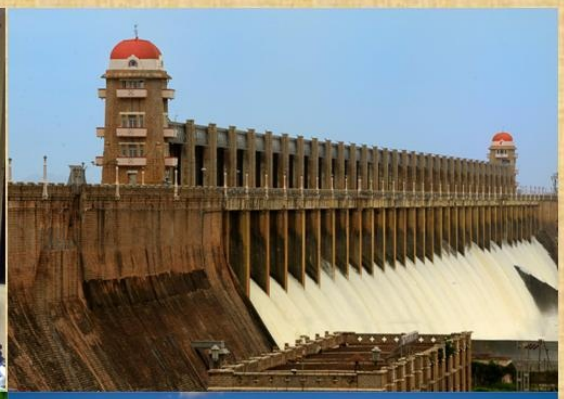
GUIDELINES FOR IMPROVING WATER USE EFFICIENCY IN IRRIGATION, DOMESTIC & INDUSTRIAL SECTORS



PERFORMANCE OVERVIEW & MANAGEMENT IMPROVEMENT ORGANISATION
CENTRAL WATER COMMISSION
MINISTRY OF WATER RESOURCES
GOVERNMENT OF INDIA

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MINISTRY OF WATER RESOURCES
CENTRAL WATER COMMISSION

Guidelines

For Improving

Water Use Efficiency
in
Irrigation, Domestic & Industrial Sectors

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FOREWORD

India has about 18% of the world's population, but has only 4% of world's renewable water resources. With ever increasing population to support food requirement of more than 1.2 billion people irrigation water demand is increasing. The concomitant rapid urbanisation and industrialisation are also taking a heavy toll on the overall water demand scenario. In the result, the gap between water demand and availability has been progressively increasing.

Unless the way the water is being dealt in use is seriously acted upon to catapult the prevailing poor water use efficiency, the available utilizable water resources would be inadequate to meet the future water demand of all the sectors. The bulk user i.e. the irrigation sector might be the worst affected one for; the water may be diverted to other competing sectors which give high returns/productivity.

The silver lining is that in the bulk consumer sector i.e. irrigation sector- consuming roughly about 80 percent, there lies tremendous opportunity of water savings. The prevailing water use efficiency in surface water resources schemes are typically low which can be substantially improved and water can be saved for the other purposes including the additional irrigation. This sector is the thrust area of MoWR, RD & GR which is also reflected in the National Water Mission (NWM) document. National Water Mission under National Action Plan on Climate Change has been unveiled by Hon'ble Prime Minister of India on 30th June, 2008. Five goals have been identified under the National Water Mission. One of the five goals of National Water Mission is to increase water use efficiency in all sectors of water use by 20% by the year 2017 i.e. by the end of 12th Five Year Plan.

In the domestic water sector the loss of water on account of leakages in mains, communication and service pipes and valves is approximately 30 to 40% of the total flow in the distribution system. By reducing these leakages the wastages could be brought down to 10-12% of the supply. The industrial plants in our countries consume about 2 to 3.5 times more water per unit of production compared to similar plants operating in other countries. By putting conservation measures in place, the water can be saved in a cost effective manner.

This highlights the need for a paradigm shift in approach from development to efficient management by making concerted efforts to achieve higher standards of efficiency in water use in all the three sectors. There is an urgent need and scope to make the systems more efficient and operate with optimal efficiency. Effective legislations needs to be brought out and enforced for treatment of domestic waste and industrial effluent discharge and its reuse so as to achieve high level of efficiencies in water use in these sectors also.

In view of NWM, CWC has finalized the instant Guidelines for improving WUE in various sectors like Irrigation, Domestic and Industrial sectors, by incorporating the suggestions regarding the earlier draft, received from various organizations like IITs, NITs, and WALMIs etc.

I appreciate the sincere efforts made by Shri Bhagat Singh, Chief Engineer, POMIO and his team (IPO Directorate) in bringing out these Guidelines. I also accredit to all, whose work has been referred in the compilation of the Guidelines & extend thanks to all engineers, scientist, authors and organizations practising in the field of improvement of Water Use Efficiency in the Irrigation, Domestic and Industrial sectors.

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New Delhi

C o n t e n t s

1. INTRODUCTION

1.1. Prevalent Water Use and Water Use Efficiency:

The National Commission for Integrated Water Resources Development (NCIWRD) estimates total withdrawal/utilization for 2010 for all types of uses as 710 BCM for high projection scenario. Out of which irrigation accounted for nearly 78% followed by domestic use 6%, industries 5%, power development 3%, and other activities claimed about 8% including evaporation losses, environment and navigational requirements.

Whereas, for the year 2050; total 1180 BCM has been estimated for high projection scenario. Out of which irrigation will be accounted for nearly 68% followed by domestic use 9.5%, industries 7%, power development 6%, and other activities claimed about 9.5% including evaporation losses, environment and navigational requirements.

To meet the diverse types of water demands of the society, various facilities/systems comprising of reservoirs, diversion structures, canals, pump houses, overhead tanks, piped supply systems etc. have been created. Such systems have been conceived with a set design operating efficiency.

The typical efficiencies for various facilities for water utilization under different methods of application are indicated in Table – 1.

