Towards An Efficient Water Management: A Case Study of Adol Multipurpose Water Resources Project

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ABSTRACT:
Water is lifeblood for the existence of life on this earth as it ensures food security, feed livestock, maintain organic life and fulfil domestic and industrial needs. For a country like India, which is not a water deficit country, but due to severe neglect and lack of efficient management of water resources, several regions in the country experience water stress. The water needs in the country have risen exponentially to an unprecedented scale, especially in recent times. The solutions to the problems related to water across the country lies largely in areas of efficient mechanism for conservation, distribution, management, and optimum use. About 80 per cent water is used in irrigation sector, which is operating at just 25 to 40 per cent water use efficiency. There is scope for improvement in the irrigation water use efficiency. Efficient water management means supplying right quantity and right quality of water to the various stakeholders at the right time with minimum losses and minimum cost. With the help of a case study of Adol Multipurpose Water Resources Project (AMWRP), located at Washim district of Maharashtra state, attempt has been made to focus on the efficiency aspect of irrigation water use. AMWRP having gross storage capacity 15.03 Mm^3, and live storage capacity of 12.90 Mm^3 was planned for irrigation water use, domestic water supply and development of fisheries. The storage capacity of AMWRP was planned after considering 50 per cent dependability as per CWC guidelines. Stakeholder involved in this project are farmers using water for their crops, domestic consumers like Maharashtra Jeevan Pradhikaran and Local Self Government using water for domestic purpose and fisheries department. Thus AMWRP is a multipurpose and multi-stakeholder water resources project. This project irrigates 978 ha area out of which, 230 ha is irrigated by lift Irrigation and remaining 748 ha by canal irrigation with approved utilisation for irrigation sector as 6.25 Mm^3. The approved utilisation for non-irrigation sector is 3.02 Mm^3 which is mainly for the domestic water supply for adjoining cities & villages. The evaporation and other losses constitute about 3.63 Mm^3. The analysis of statistics for year 2011-12 revels that out of live storage capacity of 12.90 Mm^3, the actual water available on Oct-2011 was only 6.06 Mm^3, which is just 47% of its capacity. The reported water utilisation for irrigation sector was 3.26 Mm^3 which irrigated 947 ha area in Rabbi season. This indicates that the irrigation water use efficiency is about 192%. The analysis of data revels that the huge rise in the efficiency resulted by optimum utilisation of irrigation water by the farmers through Water User's Associations (WUA's), using pipe network in the command area along with the modern methods of irrigation. Farmers lifted water from main canal and with the help of pipe and sprinkler; water is applied to the farm. Importantly, the Participatory Irrigation Management (PIM) acts as a catalyst in the success story of AMWRP. This resulted in more crop per drop of water, as water losses are reduced. This paper focuses the philosophy behind efficient water management for AMWRP.

1. INTRODUCTION

Water is vital lifeblood for the existence of life on this earth. It not only fulfil the human needs but also comply environmental needs to sustain the ecosystem. Water is bound by engineering and scientific theories, and at present it has political, legal, environmental, social, economical and even religious connotations. The increasing gap between demand and availability of water is adding pressure in society. In order to fulfil the enhanced demands for water from various stakeholders, there is urgent need to go for efficient and optimal water utilisation strategies.

According to United Nations Environment Programme (UNEP), it was estimated that the total volume of water on Earth is about 1400 million km^3. Freshwater resources are estimated around 35 million km^3, (about 2.5 per cent). Of these freshwater resources, about 24 million km^3 or 67 per cent is in the form of ice and permanent snow cover in mountainous regions, the Antarctic and Arctic regions. Further, around 10.5 million km^3 or 30 per cent of the world's freshwater is stored underground in the form of groundwater. This constitutes about 97 per cent of all the freshwater that is potentially available for human use. Freshwater lakes and rivers contain an estimated 0.105 million km^3 or around 0.3 per cent of the world's freshwater. This statistics shows that even though water is available in

ample quantity, it is not readily usable.

2. INDIA'S WATER BUDGET

India is the second largest populated country consisting of more than a sixth of the world population with over 1.2 billion people (Census of India, 2011) with just 2.4% of world's total area and 4% fresh water resources. (Planning Commission, 2008) The main source of water is annual precipitation including snowfall and it was estimated as 4000 km^3 with effective natural run off in the rivers about 1869 km^3 considering both surface and groundwater. Various constraints create barrier against utilisation and only 1123 km^3 of water can be effectively stored (690 km^3 as surface water and rest 433 km^3 as ground water). A created storage capacity is about 225 km^3; under construction projects will store 64 km^3 while proposed projects will store 107 km^3 of water. Thus likely storage available will be 396 km^3 once the projects are completed against the total water availability of 1869 km^3 in the river basins of the country. (CWC, 2010). Narsimhan (2008) estimated the water budget using and evapotranspiraion rate of 65 per cent as against the 45 per cent used in official estimate mentioned above. The utilisable water for human use thus drops to 654 km^3 as against 1123 km^3 estimated by Ministry of Water Resources (MoWR). Table 1 gives the comparative picture of the water budget as per official estimate by MoWR and Narsimhan estimates.

