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Ministry Of Water Resources, RD&GR

जल लेखा एवं जल संरक्षण के लिए सामान्य दिशा निर्देश

DRAFT GENERAL GUIDELINES FOR WATER AUDIT & WATER CONSERVATION

जल समुपयोजन मूल्यांकन निदेशालय

EVALUATION OF WATER UTILISATION DIRECTORATE

केन्द्रीय जल आयोग

CENTRAL WATER COMMISSION

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WATER AUDIT

1.0 INTRODUCTION

Availability of natural resources, particularly land and water, for people of India is inequitable at global level. Presently, with 2.4 per cent of land and 4 per cent of water resources, India has to support 17.5 per cent of world's population and 30 per cent of livestock. India gets an average precipitation of 4000 billion cubic meters (BCM) per annum whereas total available annual utilizable water resource is 1123 BCM only. Also precipitation is highly unevenly distributed with respect to time and space, over the country. On the other hand demand for fresh water is increasing with every passing day. It is not only due to rapid population growth alone, but also on account of many other factors such as rise in per capita water demand arising out of continuous upward movement of living standards, increased reliance on irrigated agriculture, massive urbanization and industrialization etc. and it will become scarce in the coming decades.

As per Standing Sub-Committee of MoWR and National Commission for Integrated Water Resource Development (NCIWRD) the projected water demand for various sectors has been summarised as below.

Projected Water Demand per annum (in BCM i.e. billion m3)

Sector	**Standing Sub-Committee of MoWR**			**NCIWRD**		
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**

As shown in the table, the annual water demand is increasing year by year. In the year 2010, annual water demand was 813 BCM and it is likely to be 1093 BCM by the year 2025 and 1447 BCM by the year 2050. Thus available utilizable water resource of the country is considered insufficient to meet all future needs. With a growing population and rising needs of a fast developing nation as well as the given indications of the impact of climate change, availability of utilizable water will be under further strain in future with the possibility of deepening water conflicts among different user groups. Under such a situation, in order to face the challenge of water deficit, apart from accelerating pace of development of available utilizable water resources, all our efforts, on the part of people from every walk of life, would need to be made to conserve every drop of water and improve efficiency in all areas of water use.

With a view to limited availability and increasing demand of water, standardization and popularization of the water audit system for conservation of water in all sectors of water use and improve the water use efficiency is must.

Keeping this in view, Central Water Commission had taken a lead role to bring out "General Guidelines for Water Audit & Water Conservation" in 2005 with the support of Central Ground Water Board. To consider the views and opinions of various stakeholders across the country covering Central Government, State Governments, PSUs, NGOs etc., a national level workshop was organized on 30.01.2004 at New Delhi. Summary of the recommendations of the workshop are given in Annex-A.

The "General Guidelines for Water Audit & Water Conservation" have been prepared as conceptual guidelines to cover broadly three main sectors of water use viz. irrigation, domestic and industrial. The aims and objectives of these guidelines are to introduce, standardize and popularize the water audit system for conservation of water in all sectors of water use and improve the water use efficiency.

As hydro-dynamics and hydrology are stochastic in nature depending on various surprises, intrinsically each and every project or water management system is unique in character. Government Departments, Public Sector Undertakings (PSUs), Agencies and other such organizations of Central and State Governments, Non-Governmental Organisations (NGOs) working for sustainable development of water resources, may formulate comprehensive guidelines considering state-specific, region-specific and project specific needs, based on these conceptual guidelines and keeping in view local/regional perspectives and aspirations.

1.1 What is Water Audit

Just as business routine, bank prepares statement of debits and credits for their customers and provides a statement of money, which is flowing into and out of accounts. The water audit displays how quantity of water flows into and out of the distribution system and to the customer. Water auditing is a systematic & scientific examination of water accounts of the projects. It provides a rational, scientific framework that categorizes all water use in your system. It is a tool to overcome shortage, leakage and losses in the system.

With the help of water audit, we identify and quantify what steps can be taken to reduce water use and losses. Water audit and its analysis which can solve not only many water related problems but also save precious resources and public money. Water audit is most effective tool for water management.

