IMPROVING IRRIGATION EFFICIENCY- ENGINEERING APPROACH

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ABSTRACT

Water is one of the most important commodities of all the community resources. The overall water resource is finite whereas the demand for water is ever increasing especially due to rapid increase in population. Therefore, it is very important to conserve every single drop of it and utilize it in the most efficient fashion. Surface water is the most visible and harnessed water resources. It is a well known fact that irrigation is the largest consumer of the water. Hence, improving irrigation efficiency will result in considerable saving of water.

National Water Mission has also set a target of improving water use efficiency by 20% by the year 2017. The success of achieving the target set by NWM depends heavily upon improving the irrigation efficiency due to its being the largest consumer of water. Therefore, strategies for improving the irrigation efficiency are of vital importance. National Water Mission stresses upon achieving this target by ensuring improved irrigation efficiency both on the demand as well as supply side.

One of the major strategies for improving irrigation efficiency would be full utilization of the created facilities, better design and proper operation & maintenance of the irrigation infrastructure. In India most of the irrigation projects are very old and suffering from many deficiencies resulting in underutilization of the potential. Therefore, modernization and renovation of existing irrigation projects is a must and should be taken up on priority.

Improvement in irrigation efficiency can also be achieved by adopting suitable structural measures while planning and designing new irrigation projects as well as ERM projects. Improvement in conveyance efficiency depends to a great extent on selective lining of canals. The decision to line a canal depends upon a number of factors, including basin characteristics, water deficit or water surplus basin, availability of storage sites in the basin etc. This paper discusses the various factors on which decision of canal lining should be based.

Besides these, volumetric assessment of irrigation water and rationalization of water rates to minimize wastage, implementation of PIM, on-farm development measures and creation of WUA etc. will also help in improving the irrigation efficiency. A basin wise approach is needed to decide the strategy to be adopted in each project to improve the irrigation efficiency. Hence, study should be carried out for preparing basin wise guidelines for improving irrigation efficiency through ERM projects as well as new irrigation projects.

This paper discusses the various measures to be adopted for improving irrigation efficiency so that the target set by National Water Mission can be achieved. The paper also attempts to formulate various strategies to achieve improvement in irrigation efficiency in a time bound manner

INTRODUCTION:

Reliable and adequate access to water is critical for the growth of the country. Across the nation, water shortages are triggering growing concern and an acceleration of efforts to increase water use efficiency. Irrigation is the largest consumer of water resources and demand of water for irrigation is increasing day by day. Net irrigated area in the country in 1950 was about 20.85 million hectares which has now increased manifold. Hence, improving irrigation

efficiency will result in considerable saving of water. Dwindling water resources makes the conservation of water and its judicious and economic use, a matter of greatest national importance.

Recently there have been lot of talk for improving water use efficiency but mostly concentrated from agronomist point of view i.e increasing water productivity by the crop and the better utilization of water in the root zone of the crop. However, this paper stresses more on the engineering aspects for increasing water use efficiency like efficiency of delivering water from source to farm besides discussing the on farm methods. To improve conveyance efficiency consideration needs to be given for water losses in the source and major conveyance and distribution systems like canals or pipe network in terms of seepage and evaporation losses. This paper attempts to rationalize the popular thinking of lining a canal and recommends judicious application of engineering prudence of lining a canal.

RELEVANCE OF THE TOPIC:

Burgeoning population, elevation in standard of living, flourishing economic activities and consequent rise in demand of water for multifaceted uses have propelled the overall demand for utilizable water resources. India has almost one fifth of the total irrigated land of the world. The success of agriculture depends on the extent to which the water requirements of crops can be met. Increase in the demand for food has led to increase in the net irrigated area and hence overall demand of the water. Overall water resource is finite. Our water resources may be insufficient to meet the long term requirement of agriculture, industry and other uses which may lead to increasing competition for available supplies as more and more water gets committed. This makes the conservation of water, and its judicious and economic use, a matter of the greatest national importance. National Water Mission has also set a target of improving water use efficiency by 20% by the year 2017 (National Water Mission, 2011) (1).

National Water Policy-2002 has also specified that "Water is a scarce and precious national resource to be planned, developed, conserved and managed as such, and on an integrated and environmentally sound basis, keeping in view the socio-economic aspects and needs of the states. It is one of the most crucial elements in developmental planning. As the country has entered 21st century, efforts to develop, conserve, utilize and manage this important resource in a sustainable manner, have to be guided by the national perspective." (National Water Policy, 2002) (2)

Hence, the need of the hour is to improve water use efficiency.