Table 1. India's Water Budget (UNICEF, FAO and SaciWATERs, 2013) (Values in km^3)

	MoWR Estimate	Narsimhan Estimate
Annual Rainfall	3840	3840
Evapotranspiraion	3840 x 40 % = 1536	3840 x 65 % = 2496
Surface Runoff	3840 x 48.7 % = 1870	---
Groundwater Recharge	3840 x 11.3 % = 433	---
Available Water	3840 x 60 % = 2304	3840 x 35 % = 1344
Utilisable Water	2304 x 48.8 % = 1124	2304 x 48.8 % = 655
Current Water Use	634	634
Remarks	Current Use (634) is well below Utilisable Water (1124)	Current Use (634) is well below Utilisable Water (655)

3. INDIA'S WATER SCARCITY

Erratic and uneven distribution of rainfall, which leads to flood and droughts at various locations and during various period is one of the concern for the planning of water resources projects. The temporal and spatial variation in availability of water was studied by Verma & Phansalkar and it was observed that 71 per cent of India's water resources are available to only 36 per cent area while the remaining 64 per cent has 29 per cent available. (Verma and Phansalkar, 2007). Various estimates point to a widening gap between water demand and supply in future. Garg and Hassan (2007) reveals that the assessment of utilisable water resources of India are overestimated to the range of 66 to 88 per cent. They estimated utilisable water resources as 668 km^3, which is much less than that of CWC, NCIWRD and National Water policy of India.

According to the official estimates, even after constructing 4525 large and small dams, the per capita storage of water in India is 213 m^3. It may touch to 400 m^3 only after the completion of all the ongoing and proposed dams. The national per capita annual availability of water decreased to 1588 m^3 in 2010 from 5177 m^3 in 1951, due to the rise in population. It is estimated that in 2050, it will drop down to 1140 m^3 as a result of increase in population, which is expected to stabilise around 1640 million. From international perspective, country with per capita availability of water less than 1700 m^3 is tagged as water stressed and less than 1000 m^3 is water scarce. Thus India is water stressed today and it is likely to be water scarce by 2050. NCIWRD estimated that in 2050, water demand for Irrigation, Domestic and Industrial use will be 807, 111 and 262 km^3 respectively. (GoI, 1999) Thus, total water demand for all the uses is likely to be 1180 km^3. The water which will be available will be 829 km^3 including 396 km^3 from surface water and 433 km^3 from ground water.

To make water scarcity issue more complex, the factors like spatial and temporal variation in rainfall, climate change, rise in population, increased urbanisation, increased demand from various sector, water pollution acts as catalyst.

4. MANAGING INDIA'S WATER SCARCITY

The water scenarios presented above brings forth some grave challenges which will need to be addressed at the earliest. The imbalance between demand and supply can be managed by enhancing supply (supply-side solution) or by curtailing demand (demand-side solution).

The main users of water are agriculture, domestic and industrial sectors. Following table gives the water demand estimates of diverse sectors by two difference agencies-the Standing Sub-committee of MoWR and National Commission of Integrated Water Resources Development (NCIWRD). (ADB, 2009)

Table 2. India's Water Demand (Values in km^3)

Sector	Estimate by Standing Sub-committee of MoWR			Estimate by National Commission of Integrated Water Resources Development		
Year	2010	2025	2050	2010	2025	2050
Irrigation	688	910	1072	557	611	807
Drinking Water	56	73	102	43	62	111
Industry	12	23	63	37	67	81
Energy	5	15	130	19	33	70
Others	52	72	80	54	70	111
Total	813	1093	1447	710	843	1180

According to Planning Commission, although the share of agriculture in the GDP declined from 50 per cent at the time of independence to less than 20 per cent in 2010, it remains the predominant sector in terms of employment and livelihood with more than 50 per cent of India's workforce engaged in it as a principal occupation. Agriculture contributes significant portion of export earnings and is an important source of raw material for many industries.