TABLE – 1

EFFICIENCIES FOR VARIOUS FACILITIES FOR WATER UTILIZATION

Sl. No.	Water Use and methods	Efficiency (%)
a	Irrigation efficiencies	
	• Conveyance	
	– through unlined canal for surface water	55-60*
	– through lined canal for surface water	70-75*
	• Application for both surface and ground water	
	– Flood irrigation	65
	– Furrow irrigation	80
	– Sprinkler	85
	– Drip	90
	• Overall efficiency for surface water system	30-65
	• Overall efficiency for ground water system	65-75
b	Urban water supply	50-60
c	Rural water supply	60-70
d	Industrial use	80

**Conveyance efficiency of the canal depends on many factors such as length of the canal, type of soil, material used for lining etc.*

1.2. Sector-wise Scope of Improvement in Efficiency:

Over the years, the systems usually do not work up to its design efficiency due to battery of reasons, mainly due to inefficient operation and poor/deferred maintenance and other factors. Further, since the quantity of water being utilized for different uses vary considerably as also the design and management efficiencies; this leads to non-uniform scope for improvement in efficiency. Just to have an idea about the possible savings, table – 2 presents the roughly estimated quantum of water being utilized for different purposes, their present level of efficiencies, scope for further increase in efficiencies, likely quantum of additional water which would be available after achieving the targeted efficiency and the relative weights.

TABLE – 2
RELATIVE WEIGHTS FOR DIFFERENT METHODS OF UTILIZATION AND FOR WATER USE FOR VARIOUS PURPOSES

Quantity in BCM

Water uses	Quantity*	Present Level of efficiency (%)^	Full achievable efficiency (%)@	Scope for increase	Quantum of water likely to be saved for full efficiency	Quantum of water likely to be saved by 20% increase or full efficiency	Relative weight for 20% increase
Irrigation							
Surface water	339	30	60	30	102	68	0.53
Ground water	218	55	75	20	44	44	0.34
Drinking water							
Urban water	33	60	90	30	10	7	0.05
Rural water	10	70	90	20	2	2	0.02
Industries (including for Power)	56	80	95	15	8	8	0.06
Others (environment, evaporation etc.)	54	-	-	-	-	-	-
Total	**710**				**166**	**129**	

** quantity for water use for specific purpose has been taken from the estimates of NCIWRD for year 2010 for high demand scenario.*

^ present level of efficiencies of various systems are fair assessments taken from various studies and reports. CWC has carried out water use efficiency on 30 major & medium irrigation projects which provides efficiency assessment for irrigation systems through surface water. Efficiency of irrigation systems through ground water has been taken from the reports of CGWB. There are varying estimates for efficiency of Drinking water systems in urban areas. The National Mission on Sustainable Habitat quotes as "It has been noted that there is 70% leakage in consumer connection

pipes and malfunctioning of water meters" makes the efficiency only 30%, whereas studies by National Institute of Urban Affairs states Unaccounted for Water (UFW) only 21%. A Study by ADB works out Non Revenue Water (NRW) in the range of 40-50%. Thus a fair estimate of the efficiency has been taken as 60%. In case of industries, the figures have been taken from experience and discussion with the experts.

@ full achievable efficiency would vary from system to system. Here it has been taken as average design efficiency of the systems

The guesstimate indicates the vast potential of water savings which can be effectively used in alleviating the pressing water scarcity as also in meeting our increasing water demands. All that is needed is long-term committed movement in the direction of optimization of the operating efficiency of the systems for irrigation, domestic and industrial sector.

1.3. The National Water Mission – Mission document:

As mentioned above, for the long term movement, National Water Mission was drafted by MoWR, RD&GR through wider consultative process. The main objective of the National Water Mission is "conservation of water, minimizing wastage and ensuring its more equitable distribution both across and within States through integrated water resources development and management". Out of its five goals, one is to improve the efficiency of water use by 20%. For achieving this, various strategies have been identified as under:

- Research in area of increasing water use efficiency and maintaining its quality in agriculture, industry and domestic sector;
- Incentivize recycling of water including wastewater;
- Development of eco-friendly sanitation system;
- Improve efficiency of urban water supply system;
- Efficiency labelling of water appliances and fixtures;
- Promotion of water efficient techniques and technologies;
- Undertake Pilot projects for improvement in water use efficiency in collaboration with States;
- Promote Water Regulatory Authorities for ensuring equitable water distribution and rational charges for water facilities;
- Promote mandatory water audit including those for drinking water purposes;
- Adequate provision for operation & maintenance of water resources projects;
- Incentive through award for water conservation & efficient use of water; and
- Incentivize use of efficient irrigation practices and fully utilize the created facilities.

2. MEASURES FOR IMPROVING THE WATER USE EFFICIENCY

Achieving high water use efficiency is thus the first step along the path towards sustainable water development and management. The National Water Policy, 2012 also lays stress on conservation of water. One way to ensure rapid sustainable development is to attempt highest standards of efficiency in water use besides demand side optimal management through mass awareness. It should be our endeavour to achieve the low demand scenario for which it is imperative that considerably higher level of efficiency is brought about in water use in all the three sectors namely Irrigation, Domestic and Industrial sector.

2.1. IRRIGATION SECTOR

As of now irrigation sector consumes about 80% of the total water use which may reduce to about 70% by 2050 due to competing demands from other sectors. Most of the irrigation projects are very old and have become less efficient. Given the quantum of use in this sector, it is needless to emphasise that it has tremendous potential for water saving on efficient irrigation water use. Whereas, current performance of a completed project vis a vis the design performance can be assessed/compared through conventional performance evaluation studies or if only hydraulic irrigation system is to be assessed, then by water use efficiency studies. CWC web has guidelines for the studies.

