figure 4, the potential created is 24737 hectare out of total area designated for Rabi crop 25091 hectare. However, this includes area irrigated by lift in adjoining high level field along the canal alignment. It is evident that due to average 800 mm rainfall in the area, the water requirement for kharif crop could not be developed in the command area of the project. This is drawing attention of designers and water managers as water reserved for Kharif has been utilized by farmers for tank bed cultivation during Rabi and also it is seen that excess water has been used in Rabi by command farmers. Therefore excessive water utilization defeated the basic objective of optimum water utilization in present study area.

Water delivery capacity index is one of the important indicators which are evaluated to know the adequacy of canal discharge capacity to meet irrigation needs at peak period. In Samrat Ashok Sagar project, carrying capacity of canal is much less than required as given in Figure 5. The actual discharge versus designed discharge where inefficiencies in entire distribution system are visible ranges from 64 to 70%. Due to less carrying capacity of canal, reliability of system is low. Water deliveries at field are delayed. Such situations causing stress on entire canal system and causing conflicts among farmers.

Unless restructuring of canal is done, it is not possible to deliver water in equity, reliability and with timeliness. Therefore, it is unavoidable that within the project, there may be pockets of inefficiencies, which can be confirmed only through reliable indicators or through measurement of efficiencies within the system. For good management of any irrigation system, three components of water are important that is, equity, reliability and flexibility (Charles, 2000). Due to inadequate canal carrying capacity, formers are drawing excess water to their fields to get it saturated considering that moisture availability for crop will be available even if their turn for next watering is delayed. This is further causing loss of fertilizers and nutritious soil top layer which is ultimately resulting low crop production.

Apart from all the aforementioned constraint, demand

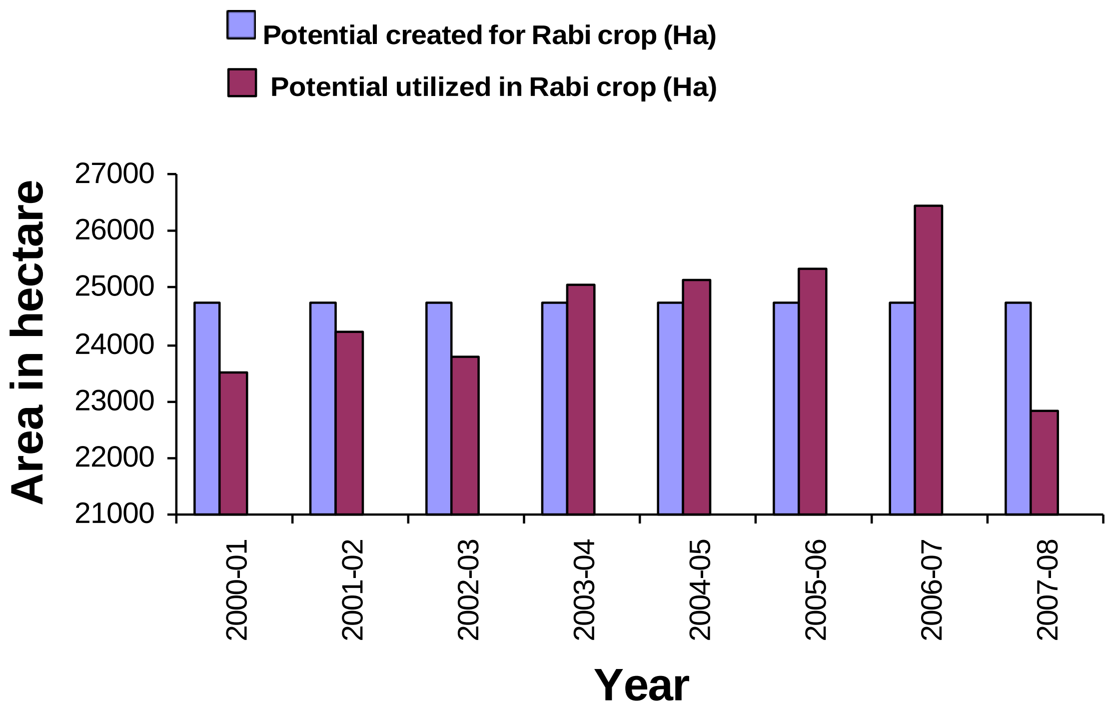

Figure 4. Status Of potential created verses potential utilised.