STRATEGIES FOR IMPROVING THE WATER USE EFFICIENCY:

A) **Structural Measures:** Measures to be adopted in the-

i) Planning & Design of Head Works:

Water can be diverted into an irrigation canal through an intake/ head regulator by constructing a diversion structure across the river. Barrage and weirs are diversion structures which divert water into canal offering little or no storage whereas dams apart from diverting water into canal also offer storage. The advantage of constructing a storage project is that it can absorb the inadequacies of the lean season flow to maintain the design discharge throughout the year as per requirement. The storage reservoirs act as a cushion against deficient rainfall periods and also provide flood management and flood control at times of extreme floods. It is recommended that wherever feasible, storage dams should be constructed instead of run-of-river schemes. The storage project can absorb the inadequacies of the lean season flow to maintain the design discharge throughout the year as per requirement.

The uncertainty in rainfall and inflow patterns due to the phenomenon of climate change warrants greater storage for ensuring assured availability of irrigation water. This becomes all the more important in water scarce basins. It is therefore recommended that while designing storage projects for irrigation 50% dependable flows may be considered instead of 75% dependable flows.

Improper design of silt excluder often leads to lot of problems, later on requiring excessive desilting of canals and enhanced maintenance cost.

It is recommended to have a slightly higher free board while designing the canal section taking into account future expansion.

ii) Planning and Design of The Canal Networks:

Proper planning and design of the canal network plays a major role in proper utilization of the available water resources. Planning and design of the canal network, inter-alia, depends upon the soil characteristics and cropping pattern. Canal network should be designed in such a way that it can cater to all the probable crops grown in the command and the water carrying capacity of the channels should be sufficient to fulfill the needs of these probable crops. Extensive survey should be carried out for deciding the crop water requirement so that the channel capacity could be optimized. So, while designing the new channel or remodeling the existing channel the duty, delta and water allowances should be worked out extensively in such a way that neither wastage is allowed nor scarcity is created.

Moreover, possible future augmentation of flow may also be borne in mind while designing the canal section. It is therefore recommended that the canal section should be designed keeping in mind the increased demand for irrigation water due to change in cropping pattern or other reasons and augmentation of flow by inter-basin transfer etc. as it is very difficult to increase the canal section later once it is in operation. Provision of higher freeboard may also be considered.

iii) Planning and Design of The Field Channels:

As reported by the Irrigation Commission in its report published in 1972, about 20% losses occur in the field channels, it becomes very important to plan and design the field channels so as to reduce these losses. Lining of the water course should be considered at the planning stage itself. Proper maintenance of the field channels should be ensured to minimize wastage.

iv) Selecting Location and Design of The Outlets:

Location and proper design of the outlets plays an important role in efficient functioning of the irrigation system. While deciding the location of the outlets following points should be kept in mind: (Manual of "On Farm Development works" of Govt. of Maharashtra, June-2002) (3).

a) The outlet should be located on the u/s of the drop or fall in the parent channel.
b) The field channel should command the area within the short distance.
c) As far as possible the field channel should not cross the borrow pit. Hence the outlet should be located accordingly.
d) To avoid the road crossing on field channels, if possible, the location of the outlet should be taken d/s of the road.

v) Lining of The Canals:

In unlined channels, only a portion of the water supplied at the canal head reaches the farmer's field. The main loss is through percolation. The commonly accepted figures for transit losses in alluvial plains of north India (Ganga basin) are 17% for main and branch canals, 8% for distributaries and 20% for water courses (Report of the Irrigation Commission, 1972) (4). The losses are less in canals on clayey soils than the one on sandy soils. The soil type also has a great influence on deciding about lining a canal or not.

River basin (sub-basin for large river basins) is a natural unit having defined watershed boundary. Basins may be either closed or open basin. In closed basin there is an inter relationship between the surface and ground water making it the suitable unit for planning the overall development of water resources.

The decision to line a canal depends upon number of factors, including basin characteristics, water deficit or water surplus basin, availability of storage sites in the basin etc. Hence it may be advisable not to line

canals in Ganga basin, which is a water surplus basin and good sites are also not available for construction of dams for storage. Therefore, when there are no storage sites in a water surplus basin, it may be a good idea not to line canals & use the recharged ground water (due to seepage of canals) for irrigation during the Rabi season. For this to happen, conjunctive use of water should be planned. The command area to be served by canal water and that to be served by the recharged ground water should be clearly marked. Generally, more groundwater recharge is likely near head reaches. Hence water planning should be carried out accordingly. Lining assumes special importance in areas which on introduction of canal irrigation would be liable to water logging and salinity.