Before optimization matters are suggested, time has come when water audit has to be implemented in material terms and water resources projects are to be audited on annual basis. Though, few State Governments are carrying out Water Audit of irrigation projects, but it is yet to be made a decision making tool. It is a very significant exercise for; it gives fair idea of total water drawn from the source, its actual use and the water lost in the system. Some of the water loss in any system is inevitable but any excessive loss of water noticed will warrant carrying out the remedial measures. It serves the purpose of a correct diagnosis of the problems faced in order to arrive at optimum solutions. It may also prove an effective tool for realistic understanding and assessment of the present performance level of the service for future expansion. Element of the water audit may include:

- Records of the amount of water earmarked.
- Record of the amount of water delivered.
- Record of amount of water loss.
- Measures to reduce water loss. (through leakages and other unaccounted water losses)

Central Water Commission and Central Ground Water Board have formulated "General Guidelines for Water Audit and Water Conservation". These guidelines have been circulated to all the State Governments and concerned Central Ministries and other utilities for framing their own specific guidelines. Guideline is also placed on the website of Central Water Commission. All State Governments should introduce Water audit as a regular activity in the irrigation projects.

A water resources manager should not only contend in maintaining the status-quo but strive for the continual improvement of performance by setting-up a healthy competition among the water resources projects of the entire State. Benchmarking of irrigation projects has to be resorted to for measuring/comparing performance of a

project/its practices with its better peers - a sequential exercise of learning from others experiences as also comparison with its own previous performance.

Whereas PE/WUE studies diagnostically may help in reclaiming a project efficiency, water audit may add further in managing it better; but benchmarking, if implemented in letter and spirit, may over the years, catapult the performance of all the projects of the State practising it. Water audit and benchmarking are the need of the day. The guidelines in the benchmarking, giving the performance indicators, data requirements etc. have already been published by Indian national committee on irrigation and drainage (INCID) and circulated among various agencies. These vital management tools do not involve much cost as such but only require the will-power for earnestly practising it. In principle, all State governments must include benchmarking as a regular activity in irrigation projects.

Reduction in water losses in conveyance and distribution system through periodic maintenance, applying the right quantity at right time, effective involvement of farmers in water management, right cultivation and irrigation practices including increased use of water saving devices like sprinkler and drip, precision levelling, provision of effective drainage channels, conjunctive use of surface and ground waters, reuse of seepage waters, recycling of domestic & industrial waste water, demand management through mass awareness and proper water pricing are some of the measures for efficient and optimal use of scarce water resources. Further, reforming irrigation institutions is central to increasing the productivity and the efficiency of irrigation systems in a transparent and accountable manner with increased participation by the users. Water Use Efficiency/Performance Evaluation Studies along with Water Audit and Benchmarking have an important potential to contribute to improve the services and the efficiency of the operations. Within the general efforts of reforms, these can provide essential input.

Policy Measures for improving Efficiencies

2.1.1. Irrigation Sector Reforms

The synergy among the three crucial institutions - Water Resources Department (WRD), Command area development authorities (CADA) and the WALMIs responsible for ensuring overall efficient management of water resources systems in States has to be ensured. State Governments may restructure the Water Resources Departments to bridge the knowledge gap in planning, development and management of water resources in a sustainable manner as also making it more service centric/professional. States need to formulate and adopt/implement State Water Policy in consonance with National Water Policy. They have to set up State Water Resources Regulatory Authorities to regulate water resources within the state for judicious, equitable and sustainable allocation/ distribution of water and its utilization. Systematic policy focus and administrative initiatives like revision of the State Irrigation Acts are imperative for achieving the high standard of water use efficiency in irrigation sector. It is also required to strengthen the WALMIs for facilitating training and technical support to the water resources personnel, professional bodies and WUAs.

Participatory Irrigation Management involving stakeholders, particularly Water Users Associations (WUAs), local bodies and gram panchayats, NGOs including

women should be practised in letter and spirit. Induction of Non-Government Organisation may be considered to motivate the users in educating farmers in efficient water use and management of the irrigation system.

The water rates being charged at present are very low and are not able to meet even the operation and maintenance costs of the irrigation projects. Farmers on the other hand, who otherwise may not be averse to paying increased water charges refuse to do so unless the quality of services is first improved and there sets a vicious circle. There is an urgent need for the Paradigm shift by reversing the vicious cycle of low water rates-low revenue-lack of funds for operation and maintenance-poor quality and unreliable water delivery service-farmers reluctance to pay higher water rates to; virtuous cycle of increased water rate-higher revenue-adequate funds for operation and maintenance-good quality and reliable water delivery service- farmers willingness to pay higher water rates. State Governments should evolve a policy for periodical rationalization and revision of water rates so that the revenue generated by the irrigation sector is able to meet the cost of operation and maintenance and realize economic returns on the investment made on irrigation projects. However, revision of water rates should go hand in hand with measures to improve the quality of services through stake holder's participation in the management of the water resources. Besides charging of irrigation water on volumetric basis and linking it to reliability, timeliness, and adequacy of irrigation water supplies; the incentives & disincentives like as under may also be considered:

- Institution of Awards at minor/major distributary level for implementing scientific water management procedures
- Providing incentives to WUAs, in the form of reduced bulk rates for water, subsidized inputs etc.
- Creating dis-incentives for growing high water loving crops in soils and climate that are not conducive for such crops.

Water resources development and management should be planned for a hydrological unit such as drainage basin as a whole or for a sub-basin, multi-sectorally, taking into account surface and ground water for sustainable use incorporating quantity and quality aspects as well as environmental considerations. All individual developmental projects and proposals should be formulated and considered within the framework of such an overall plan keeping in view the existing agreements / awards for a basin or a sub-basin and transfers of water from one river basin to another, based on a national perspective, after taking into account the requirements of the areas / basins so that the best possible combination of options can be selected and sustained. It is also emphasized through Goal V of National Water Mission for promotion of basin level integrated water resources management (IWRDM). All State Governments should give priority to IWRDM for holistic development of water resources and for its efficient use.