The significant engineering achievement in water resources sector of India continues to be undermined by poor demand and supply side management. In order to mitigate the water scarcity crisis in India, supply side solutions and demand side solutions should be implemented. The supply side solutions have three components, namely (1) creating new potential for enhancing supply, (2) achieving equitable distribution, and (3) meeting the needs of sustainable development. Where as, demand side solutions includes (1) creating new technologies for reducing water demand, (2)bringing about changes in the societal mindset about water usage, and (3) initiating and enforcing water related structural reforms. (Maheshwari, G.C).

5. APPROACH TOWARDS EFFICIENT WATER MANAGEMENT

To achieve sustainable development for a country like India is a big challenge. Irrigation accounts for about 80 per cent of India's total water usage. The utilisation of irrigation potential created is main concern for the policy makers. The gap between potential created and potential utilised has been increasing steadily over time, because of several reasons. As per statistics reported in Eleventh Five Year Plan, for a gross irrigated area of about 87 MHa, the water use is 541 Bm^3, which gives a delta of 0.68m per ha of gross irrigated area. Taking 70% of the average annual rainfall which is 1.17m as a effective for crop consumptive use, the gross water use is about 1.45m per ha of gross irrigated area. This is very high as compared to water use in countries like US, where water allocation is less than 1m, per ha of gross irrigated area. (Planning Commission, 2008) This shows that our irrigation system is very inefficient and there is urgent need to go for innovative solutions in order to improve the water use efficiency.

From economy point of view, Water Use Efficiency in agriculture can be defined as the value of agricultural produce in monetary terms per unit of water consumed for the production of said produce. But, most common and widely accepted definition of water use efficiency in agriculture/irrigation sector is the ratio of actual volume of water consumed by crop during evapotranspiraion and the volume extracted or derived from a supply source.

Efficient water management means supplying right quantity and right quality of water to the various stakeholders at the right time with minimum losses and minimum cost. The efficient water management benefit both the user and supplier, as well as environment. The range of potential benefits includes-

- Better water service to the stakeholders
- Efficient and optimum use of scarce water resources
- Reduction in operation, management and maintenance cost
- Improved revenues to the Government
- More crop per drop of water
- Minimization of over-exploitation of ground water
- Reduction in adverse impacts of Climate Change

6. OVERVIEW OF ADOL MULTIPURPOSE WATER RESOURCE PROJECT (AMWRP)

Adol Multipurpose Water Resources Project is a very crucial example of how water can be efficiently managed, in order to get more crop per drop of water. For a country like India, which is not a water deficit country, but due to severe neglect and lack of efficient management of water resources, several regions in the country experience water stress. The decreasing per capita water availability and decreasing share for various water stakeholders adds pressure in effective management of the water resources project. It is need of the situation to prevent water crisis by adopting demand-side solutions as well as supply-side solutions. Irrigation is a major consumer of water and consumes about 80% of water. The improvement in water use efficiency in irrigation sector would drastically decrease the demand for irrigation water, and hence decrease the stress on total water available. The efficient use of water for irrigation can be achieved just by attempting pipe distribution network and use of micro irrigation techniques such as drip, sprinkler technologies etc.

AMWRP is basically Irrigation project with multiple benefits for various stakeholders. The dam site is located on Adol river near village Borala Jahangir, Taluka-Malegaon, District-Washim of Maharashtra state, which comes under Painganga sub-basin of Godavari basin. Free catchment area at site is 116.55 km^2. The project was administratively approved by Government of Maharashtra in 1980 and finally completed by Water Resources Department in 1989 due to land acquisition and other problems. The gross storage of project is 15.03 Mm^3, where as live storage is 12.90 Mm^3. Two main canals were constructed on either side of the river. The Left Bank Canal (LBC) is 8.4 km long with discharge capacity of 0.59 m^3 where as Right Bank Canal (RBC) is 10 km long with discharge capacity of 0.65 m^3/sec. The total Gross Command Area (GCA), Culturable Command Area (CCA) and Irrigable Command Area (ICA) of AMWRP is 1269, 1061 and 978 ha respectively. Out of ICA of 978 ha, 230 ha is irrigated by Lift Irrigation on reservoir, and remaining 748 ha by canal irrigation. Seven villages on Malegaon Tahsil and Three villages from Risod Tahsil of Washim district are benefited from irrigation. Two water User Associations are established on a project, one on each canal.