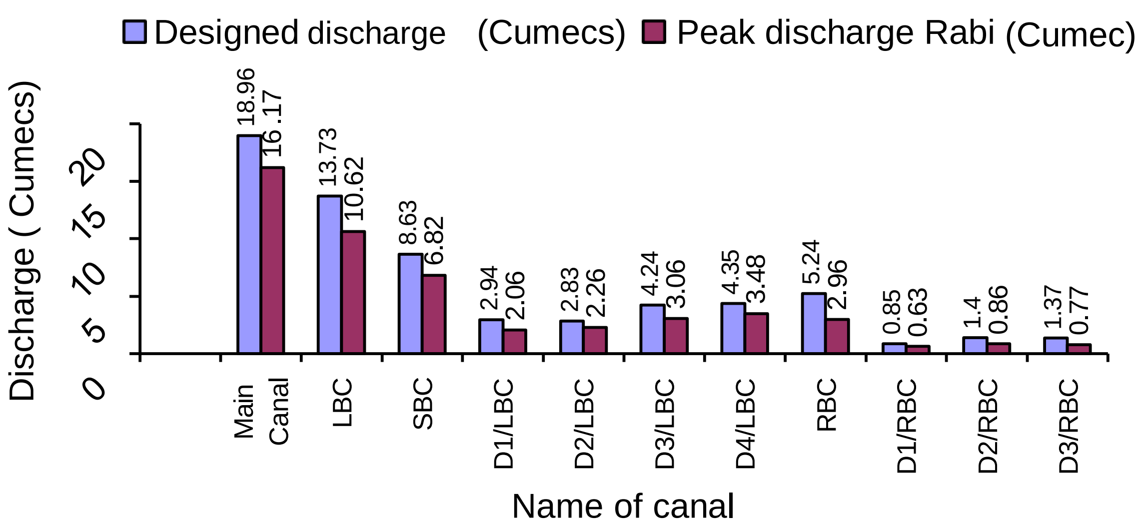

Figure 5. Water delivery index.

for water supply to Vidisha township is also causing extra pressure on right bank canal system during peak water demand for Rabi. As drinking water supply is on top priority, project authority has no option but to postpone irrigation schedule on adhoc basis. This is a great concern and ultimately reduces the productivity too.

Poor performance leads to many unfavorable effects such as low yields per unit of area and/or per unit of water. Improving the irrigation system from headwork to outlet into the farmer's field has to be paid adequate attention. The evaluation of performance of system as a whole or of any of its component will help in enhancing the present system performance and plan a proper strategy for future improvement in management and operation.

From Figure 6 it is clear that the total annual volume of

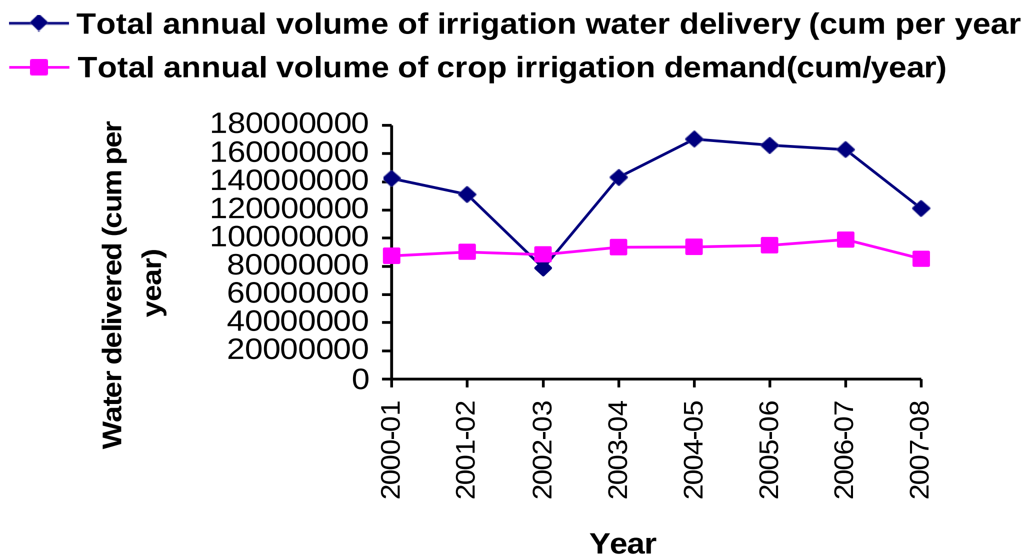

Figure 6. Annual water delivered against crop water requirement.