However, in a water scarce basin, it may be necessary to line the canals so that scarce water can be conserved and can reach to all the intended users of the water. In water scarce basins (dry areas like Rajasthan etc) the water lost due to seepage from unlined canals percolates deep down and is difficult and uneconomical to be lifted for use. Hence in such water scarce basins it may be a good idea to line the canal to minimize seepage losses so that the intended command area can be properly served.

Moreover, the decision to line the canal should be taken at the time of planning any project. In the early stages of a river development, water may be plentiful, and the immediate need for saving percolation losses not so urgent. But it must be borne in mind that it is very difficult to provide lining later on. Once an unlined canal has been designed and constructed, it comes in a regime. If the decision to line is taken afterwards, the unlined section is much greater than that required for a lined canal. If the lining is carried out on the same section then it will be difficult to maintain the required water levels for the same discharge. However, if there is an augmentation of discharge at the head regulator, then it is desirable to carry the extra discharge through the same section after lining it. It is therefore recommended that the desirability of lining a canal should be carefully studied, when an irrigation scheme is formulated.

The decision to line a canal must be carefully taken keeping these factors in mind so that it gives maximum benefit.

B) **Irrigation Management**:

The irrigation management practice of Warabandi is followed in many parts of the country. In this system each farmer gets irrigation water on his turn for a certain period in a week. So, when he gets water he tends to over irrigate his farm as he is not very sure when he will get irrigation water again. This leads to wasteful use of the precious irrigation water. Supply based irrigation needs to be replaced by demand based irrigation. This will save precious irrigation water.

In South Africa an innovative decision support program called ‘Water Administration System’ (WAS) has been developed. The WAS is used by WUAs on their irrigation scheme to manage their water accounts and water supply to clients through rivers, canal network and pipelines. It replaces the old manually operated water distribution system commonly used on government irrigation schemes. By enabling water supply of the required volume at the requested time, WAS facilitates efficient water use at the farm level and increase in the water productivity. WAS has been implemented on irrigation schemes with a total area of 142843 ha, which is approximately 27.5 % of the irrigated area of the SA serviced by the WUAs. Field measurements have shown that the losses were reduced upto 20% through improved water releases in rivers and canals. (Suresh Kulkarni, 2011) (5)

Moreover, the farmers need to be trained about ill effects of over irrigation as it often leads to problem of waterlogging and salinity. Waterlogging and salinity has resulted in loss of considerable area of arable land in India. In South Africa and Australia, a simple mechanical device called “Wetting Front Detector (WFD)”, which shows the irrigator that how deep the water has penetrated into the soil was introduced to help better irrigation scheduling. The WFD also captures and stores a soil water sample after irrigation which can be used to improve salt and fertilizer management. The WFD provides information about the depth of water penetration in the soil profile and helps them to make a decision about the timing and duration of the next irrigation, thereby improving on farm water application efficiency, leading to water saving (Suresh Kulkarni, 2011) (5). The WUAs can also play an important part in making farmers realize

not to waste precious irrigation water. The farmers in the head reach also tend to over-irrigate their fields and the farmers at the tail end receive less or no water.

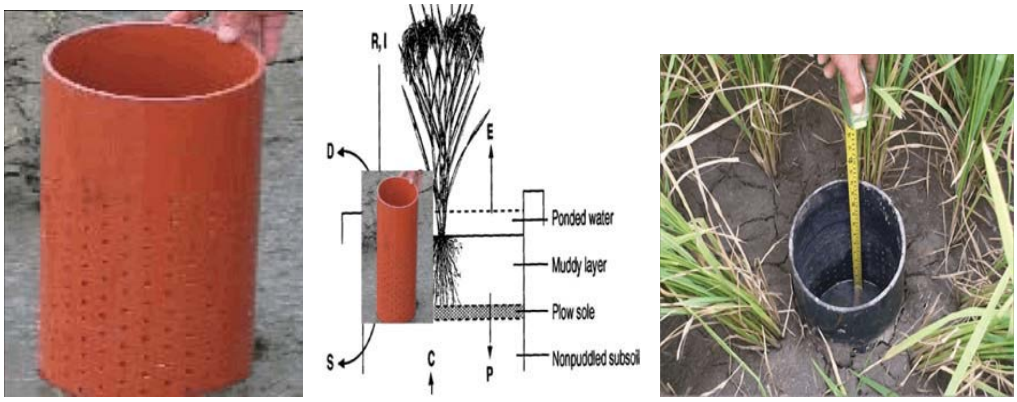

Fig - 1 A simple perforated pipe (water tube) installed in the rice field allows farmer to monitor water level beneath the soil surface (Suresh Kulkarni, 2011) (5).