2.1.2. Adoption of Scientific Water Management Practices

This may include measures as under:

i) Proper assessment of command area size, and proper fixing of outlet sizes to match the crop water requirements, ii) lining of the critical segments of the water conveyance system including water courses, iii) linking timing of irrigation supplies to plant water needs and water availability not on "duty" values, iv) Scientific

estimation of crop water demands, v) scheduling of irrigation based on soil - water- plant interactions, vi) Adoption of efficient water scheduling policies and operating rules, vii) Application of irrigation water with least wastage avoiding field to field flooding irrigation, vii) Adequate provision for draining excess water from fields, viii) Proper control of wastage, leakages, losses and unauthorised uses, ix) tuning irrigation schedules to medium range weather forecasts (MRWF) to synchronise with the critically long dry spells to get maximum benefit of irrigation water, x) minimising evaporation losses from irrigated fields through use of mulches, xi) adoption of efficient methods of irrigation such as alternate furrow irrigation, surge flow irrigation, and pressurised irrigation (micro and sprinkler systems) etc.

2.1.3. Technological up-gradation

Use of Management information system (MIS) & Decision support system (DSS): There is a dire need for a canal system to respond quickly to flow changes. This can done by computer assisted MIS & DSS which primarily requires precise discharge measurements and better communication facilities. Precious water can be saved and efficiencies improved by quickly responding to sudden change in demand.

Micro Irrigation System: Considerable savings in water can be achieved by adoption of sprinkler, drip/ micro-sprinkler/drip irrigation systems in water scarcity areas, having conditions conducive to their application as also keeping in view the cost & maintenance considerations. This can be further coupled with auto irrigation systems in which soil water stress is sensed continuously by tensiometers installed at suitable depths and location, the output of tensiometers is converted into an electrical signal with the help of a transducer. The anticlockwise and clockwise rotation of the motor actuated through control circuitry opens or closes the valves for initiation or termination of irrigation.

2.1.4. R&D Efforts

For meeting the challenges of the future, R&D efforts in irrigated agriculture should go in un-flagged manner in the following aspects like:

1. Development of data base on agricultural utilization.
2. Saving in agricultural use, soil moisture, conservation through use of mulches, improving water use efficiency, selective lining of canal.
3. Conjunctive use of surface and ground water.
4. Conjunctive use of multi source and multi quality waters. (Use of saline waters).
5. Economising in micro irrigation systems.
6. Environmental protection for water pollution, reuse of irrigation water.
7. Developing policy guidelines for rationalising water pricing.
8. Cropping for flood affected / flood prone area.
9. Biotechnology for developing salt/drought tolerant crops, low water requiring crops etc.
10. Membrane Technology for water treatment and desalinization at low cost.
11. Improved water management.
12. Participatory irrigation management.
13. More crop per drop.
14. Water-logging and soil salinity.

2.2. DOMESTIC SECTOR

Domestic water requirement is estimated to nearly double in the next 40 years (56 BCM in 2010 to 102 BCM in 2050 (MOWR, RD & GR 2000). The ever rising scarcity has put the managers in a bracket and left with no choice but to critically review and optimise the business as usual. The typical reasons water supply system under-performance could be like poor conservation, inefficient management, improper operation and maintenance system, lack of revenue generation (poor metering; low tariff), and most significantly, wastage due to leakage and pilferage etc. In-fact, the Ministry of Urban Development, with the help of the National Environmental Engineering Institute (NEERI) had conducted studies on leaks in water distribution systems across 13 cities, including Delhi, Calcutta, Mumbai and Chennai during 1990's. It was observed that about 17-44 percent of the total flow in the distribution system was lost on account of water loss through leakages in mains, communication and service pipes and leaking valves. A recent study by ADB (2007) across 20 towns and cities corroborated the past studies and showed the water losses due to leakage, pilferage etc, to be of the order of up to 60 per cent. It also highlighted the fact that maximum leakage occurs in the house service connections, i.e., in the tertiary distribution networks. This is a reflection of the inefficiency in the management side which needs immediate attention.

Leakages and unaccounted use must be controlled and brought to the minimum level. Unfortunately, unaccounted-for-water also constitutes a significant fraction of total water supplied in poorly managed water transmission and distribution systems. Measures like detection, control and prevention of leakage, metering of water supply, installation of properly designed waste-not-taps and prompt action to repair and maintain distribution system components should be adopted. This can be achieved through water audit.

2.2.1. Water Audit

Potable water supply is a costly proposition and thus it becomes imperative to closely monitor its volumetric movement within the supply network by a detailed water audit which also helps in determining the amount of water lost due to various reasons.

For the purpose of water audit, bulk metering system may be devised zone-wise, including group-consumer-wise in a system or a sub-system. This will facilitate in identifying the reaches where actually the waste of water is taking place. A worksheet may be developed, with a set study period of say one year for it includes all seasons and gives enough time to eliminate the effect of meter reading lag.

Once the study period has been set and a worksheet has been developed, the audit can be conducted. Records should be compiled and meters should be checked so that accurate usages are recorded. Once usages are computed, the worksheet should then be filled in, and water delivered should be balanced with water used. Unmetered uses should be documented along with the methods to quantify them. An attempt to account for water loss should be made. Based on the findings of the audit, options should be developed to reduce water losses.