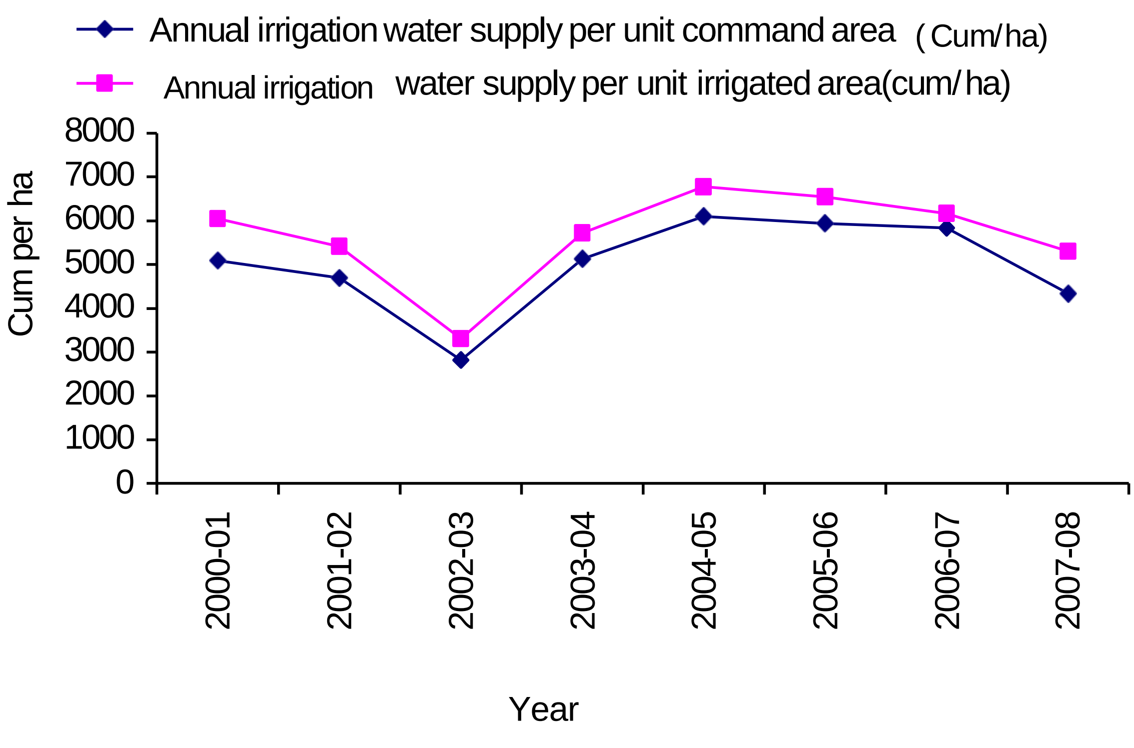

Figure 7. Annual irrigation water supply per unit command area and irrigated area.

water delivery is much higher than total annual volume of crop irrigation demand. It is also seen that in the year 2004 -2005 to 2006 - 2007 when water availability was in surplus the gap between these two was wider than year 2007 - 2008 when water availability was less. The reason of excess use of water may be categorized as flooding method use for water application in the study area, higher seepage losses and inefficient distribution system etc.

Figure 7 shows annual irrigation water supply per unit command area and annual irrigation water SUPPLY per unit irrigated area. As shown in the Figure, total annual water delivery per command area was the lowest in Year 2002 to 2003 with 2822 m³/ha and the highest in 2004 to 2005 with 6102 m³/ha. Annual irrigation water supply per