It is recommended that irrigation supplies should be more reliable and demand based. The charges for irrigation water should be on volumetric basis.

Trading in the virtual water can also be resorted to for arid and semi arid places thereby saving considerable amount of virtual water. Importing agriculture produce from water surplus regions to water deficit regions which is a kind of trading in virtual water can help in mitigating the scarcity of water in water deficit regions.

These steps will minimize the wastage of irrigation water and lead to improved irrigation efficiency.

C) **Managing Cropping Pattern**:

The cropping pattern in a command area is generally planned / modified on the basis of a study of soils, climate, rainfall, existing cropping patterns and marketability of the produce. The role of WUA is very important in assessing the cropping pattern by the agriculture department in consultation with the irrigation department.

The cropping pattern often undergoes a sea change after introduction of irrigation schemes which may lead to use of more water by farmers in the head reach leading to shortage of irrigation water for downstream farmers. The farmers in the head reach often start cropping cash crops requiring more water after assured irrigation is guaranteed to them. Hence the likely future cropping pattern and the optimum one needs to be assessed in consultation with stakeholders for correct planning and management.

D) Increasing Awareness Through Training and Education:

As already discussed above, farmers tend to apply more water when they get their irrigation supply due to various reasons. The main reason is uncertainty about the next supply and misconception that applying more water will improve their yield. Thus farmers must be trained so that they realize the importance of optimum use of irrigation and its timing. Information about optimum irrigation needs and timing of irrigation for different crops should be given to farmers, WUA"s and other stakeholders. Creating awareness will help in minimizing wastage and improving irrigation efficiency.

E) **Modernisation & Renovation of Existing Irrigation Projects**:

Most of the available sites for big irrigation projects have already been developed. Mostly the irrigation system is in place. Hence, urgent measures should be adopted for improving existing irrigation infrastructure to conserve water and economize its use. As these projects were designed long back, the changing needs might have outlived their utility in providing irrigation efficiently. The structural deficiencies, lack or inadequacy of storage, loss of water due to seepage from unlined canals, distributaries and field channels are some of the most usual problems faced by the existing structures. Also, the existing old projects have handicaps such as out-moded headworks, faulty or absence of suitable silt excluding devices, and unsatisfactory arrangements for cross drainage structures. So, ERM projects for improvement in the existing irrigation infrastructure should be given priority.

F) On Farm Development (OFD) Works:

The OFD works include maintenance / renovation of field channels / water courses, surface drainage system, field channel protection works, and land forming i.e. smoothening, grading, and leveling of the field. It is a very common feature that generally irrigation infrastructure is in place but the command is not properly developed eg field channels may be in a dilapidated condition, fields may not be properly leveled etc. This leads to wastage of irrigation water thereby loweing irrigation efficiency. Hence, command area development should be taken on priority which will help in optimization of water utilization.

1) Action plan for improvement of the water use efficiency in the existing projects:

a) Each irrigation project is unique and should be studied in a holistic manner by an inter-disciplinary expert group for suggesting measures for improving irrigation efficiency. However, a basin wise study should be conducted to formulate guidelines to improve irrigation efficiency in the projects lying therein. Sometimes, the conjunctive use of water is not considered while planning the surface irrigation projects. The basin wise studies should take into account conjunctive use of water, wherever possible (depending on various factors), so that comprehensive planning and integrated approach can be adopted while planning the projects.

b) The decision to line a canal depends upon number of factors as discussed in the preceding section. It is also recommended that the desirability of lining should be carefully studied, when an irrigation scheme is formulated at the planning stage itself as lining the canal later becomes difficult and if the unlined section is lined for the same design discharge, it may be difficult to maintain the desired FSL.

c) The action plan depends very heavily on improving the conveyance efficiency through ERM of major and medium irrigation projects. Hence, in order to achieve the target of improving irrigation efficiency by 20%, a large number ERM projects may have to be undertaken.

d) Presently there are no separate guidelines for appraisal of ERM (irrigation projects) & they are treated as new projects. So, there is a need to frame guidelines for preparation of DPR of ERM projects, wherein certain conditions to improve irrigation efficiency may be incorporated eg the TEC clearance of ERM projects may be subject to the condition that regular data collection on water use efficiency may be carried out by the state government & submission of the same to the monitoring unit should be made mandatory. The TEC clearance may also be subject to condition that there should be volumetric supply of irrigation water and rationalization of water rates so that at least the O&M cost required for the proper maintenance of the project, is recovered.