The satellite map of the project is given below-

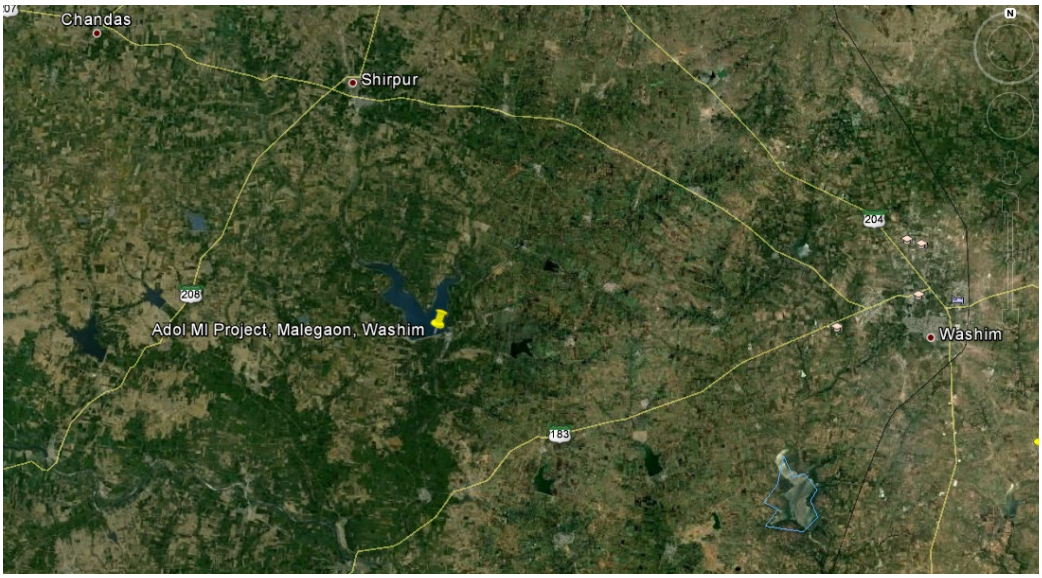

Figure 1. Location of AMWRP, Tal-Malegaon, Dist-Washim, Maharashtra (Google Earth Image)

Figure 2. Reservoir of AMWRP, Tal-Malegaon, Dist-Washim, Maharashtra (Google Earth Image)

7. APPROVED WATER UTILISATION FOR VARIOUS STAKEHOLDERS

The approved utilisation for irrigation sector is 6.25 Mm^3. The approved utilisation for non-irrigation is 3.02 Mm^3 which is mainly for the domestic water supply for Risod Tahsil, Shirpur Village, Waghi Village, Shelgaon Village and Taktoda Village. The evaporation and other losses constitute about 3.63 Mm^3. The projected benefits of the project were irrigation use, domestic water supply and fisheries. There are various stakeholder involved in this project including farmers using water for their crop, consumers consuming water for domestic use and fisheries department using water for development of fisheries. Thus AMWRP is a multipurpose and multi-stakeholder water resources project.

8. ACTUAL WATER UTILISATION BY VARIOUS STAKEHOLDERS IN 2011-12

Out of live storage capacity of 12.90 Mm^3, the actual water available on Oct-2011 was only 6.06 Mm^3, which is just 47% of its capacity. Thus, due to less rainfall more than half of the reservoir was empty in 2011. The evaporation loss was reported as 1.10 Mm^3. The actual water utilisation for irrigation

sector was reported as 3.26 Mm^3 which irrigated 947 ha area. The domestic water utilisation in 2011-12 was 0.92 Mm^3. Thus, in irrigation year 2011-12 water utilisation from project was 5.28 Mm^3, with residual of 0.78 Mm^3.

9. EVALUATION OF WATER USE AND PROJECT EFFICIENCY

The water is released keeping co-ordination with WUA in the main canals of project and with the help of pumps installed by farmers; water is lifted and distributed to the field by pipe network. Then with the help of micro-irrigation techniques, such as drip, sprinkler etc. water is applied directly to the roots of plants. Thus, water directly reaches to the farm from the cement-concrete lined main canal, minimising conveyance losses in main canal to some extent and avoiding conveyance & evaporation losses in distributaries, minor and field channels. The design water use efficiency of overall canal distribution network is about 40 to 45 per cent as water is conveyed through main canal, branch canal, distributory, minor and field channel. Further, due to managerial reasons, actual water use efficiency is observed as 25 to 40 per cent. Studies showed that if instead of conventional Canal Distribution System (CDN), if Pipe Distribution System (PDN) is implemented, the water use efficiency increases to 70 to 80 per cent. (Kolhe, P.S., 2012). The reported statistics revels that the water use efficiency for the AMWRP is about 85 to 90% due to reduction in losses in branch canal, minor and field channels. Further water application is not by regular flooding method, but it is by sprinkler and drip due to the saline nature of soil. Excessive irrigation could damage the soil, hence farmers uses micro sprinkler and drip irrigation system, which provides maximum water use efficiency.