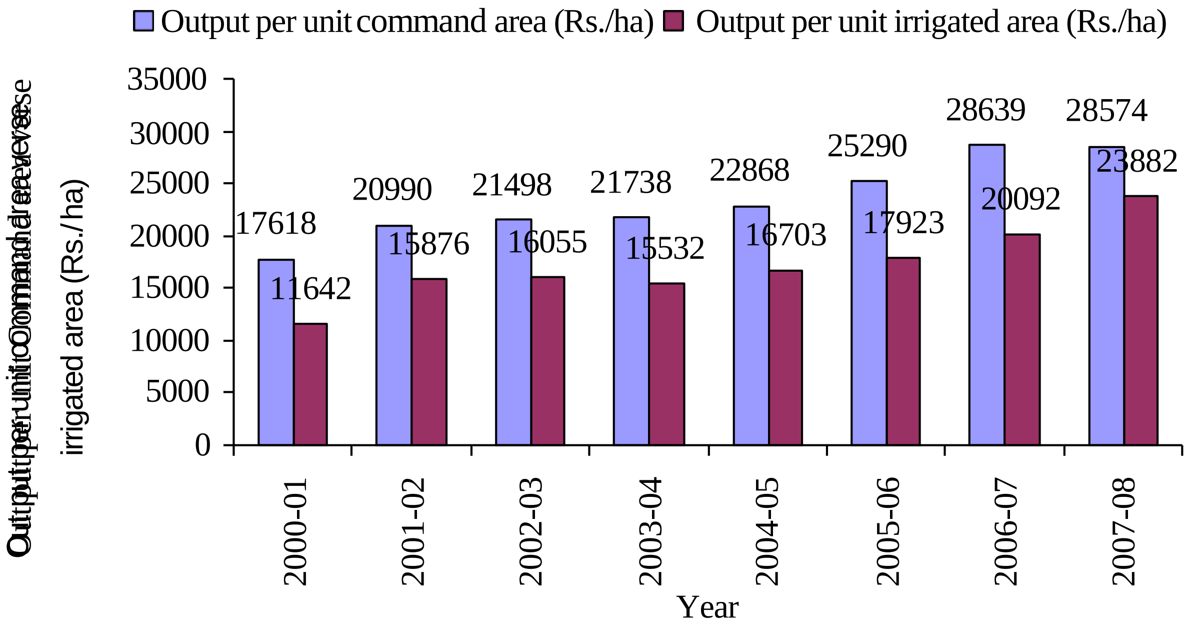

Figure 8. Out-put per unit command area verses irrigated area.

unit irrigated area is total quantity of water supplied for irrigation in all the seasons of a year divided by the irrigated area in that year. Annual irrigation water supply per unit irrigated area varies with water availability, cropping pattern, climate, soil type, system conditions, system management etc. Figure 7 also shows annual irrigation water supply per unit irrigated area. The total annual water delivery per irrigated area was the lowest in 2002 - 2003 with 3311 m³/ha and the highest in 2004 - 2005 with 6780 m³/ha. The results of upper wardha project (1997 - 1998 to 2001 - 2002) shows average annual irrigation water supply per unit irrigated area is 18789.45 cum per ha and for year 2002 - 2003 21005.46561 cum per ha. If the farmers in the head reach take all the water they need for water intensive crop, the farmers towards the middle and tail end would be left dry or may get less water than their requirement (Development Support Centre, 2003).

Production performance

Due to declining per capita production of food grains and increasing numbers of people living in poverty and hunger, there is a growing need worldwide to identify and develop new lands with adequate agricultural potential (Hargreaves and Olsen, 1999).

Despite this, productivity with reference to availability of water is very low may be due to users are drawing excess water in an inequitable manner without adherence of time schedule for crop water requirement. Cakmak (2002a), determined output per unit command area for 8 irrigation associations in Kızılırmak Basin for 1999 - 2000 as between 3195/- to 179730/- Rs/ha (71 to 3 994 $/ha). Similarly, Cakmak (2002b) also determined the output for Ceylanpınar irrigation association for 1995 - 2000 as between 34695/- to 76995/- Rs/ha (771-1711 $/ha). The study area shows that lowest output per unit irrigated area is Rs.11642 per ha for year 2000 - 2001 and Rs. 23882 per ha highest in 2007 - 2008. The results of upper wardha project (1997 - 1998 to 2001 - 2002) shows average output per unit irrigation water supply per unit irrigated area is 13610.177747 Rs. per ha and for year 2002 - 2003 11887.61 Rs per ha. Figure 8 shows that production per unit command area verses irrigated area indicate that the veriation is due to cost escalation and certainly it can not be claimed that productivity per drop of water has increased.

Financial performance

Financial performance is vital for any system to be self-sustainable that at least Operation and Maintenance (O and M) expenditure is met from its own revenue. Cost recovery ratio is shown in Figure 9. It is the ratio of recovery of water charges to the cost of providing the service.