Inventory of meters may contain details such as types, sizes, and age of meters in the distribution system. This will help in estimating the accuracy of the

meters in a system on wide scale. This can complement the water usage information and show usage patterns in the distribution system. It will also help any meter replacement program and cross-connection control program. Possible corrective measures include leak detection programs, meter replacement or installation programs, and conservation programs. Factors to be considered for corrective measures may include

(a) Where the losses occur
(b) How much loss is in each problem area
(c) What possible solutions exist
(d) Cost of the solutions, and
(e) Time to make the solutions

It will be important to verify records and check meter accuracy, as these will affect the accuracy of the audit. Records should be checked carefully to make sure that units are correct, all measurements are included, measurements represent the same time period, and that calculations are correct.

Water Losses and Follow up

There are two types of losses, real and apparent losses. Real loss includes water lost through leakage of distribution systems, service connections, and storage tanks (including overflow). Apparent loss includes meter and record inaccuracies and unauthorized water uses such as theft and unauthorized connections. Authorized unmetered uses can be considered a special type of lost water, and they can also represent lost revenue and therefore they should be estimated carefully.

If the unaccounted or unmeasured water loss is beyond permissible limit, it is recommended to prepare a plan within a reasonable time period outlining steps necessary for further identification and reduction of water losses. Such steps may include initiating or expanding leak detection and repair program or eliminating unmetered accounts. Cost benefit analysis should be conducted to choose the right option. If future annual audits continue to show unmeasured water loss greater than the permissible limit, the plan for reducing water losses should be updated.

Long term follow up should include updating the audit, reducing loss and checking meters. After the first audit, areas where data is lacking should be identified and addressed. Subsequent audits should provide greater accuracy and reduction of water losses.

2.2.2. Remedial measures for improving Efficiencies

Besides according high priority to maintenance and preventive measures, as part of an effective O&M schedule, following measures like metering, leakage reduction, tariff systems, water-saving devices, regulations, reuse and cultivation of appropriate plant species, and information and education may be implemented for the purpose as under:

i. Metering

Metering required both at source level and user level. Metering at source level involves measuring the water flows impounded, conveyed and distributed. Metering at user level is to measure each user’s consumption periodically in order

to charge for the service. The metering can have an influence on domestic water use, with reductions of up to 25% in areas that previously had no metering. A strategy for the installation of meters at all user level is to be identified and implemented.

ii.Leakage Control

Leakage constitutes a major part of losses in drinking water systems: leaks in purification plants, distribution networks and home outlets leading to wrong estimates, unauthorized outlets and unrecorded volumes consumed by municipal services such as the watering of public gardens or fire hydrants. Leaks in the supply network may be visible or concealed; they first rise up through the soil or pavement, the latter are not visible and flow into the drainage system or aquifer. Leakage reduction through detection and repairs can save lot of water. Studies carried out by Ministry of Urban Development suggest that proper maintenance by keeping valves clean and repairing in time can increase the carrying capacity of pipes considerably and wastage could be brought down to 12 percent to 15 percent of the supply. Severe penalties may be levied on those found responsible for leakage and wastage of water.

iii.Tariff

Water costs are largely subsidized by governments, but it has become increasingly difficult to continue with such financing proposition, and it is now a question of rationalizing rate policies through well designed tariff structure. If users are charged appropriately for water services, consumption becomes more efficient, since the amount of water used tends to diminish. Thus it can be an effective tool to control wasteful use of water and effect water savings up to 10%, but user's cooperation remains a critical factor.

iv. Water conservation measures

A paradigm shift is required to promote a conservation ethics in the society. Wherever feasible, artificial recharge of ground water and rainwater harvesting has to be encouraged. Rainwater may be charged into the groundwater aquifers through any suitable structures like dug wells, bore wells, recharge trenches and recharge pits. Various recharge structures are possible; some of which promote the percolation of water through soil strata at shallower depth (recharge trenches, permeable pavements) whereas others conduct water to greater depths from where it joins the ground water (e.g. recharge wells). At many locations existing structures like wells, pits and tanks can be modified as recharge structures, eliminating the need to construct any structures afresh.

Instead of constantly looking for new and distant sources of water supply, the local bodies should lay emphasis on water harvesting. The rooftops of various buildings could be used wherever possible as hard catchments of rainwater for use after its treatment as also for ground water recharge. The Ministry of Urban Development had already forwarded the guidelines on roof top rainwater harvesting and artificial recharge of ground water (prepared by the Central Ground Water Board) to all the States including the CPWD to implement rain water

harvesting and artificial recharge of ground water in all the government buildings to start with. The Town and Country Planning Organization (TCPO) has also prepared model building byelaws incorporating mandatory provision of rainwater harvesting and recycle of wastewater. This has been circulated to all the States for preparing similar byelaws by the respective Urban Local Bodies (ULBs), so that rainwater harvesting can be implemented in all the premises having plinth area more than 100 sq m.

Use of treated effluents, in place of filtered water for horticulture and gardening, and fitting of waste-not taps on public places to avoid wastage of water should be encouraged. Water-efficient systems for flushing should be made mandatory. Conservation of water should be recurring theme for both users as well as those managing the water supply system.

v. Restricting over-exploitation

Exploitation of ground water resources should be so regulated as not to exceed the recharging possibilities, as also to ensure social equity. The detrimental environmental consequences of over-exploitation of ground water need to be effectively prevented by the Central and State Governments. Over exploitation of ground water should be avoided especially near the coast to prevent ingress of seawater into sweet water aquifers.

vi. Pressure Reduction

Flow rate can be reduced by reducing operating pressure e.g. a reduction in pressure from 7.0 kg per square centimetre to 3.50 kg per square centimetre at an outlet can result in a water flow reduction of about one-third.