The planned water use and actual utilisation in 2011-12 in various sectors is presented in following table-

Table 3. Planned Water Use and Actual Utilisation in 2011-12

Sr.No.	Sector	Planned Utilisation (Mcum)	Actual Utilisation in 2011-12 (Mcum)
1)	Irrigation	6.25	3.26
2)	Domestic	3.02	0.92
3)	Evaporation & other Losses	3.63	1.10
4)	Residual	--	0.78
5)	Total Live Storage	12.90	6.06
6)	Dead Storage	2.13	2.13
7)	Gross Storage	15.03	8.19

From the above data, the planned utilisation for the irrigation sector was 6.25 Mm^3 for irrigating 978 ha of land is achieved only by 3.26 Mm^3 water irrigating 947 ha of area. Thus the irrigation water use efficiency is about 192%. The duty, i.e. the area of land that can be irrigated with unit volume of irrigation water is 290 ha/Mm^3. These results are extraordinary and the reason behind this is optimum utilisation of irrigation water by the pipe network in the command area

This project is a very crucial example of how water can be efficiently managed and distributed to various stakeholders in order to achieve its desired benefits.

10. BENEFITS RECEIVED FROM EFFICIENT WATER MANEGEMNT

In order to mitigate water crisis of India, there is an urgent need for improving irrigation water use efficiency, which is currently 25 to 40 per cent. This objective can be achieved by use of pipe distribution network which operate at 70 to 80 per cent efficiency. (Kolhe, P.S., 2012). The efficient water management not only benefits government, it also improves the functioning of Water User Associations, and farmers. The following benefits cane be visualised as a result of efficient water management at AMWRP-

1) Better water services to the water users.
2) Saving in water quantity
3) Reduced operating costs
4) Improved revenue to the Government
5) Improved crop yield and quality

6) Reduced on farm costs
7) Reduced maintenance cost
8) Reduced drought impacts
9) Improved fertility of the land

11. PARTICIPATORY IRRIGATION MANAGEMENT

The equitable and optimal use of water from canal irrigation has been matter of continuing concern. The traditional approach of pursuing these objectives through the field level functionaries of irrigation department has its own constraints. According to World Bank (2002), PIM refers to the involvement of irrigation users in all aspects of irrigation management, and at all levels. PIM is a process for improving productivity and sustainability of irrigation system. Participation refers to a continuum of involvement in management decisions. The participation of the beneficiaries through PIM and the co-ordination during management of canal network through WUA's have been observed as very beneficial in this project.

12. CONCLUSION

For a country like India, which is not a water deficit country, but due to severe neglect and lack of efficient management of water resources, several regions in the country experience water stress. The decreasing per capita water availability and increasing share for various water stakeholders adds pressure in effective management of the water resources project. The challenges like Climate Change are making situation worse. The water needs in the country have risen exponentially to an unprecedented scale, especially in recent times. The solutions to the problems in water across the country lies largely in areas of effective mechanism for conservation, distribution, management, and use of this resource. It is need of the situation to prevent water crisis by looking for demand side solutions as well as supply side solutions. Irrigation is a major consumer of water and consumes about 80% of water. The improvement in water use efficiency in irrigation sector would drastically decrease the demand for irrigation water, and hence decrease the stress on total water available. The efficient use of water for irrigation can be achieved just by attempting pipe distribution network and use of micro irrigation techniques such as drip, sprinkler technologies etc. In this paper, the philosophy of efficient management of multipurpose multi-stakeholder Adol Multipurpose Water Resources Project (AMWRP) is explained with the help of water utilisation statistics of year 2011-12. The outcome of evaluation of project efficiency implies that 100 per cent efficiency in irrigation sector can be increased by adopting modern irrigation techniques. Implementing modern irrigation practice will improves overall water use efficiency to 70 to 80 % as against conventional canal distribution network having water use efficiency as 25 to 40 %. As per NCIWRD, the irrigation water requirement of Indian agricultural sector in 2050 is 807 km^3, which can be curtailed down to the half of that by improving water use efficiency from 40% to 80% using PDN as exercised in present case study. Thus, only 404 km^3 water will be sufficient for fulfilling demand of irrigation sector without curtailment in the area. Clubbing all other demands, including irrigation, drinking water, industries, energy and other, the total water requirement in 2050 decreases to 777 km^3 from 1180 km^3. This allows policy maker to allot balanced water to another sector. Thus the case study of AMWRP is crucial in efficient water management and mitigating water crisis.

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DISCLAIMER

Views expressed in this paper are those of the authors and do not necessarily reflect those of the department or governments.

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