It is imperative to devise water rates and mechanism for recovery of water charges for irrigation use in such a manner to meet, at least, annual cost of management, O and M) of system and recovery of some portion of capital investment on the projects in order to make the system self sustainable. Theoretically the cost recovery ratio

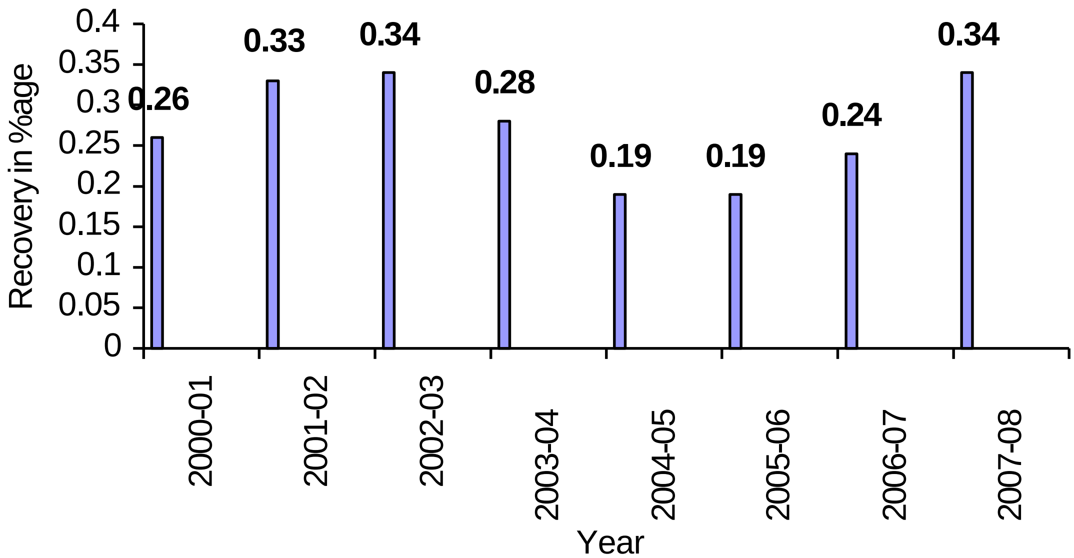

Figure 9. Cost recovery ratio.

should be at least equal to one. This is a matter of concern for water managers and decision makers to enhance the recovery of water charges so that the O and M cost can be met. The issue of whether the revenue collected is sufficient to cover the management, operation and maintenance (MOM) for the year is related to financial sufficiency. Cost recovery ratios calculated based on revenue collected from the users and MOM costs were the lowest in 2004 - 2005 and 2006 - 2007
with 19% and the highest in 2002 - 2003 and 2007 - 2008 with 0.34%. In a previous study, Cakmak (2002b) determined the financial sufficiency rate of irrigation association between 105 to 211%. Molden et al. (1998) determined the financial sufficiency rates between 28 - 139%. The results of upper wardha project (1997 - 1998 to 2001 - 2002) shows average cost recovery is 2.28 and for year 2002 – 2003, 2.23 Rs. Per cum (Dhingra, 2006).

In Figure 10, the lowest total O and M cost per unit area is Rs 618 per ha in 2001 - 2002 and highest total O and M cost per unit area is 2006 - 2007. The results of upper wardha project (1997 - 1998 to 2001 - 2002) shows total O and M cost per unit area is 500.59 Rs. Per ha and for year 2002 - 2003 it is 453.75 Rs. Per ha (Dhingra, 2006).

They determined the rate as about 100% for farmer operated irrigations and 30 - 50% for state operated irrigations. Raju (2002) identifies the causes for the problems as being (i) government dominance and limited user involvement; (ii) poor cost recovery; (iii) insufficient O and M allocations; (iv) deteriorating condition of the irrigation and drainage network; (v) low quality of agricultural extension; and (vi) weak incentives for government agencies to perform (Figure 11) .