Homeowners can reduce the water pressure in a home by installing pressure-reducing valves. The use of such valves might be one way to decrease water consumption in homes that are served by municipal water systems. For homes served by wells, reducing the system pressure can save both water and energy. It can also save water in other ways as it reduces the likelihood of leaking water pipes, leaking water heaters, and dripping faucets. It can also help reduce breakdowns in a plumbing system.

2.2.3. Pricing a tool for demand management

It is high time water is treated as an economic good rather a free commodity. There is an urgent need for revision of the tariffs in most cities to cover not only the O&M costs but also part of the capital cost, depreciation, etc. Cent percent water cess collection has to be ensured. Illegal connections will have to be identified and regularized, wherever feasible.

2.2.4. Reuse of water

With tertiary treatment, water from treated sewage can be used even for air-conditioning, industrial cooling and other non-potable uses. This should be made a thrust area. Suitable fiscal concessions and subsidies may be considered by the Central and State Governments to commercial establishments or local bodies which

practise waste water reuse, recycling and resource recovery. In case of big establishments like hotels, large offices and industrial complexes, community centres, etc dual piped water supply may be insisted upon. Under such an arrangement one supply may carry fresh water for drinking, bathing and other human consumptions whereas recycled supply from second line may be utilized for flushing out human solid wastes.

The Town and Country Planning Organization (TCPO) has also prepared model building byelaws incorporating mandatory provision for recycle of wastewater of the premises discharging more than 10000 liters per day (for use in horticulture etc.) However, concerted efforts are required to achieve these objectives.

2.2.5. Institutional and policy reforms

Inadequate attention to operation and maintenance of the assets created leads to the deterioration of the useful life of the systems up to 50 per cent to 60 per cent necessitating premature replacement of many components. The key issues that contribute to the poor operation and maintenance are as follows:

- Lack of funds and inadequate revenue generation
- Inadequate data base on O&M
- Multiplicity of agencies and overlapping of responsibilities
- Inadequate training of personnel and lesser attraction for maintenance jobs, investigation and planning
- Lack of performance evaluation and monitoring
- Inadequate emphasis on preventive maintenance

It has been observed that about 30 to 40 per cent of the total O&M cost goes towards establishment and 40 to 50 per cent is incurred on power and the balance is used for consumables, repairs, etc. Thus hardly any funds are left for preventive maintenance of infrastructure. To augment the resources and improve the service levels of consumers, it is important that availability of funds for preventive maintenance of infrastructure may be ensured. In this respect, Public Private Partnerships (PPP) may be encouraged in the functions of operation, maintenance, distribution, billing and collection of revenue from consumers.

States may need to expedite the transfer of responsibility for O&M of water supply and sanitation schemes including empowering to Urban Local Bodies (ULBs) to revise tariff on their own, as per requirements, for sustainability of the schemes. Strategy to effectively equip and ensure the involvement of ULBs in creating and maintaining such infrastructure is the need of the hour and they may be made independent of State Governments for fund requirements.

Unrealistic tariff structures, poor collection efficiency, lack of finance, poorly directed subsidies, absence of commercial accounting systems have brought down the credit worthiness of the utilities, disabling them to access capital markets for funds. Lack of capacity building with community participation and regulatory mechanism and inability of ULBs to run the utilities on commercial lines and absence of public private partnerships have also added to the vicious cycle. In order to ensure universal access to safe drinking water to all the citizens in urban areas,

it is necessary to introduce operational, financial and institutional reforms, besides improved resource management, which would lead to water conservation and avoidance of wastage of water.

2.2.6. Public Awareness and Participation

Mass campaign should be started through all available media and by the utility management itself setting an example for conservation. All urban dwellers should be made aware of the source from which water is being brought to the city and from which additional water will have to be brought in future. They should be aware of the costs involved, not only in financial terms, but also the costs that other communities have to incur in terms of opportunity lost by not using the water. Public awareness needs to be created for reducing water consumption. Women's participation is particularly important and needs to be encouraged to the maximum as they are the major users and have to fetch water from a distance if the local system does not work. Congenial environment has to be created for motivating people, community and local governments to come forward and take up operation, maintenance and management of the system.

Water saving Techniques

There are following measures, though appear trite, but are worth repeating here as under, for promoting these:

Plumbing: Low-flow plumbing fixtures and retrofit programs are permanent, one-time conservation measures that can be implemented automatically with little or no additional cost over their lifetimes. In some cases, they can even save the resident money over the long term.

Toilets: Residential demands account for about three-fourths of the total urban water demand. Indoor use accounts for roughly 60 percent of all residential use, and of this, toilets use nearly 40 percent. Traditional toilets use between 16 and 20 liters per flush, which means an average consumption of 80-100 liters daily per inhabitant; water-efficient toilets using only 6 litres per flush can reduce that figure to 30 litres a day per inhabitant. In new construction and building rehabilitation or remodelling there is a great potential to reduce water consumption by installing low-flush toilets. Since low-flush toilets use less water, they also reduce the volume of wastewater produced.

Showers: Showers account for about 20 percent of total indoor water use. By replacing standard 20 litre-per-minute showerheads with 10 litre-per-minute showerheads half of the water can be saved. This can be accomplished by using new shower-head designs or flow reducers.