e) Also, since implementation of ERM of major and medium projects is the main vehicle for improving water use efficiency, hence proper arrangements of funding these projects should be ensured. These ERM projects are to be executed by the state governments and unless adequate funds are earmarked they may not take up these projects. Besides, for proper monitoring of such projects strengthening of the concerned organization/ institution both at central & state level should be carried out to achieve the target.

f) At least one pilot project for improvement in water use efficiency in collaboration with the state should be undertaken in each basin & each state of the country. The projects should be selected in consultation with the state governments, so that the projects currently operating at low efficiencies may be taken up. Thus about 30 to 40 pilot projects covering all the basin and state should be under taken. This should be followed by preparation of DPRs of ERM of these projects by the state governments so that they can be taken up for execution. This will be helpful in not only improving the irrigation efficiency of these projects but also in planning ERM & new projects lying in the respective basins.

g) The state governments may be requested to take necessary action on the reports of the 30 major & medium projects where Water Use Efficiency studies have been carried out. All help should be provided to the state governments in preparation of DPRs for these projects so that they can be implemented in a time bound manner.

h) Improvement in Water Use Efficiency through on farm development works is the second most important strategy in achieving the overall target of 20% improvement in irrigation efficiency. As already discussed, the losses in water course is about 20%, hence considerable water saving can be effected by having brick lined water courses and proper on farm development works. Apart from CAD, other measures needed are:

- Land leveling & shaping including bordering the farms.
- Lining of field channels and water courses.
- Participatory irrigation management.

The rural employment schemes like MGNREGA etc. can be used effectively for land leveling, shaping & other related farm works necessary to improve the farm water application efficiency. This may be very helpful in improving overall irrigation efficiency.

i) To take up administrative and managerial measures including formation of WUA, implementation of PIM, rationalization of water rates, volumetric supply of irrigation water to minimize wastage, benchmarking etc, wherever necessary, to improve the irrigation efficiencies.

River Basin Organisations (RBOs) can be very helpful in implementing the action plan and thereby achieving the target of improving irrigation efficiency by 20% by 2017.

2) **Conclusions and Recommendations:**

- It is very important to have a comprehensive plan of the whole basin to optimize the utilization of water and hence increasing the overall water use efficiency. Conjunctive use of water should form the basis of planning any irrigation project to maximize benefits. However, every basin has its unique characteristics. Hence, a water budget of all sources of water of the basin, surface as well as underground should be prepared on the basis of which a comprehensive plan should be chalked out for the particular basin. This plan should be updated at regular interval. It is therefore recommended to carry out basin wise study to formulate guidelines to improve irrigation efficiency in the projects lying therein.

- While planning new irrigation projects, storage schemes may be preferred over run of the river schemes, wherever feasible, to absorb the inadequacy of lean season flow and to ensure availability of design discharge as per requirement.

- New Irrigation projects should be planned and designed for 50% dependable flows rather than 75% to store more water wherever feasible and especially in water scarce basins.

- Improving irrigation efficiency in a time bound manner depends very heavily on lining of canals. ERM of existing projects depends largely on lining of canals, wherever canals are unlined. However, the decision to line a canal should be taken depending on various factors discussed in the paper. Ideally, decision whether to line or not line a canal should be taken at the planning stage itself.

- Proper design of headworks, silt excluding devices ,canal network, outlets etc are essential for minimizing wastage of water and obtaining better irrigation efficiency.

- Proper irrigation management should be ensured. Supply based irrigation needs to be replaced by demand based irrigation to minimize wastage. Innovative methods suggested in the paper which are also being used in many places in the world may be considered.

- Rationalising water rates and volumetric based assessment for irrigation charges will ensure minimizing wasteful use of precious irrigation water and help in improving irrigation efficiency.

- Proper training and creating awareness amongst all the stakeholders and promoting WUAs and PIM may be very helpful in improving irrigation efficiency.

- Since considerable wastage of water occurs in the water courses and field channels, it may be a good idea to line the water courses wherever feasible. WUAs can play a very important role here, as field channel is outside the jurisdiction of irrigation department.
- Apart from lining water courses, considerable water saving can be effected by land leveling and shaping including bordering the farms and other OFD works.

- Project authorities may be advised to ensure regular data collection on water use efficiency of projects so that corrective measures, wherever required, can be adopted.

- Improving irrigation efficiency requires an integrated approach and considerable efforts from all the stakeholders. The action plan suggested in this paper may be considered for achieving time bound results.

- Creation of River Basin Organisations will be very helpful in implementing the suggested action plan to achieve the target of improving irrigation efficiency by 20% by the year 2017.

(Views expressed in the paper are personal opinions of the authors and may not be construed to be that of the organisation)

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