Total O and M cost per unit water supplied is obtained by dividing total O and M cost by total quantity of water supplied for irrigation and non irrigation use during the year. Total O and M cost per unit volume of water supplied should be as minimum as possible to achieve economy in supply. Total O and M cost per unit water supplied was lowest in 2000 - 2001 and 2001 - 2002 Rs.
0.10 par cum but it is highest in Rs. 2002 - 2003 Rs 0.14 per cum. But due to unreliable data for 2002 - 2003, the results are ignored. As actual maintenance cost is Rs. 100 per ha in the state for operation and maintenance out of which Rs. 60 per ha is allocated to water user associations and remaining Rs. 40 per ha to distribution committee and project committee for head works and main canal etc. However, total O and M cost includes Rs100/- per ha plus cost of establishment on regular employees involved in irrigation services that is Sub Engineer, Amin, Chaukidar etc. The expenditure on establishment is increasing every year due to pay revision. In Maharashtra state, the efforts are made to downsize the management establishment, to keep just a bare minimum staff required as per norms laid down for the management. It is anticipated that the supply of water in bulk to WUAs on volumetric basis will overcome the problem of under assessment. The results of upper wardha project (1997 - 1998 to 2001 - 2002) shows average operation and maintenance cost per unit irrigation water supply is 0.673765175 Rs. Per cum and for year 2002 - 2003 0.57 Rs. Per cum (Dhingra, 2006).

Environmental indicators

Water logging, salinity, acidity and alkalinity

The depth of subsoil water table was observed from the open wells to be 6 to 8 m in pre monsoon period and 3 to 4 m during post monsoon period in project area. During the research period no instances of water logging have

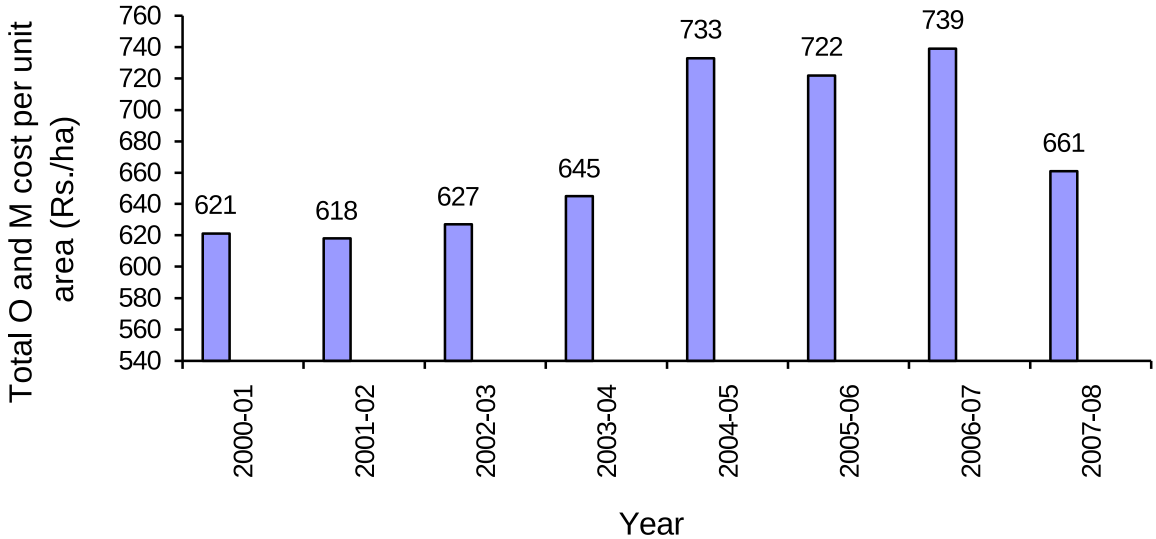

Figure 10. Total O and M cost per unit area (Rs./ha).