Basin and sink faucets aerators: Flow reduction in these fixtures is achieved by using aerators. Faucet aerators, which break the flowing water into fine droplets and entrain air while maintaining wetting effectiveness, are inexpensive devices that can be installed in sinks to reduce water use. Aerators can be easily installed and can reduce the water use at a faucet by as much as 60 percent while still maintaining a strong flow. More efficient kitchen and bathroom faucets that use less water unlike standard faucets may be used for saving water.

Washing machines and Dish washers: There are basically two types of washing machines: front loaders and tub machines (top loaders); the first type can be more efficient than the second type. Further, the efficient washing machines have reduced water consumption by up to 24% in comparison with traditional models.

Indoor leak detection: A great deal of water is lost in homes through leaks in pipes, plumbing fixtures and toilets. The real solution is the manufacture of leak-proof fittings.

Garden watering: Domestic wastewater composed of wash water from kitchen sinks and tubs, clothes washers, and laundry tubs is called gray water. It can be used by homeowners for home gardening, lawn maintenance, landscaping, and other innovative uses. The best way of saving water in gardening is to observe appropriate garden watering practices. The best time to water is between 4 and 8 a.m. or 8 p.m. and midnight.

Car washing: One of the most wasteful ways of using water is washing down cars with a hose. It is recommended using wet cloth and to patronize public car wash services that reuses water.

Swimming pools: It is hardly ever necessary to change the water in a swimming pool. It can always be treated for reuse by using portable equipment and the appropriate chemicals. The other factors that cause waste in swimming pools are seepage and evaporation.

User Education: Mass awareness programmes serve to save water substantially and require well planned and coordinated efforts by Govt. Agencies.

Possible saving in domestic use may be like under:

What we do		What should be done		Saving of water in litres
Activity	Use of water in litres	Activity	Use of water in litres	
Bathing with Shower	100	Bathing with Bucket	18	82
Bathing with running water	40	Bathing with Bucket	18	22
Using old style flush in Latrines	20	Using new style flush	6	14
Shaving with Running water	10	Shaving by taking water in mug	1	9
Brushing teeth with running water	10	Brushing teeth taking water in mug	1	9
Washing cloth with running water	116	Washing cloth with bucket	36	80
Washing Car with running water	100	Washing Car with wet cloth	18	82
Washing floor 15'X 10' with running water	50	Washing floor with wet cloth	10	40
Washing hand with running tap	10	Washing hand with mug	0.5	9.5

2.3. INDUSTRIAL SECTOR

Though the industrial water demand (including energy demand) at present constitutes only about 8% of the total water demand, its share of water use is rising rapidly and by the year 2050 is expected to increase to about 13% of the total projected water use at that time. The overall demand of water for industries is expected to go up from 56 BCM (including Energy, mainly Thermal Power) that was in the year 2010 to 151 BCM by the year 2050. At present the industrial plants in our countries consume about 2 to 3.5 times more water per unit of production compared to similar plants operating in other countries. There is an urgent need and scope to make the systems more efficient and operate with reduced quantity of water. Further unlike in Irrigation the industries require water on regular basis throughout the year. Therefore, to ensure reasonable availability of water for industries even during the lean periods, the industries will have to inculcate the habit of efficient water use. Besides this, industrial water management has to address a major issue of water quality of effluents which can also be tackled to some extent through efficient water use.

However, water requirements of various sectors of Indian Industries as per volume II of NWM document are tabulated as under:

Water Requirement in Mm^3 / year Production in 1000 tonnes

Sl. No	Category of Industry	Water Requirement per tonne in m^3	Year 2000		Year 2010		Year 2025		Year 2050	
			Production	Water Req.	Production	Water Req.	Production	Water Req.	Production	Water Req.
1	2	3	4	5	6	7	8	9	10	11
1	Iron & Steel	22	174050	3829.1	265350	5837.7	273300	6013	547050	12035
2	Smelters	82.5	203.6	16.76	292.6	24.14	391.6	32.31	537.6	44.35
3	Textiles & Jute	200	51193	8153.7	95094	19019	183507	36701	234618	46924
4	Leather Products	30	1277.5	1244.7	2191.3	65.74	3102.5	93.08	4927.5	147.83
5	Inorganic Chemicals	200	3730	165	8000	1600	16730	3346	30076	615
6	Pharmaceuticals	25	4960	124	8370	209.25	11046	276.2	17170	429.15
7	Distillery	22	1790.8	6357.2	3059.6	66.31	4454.6	318	6020	5203.9
8	Paper & Pulp	200	4950	1260	10350	207	51200	10240	97450	19490

From the above table it may be seen that some of the industries like Textile, Paper & Pulp and Iron & Steel etc. consume lot of water. Efforts shall be made to reduce their water use. Further existing Thermal Power Projects consume lot of water in their cooling process. There is lot of scope in reducing their water demand by adopting efficient cooling technologies.

Measures for improving efficiencies

The efficiency of water use can be increased by adopting suitable water conservation procedures involving minimizing of water losses, prevention of water wastage, etc. There is need for mandating recycling of water in certain sectors including measures like effluent treatment etc. The measures like incentivization of water conservation or adopting such technologies using least amount of water may also be necessary, in the time to come. Water management plans must be part of an integrated approach that examines how change in water use will impact all other areas of operation. Water conservation involving both distinct areas i.e. technical and human should be properly addressed. Some of the action points towards water conservation for improving efficiency in industrial sector are as under:

2.3.1. Water Audit

The water audit will consider both quantity and quality aspects; as the need to reduce polluting discharges to the aquatic environment or to sewage systems is often the key driver to water saving. The starting point will be large units in water-intensive industries such as paper and pulp, textiles, food, leather (tanning), metal (surface treatment), chemical/ pharmaceutical, oil/gas and mining.

Central Water Commission and Central Ground Water Board have formulated "General Guidelines for Water Audit and Water Conservation". These guidelines have been circulated to all the State Governments and concerned Central Ministries and other Utilities for framing their own specific guidelines. Guideline is also placed on the website of Central Water Commission. Water audit is to be carried out annually. All industries should introduce Water audit as a regular activity. While carrying water audit following points may be considered,

Survey in the Plant

- A plant survey identifies areas where water is wasted or where water could be reused.
- Identify all points where water is used, including hose connections, and determine the quantity of water used at each point.
- Determine the capacity of each water-containing unit and frequency of emptying.
- Determine the quality, quantity, and temperature of water carried by each major water line.
- Determine the quality of each continuous discharge not yet being re-used.
- Determine whether flow rates in floor gutters are adequate to prevent solids accumulation.

  and some action plan relevant to particular industry may be prepared.

Evaluate Survey Results

- Identify the major water-using operations.
- Review the water reuse practices currently employed.
- Evaluate the feasibility of installing cooling towers (as applicable).
- Study the potential for screening and disinfecting reclaimed water to increase the number of times it can be re-used.

Other General Suggestions

- Ask local water agency about rebates or financial incentives for water use efficiency.
- Appoint a water conservation coordinator with the responsibility and authority for a water use efficiency program.
- Make the plant manager and other employees aware of the water conservation coordinator's duties.
- Conduct contests for employees (posters, slogans, or efficiency ideas).
- Install submeters and read water meters regularly (daily, weekly) to monitor success of water use efficiency efforts and to help detect leaks.
- Provide an easy way for employees to report leaks.

2.3.2. Benchmarking for industries

In India, many studies have been conducted by various organisations on water conservation and management. However, specific information on water use patterns & benchmarks in the select water intensive industry sectors is lacking at national level. Due to lack of information, awareness & motivation, very few industries have proactively adopted available best practices. Further, though the scientists constantly innovates the new techniques, there is a gap on the application of the appropriate technologies, which needs to be removed. Action has already been initiated by MoWR, RD & GR with active involvement of organisations like FICCI & CII to assess the present level of water consumption for various water intensive industries (including energy, mainly thermal projects). Water audit of industries has also been initiated and this will help in the quantifying actual water use viz a viz withdrawals from source. The aim is to identify the companies in the same industry which are managing with less water, establish bench marks, take up research to identify water efficient technologies that can be adopted by industries without appreciable additional investment, specially in water intensive industries and encourage them to adopt the same.

2.3.3. Technological improvements

Water use efficiency in India in the industrial sector is quite poor as compared to similar industries in other countries. Substantial water savings, can be obtained by introducing water saving technologies, treatment, reuse of wastewater and changing industrial processes e.g. three cooling water conservation approaches are evaporative cooling, ozonation and air heat exchange. The ozonation cooling water approach can result in a five-fold reduction in blow down when compared to traditional chemical treatment and should be considered as an option of increasing water savings in a cooling tower. With number of Thermal and Nuclear Plants coming up, water use efficiency for cooling will have to go up to cater to the increased demand. The dry cooling tower technique is one of the water saving methods suggested for this purpose.

2.3.4. Reuse of waste water

Recycling and reuse of water should be made mandatory to reduce pressure on demand of fresh water. Reusing and recycling the waste water from such water intensive activities and making the reclaimed water available for use in the secondary activities within or outside the industry will save lot of water. Incentives in

the form of tax relief, excise exemption, etc. can also be provided for industries and commercial establishments to encourage recycling and reuse by the State Governments / concerned local authorities. Also, the cost of industrial water recycling varies from site to site and depends on comparison of cost of waste treatment prior to disposal with that of treatment of waste water for reuse within the Plants. But the recycling cost may work out less-in future as cost of water supply may go up.

2.3.5. Regulatory measures

The existing system of subsidies and tax structure on investment in pollution control, water conservation and water recycling technologies should be reviewed. Particular attention needs to be paid to introduce a significant and punitive variable tax on the act of pollution.

Tariff rates have to be prescribed such that the industry is motivated for implementing the recycling and look into technological interventions leading to reduced use per unit production. For effecting maximum conservation, production processes have to be modified, to have lesser generation of effluent water.

Selection and zoning of industries associated with potential risks especially those releasing toxic waste need a thorough analysis and planning before they are set up in any water basin. The concerned State Government and other local bodies should have a coordinated approach in selecting and locating industries of a specific nature with respect to their water requirement and facilities for wastewater disposal. A policy for zoning the water basins according to the types of industries, quantity of water consumed/discharged needs to be laid down. Clearance from the concerned Ministry dealing with State Water Resources may be made mandatory for discharging effluents in the drainage system.

Periodic water auditing should be mandatory and a norm for water budgeting. The research efforts in Industrial & Energy sector are to be given due importance for furthering the efficiency in industrial sector.

2.3.6. Awareness and participation of employees in industries

The water conservation program should be organized. Water conservation equipments should be installed & a water conservation team may be constituted to evaluate conservation ideas, methods and equipment. To realize maximum effectiveness, employees should be informed about the water conservation program and its goals. Employees should be educated on the importance of water conservation and suggestions may be solicited on ways to use water more efficiently. Employees should be effectively roped into the conservation efforts.

The most of the problems viz., tariff, metering, unaccounted for water, storage, source etc common with that of domestic sector have already been dealt with under the domestic sector and thus not reproduced here, but stands relevant and applicable to industrial sector too.

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