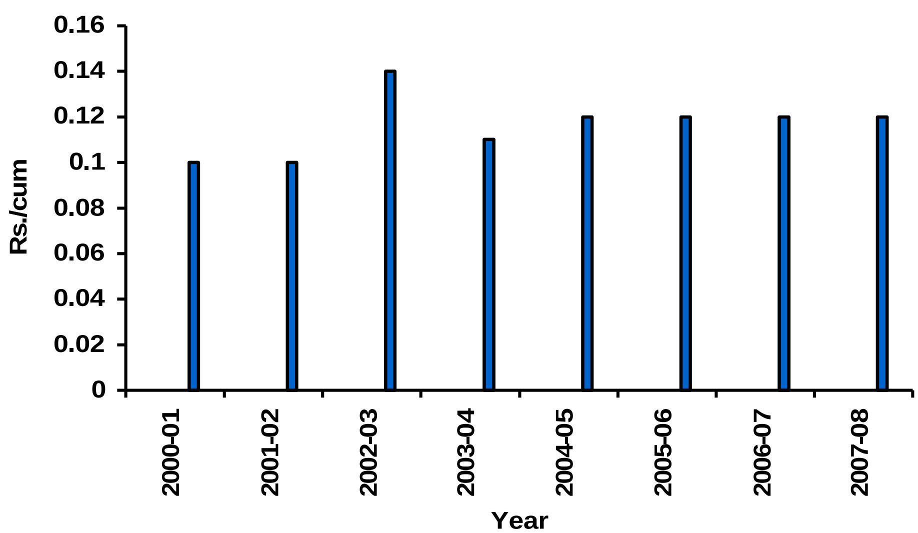

Figure 11. Total O and M cost per unit of water supplied (Rs./cum).

been reported except very little area say 0.001% was having problem of poor surface drainage due to obstructions created during infrastructure developments in command. Several unforeseen environmental problems emerge under irrigation system (Phanish et al., 2002). These problems if neglected can cause considerable damage to irrigated agriculture and to the local population. It is therefore, necessary that the WUAs and farmers should be aware of the problems that threaten the system, health of soils, and crops in the command area. Such problems are best tackled in early stages. Any negligence in this respect is only at the cost of poor and vulnerable group of farmers. Irrigation projects in developing countries have a history of poor performance. Inefficiencies result as water applications deviate from plans and induce greater than projected rates of soil degradation through water logging and salt accumulation. Over a time, the collective impact of these forces will converge to equilibrium with a level of output that may be far below the system's potential (John, 2004). Implementing appropriate versions of these policies may reduce the rate of increase in waterlogged and saline areas (Wichelns, 1999).

The pH range from 7 to 8.5, salinity and alkalinity are fairly within the acceptable limits. These values are observed to be within the permissible limits as specified by IS: 2296. Due to the pressures of increasing population and developing economy all over the world, the present situation of water-quality management is far from satisfactory. To enhance sustainability of water-quality-management systems, in-depth research of the related barriers and the relevant mitigation approaches is desired (Huang and Xia, 2001).

pH of the soil, which is a measure of its acidity or alkalinity, is an important consideration in classifying land for agricultural use. It is observed that pH is varying from 7.9 to 8.4. The soil test results during the present study as well as field observations and discussions with the staff working in the area and cultivators did not report any appreciable change or damage to soil health after project.

There are 1163 dug wells and 28 tube wells in the command area and the estimated ground water is about 4.35 M. Cum. The water recharge is about 179.85 M. Cum and water balance is about 175.50 M. Cum. The rate of yearly ground water development is estimated, as 0.53 M. Cum which is 0.29% of the water reserve. MP pollution control board was also contacted to find the details of pollution if any in the water bodies in the area. It was learnt that water samples in Halali River revealed the values of related parameters within permissible limits (Walmi, 2006).

There are limited industries in the area and the area is mostly agricultural and inhabited by villages with low population density. Thus negligible air pollution threats were reported in the area. In general no pollution beyond permissible limits was reported in the command area.

Conclusion

In this study, system performance, financial performance, agriculture production performance and environmental performance of Samrat Ashok Sagar major irrigation project are evaluated for the years 2000 - 2001 to 2007 - 2008. System performance shows that canal carrying capacity ranges between 60 to 70%, hence it is not possible to irrigate entire command area with equity, reliability and timeliness due to inefficiencies existing in irrigation facilities. It is a basic problem that poor practices of irrigation by flooding method exist due to abundant water availability and socio-economic factors in the study area. In productivity performance, the output per unit irrigated area is low and it is as low as in rain fed area. Irrigation infrastructure is poor due to fewer funds available for maintenance. Revenue recovery is very poor and ranges 0.19 to 0.34 against ideal ratio 1. The system is transferred to water users associations without improving environmentally degraded system. It needs urgent attention to modernize and restructure the system to desired level so that productivity targets can be achieved. Despite flooding irrigation and practices adopted of using excess water, environmental issues like salinity and alkalinity is within range including water table in the command area hence situation is manageable and it could be possible with effective monitoring on regular basis. On the basis of the analysis of results and discussion it can be concluded that participatory approach is a key to success of developmental schemes in water sector to protect environment and maximize benefits of schemes if it is monitored regularly by tools like benchmarking.

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