Comprehensive Water Audit can give a detailed profile of distribution system and water users, there by facilitating easier & effective management resources and improved reliability. It may also prove as an effective tool for realistic understanding & assessment of present performance level of the service for future expansion Water auditing process involves checking of sector-wise water use against project planning and losses actually realized on the projects.

Elements of water audit include a record of the amount of water produced (total water supply), water delivered to metered users, water delivered to unmetered users, water loss and suggested measures to address water loss (through leakages and other unaccounted for water losses). Thus it is a tool to identify public money wastage due to

the water loss, un-authorized connections as an advantage over the optimized use of water resources with environmental protection.

1.2 Benefits of Water Audit

Water audit improves the knowledge and documentation of the distribution system, problem and risk areas and a better understanding of what is happening to the water after it leaves the source point. Leak detection programs help in minimizing leakages and tackling small problems before they become major ones. These programs lead to-

(a) Reduced water losses,
(b) Improved financial performance,
(c) Improved reliability of supply system,
(d) Enhanced knowledge of the distribution system,
(e) Efficient use of existing supplies,
(f) Better safeguard to public health and property,
(g) Improved public relations,
(h) Reduced legal liability, and
(i) Reduced disruption, thereby improving level of service to customers

1.3 Approach for Water Audit

The approach used for Water Audit, should be that all water is " accounted for" and quantified as either a component of beneficial consumption or wasteful loss by measuring (metering) or estimating water quantities. Under this approach, no water should be "unaccounted for," and this flawed term and the flawed indicator "unaccounted-for-water per-centage" should be avoided.

Table- 1 shows the Water Balance of the Water Audit Method. All quantities of water fit into one of the boxes of the water balance. The sum of the quantities of each column in the water balance is the same; hence, all quantities balanced.

<table>
<tr><td rowspan="8">System Input Volume</td><td>Authorised consumption</td><td>Billed Unauthorised consumption</td><td>Billed metered consumption</td><td rowspan="2">Revenue Water</td></tr>
<tr><td></td><td></td><td>Billed unmetered consumption</td></tr>
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<tr><td></td><td>Billing adjustment and waivers</td></tr>
<tr><td rowspan="2">Real losses</td><td>Report Leaks</td></tr>
<tr><td></td><td>Unreported loss</td></tr>
</table>

Table-1 Water Balance

Source : IWA / AWWA

Standard terms shown in Table-1 are defined as under:

System Input Volume: The total water supplied to the water distribution system, corrected for any error in the production meters. It includes the sum total of purchased surface or groundwater, water obtained through the utility's own wells, water purchased through contracted interconnections with other water suppliers, or water obtained from other sources. This is the total of all production meter readings for the entire audit year from all sources.

• **Production Meter Accuracy—**All production and bulk purchase volumes should be metered. Meters should be well maintained and calibrated to ensure a high degree of accuracy. For any given water utility, one or more production meters may incur a degree of inaccuracy due to wear, malfunction, or improper installation.

• **Corrected System Input Volume—**The level of production meter accuracy is usually a percentage. To calculate corrected system input volume, divide the system input volume by the percentage of accuracy to achieve the corrected system input volume—the volume actually placed into the distribution system. Since inaccurate meters often under register, this number will usually be larger than the reported system input volume.

Authorized Consumption: This category consists of all water that has been authorized for use by the utility and its customers. Authorized consumption includes, but is not limited to, water used for residential and commercial uses, fire fighting, public fountains, golf courses, municipal landscape watering, line flushing, city offices, water treatment facility use, dust control, and construction practices. Authorized consumption is all the water the utility gave permission to a business, individual, or itself to use. It may be billed or unbilled, metered or unmetered.

• **Billed Metered—**Water that is appropriately metered and billed.

• **Billed Unmetered—**Estimated water that has been sold but not metered; for example, dust control trucks and types of businesses using authorized water drawn from fire hydrants or other unmetered uses.

• **Unbilled Metered—**Water that is metered but not billed, such as city/government offices, city park irrigation, water treatment facility use, some fire department use, and line flushing.

• **Unbilled Unmetered—** Estimated water that is not billed or metered, such as most line flushing. Estimations may also be entered for this category. Installing meters on any of the sources of significant unmetered water represents bottom-up activity to improve the accuracy of the top-down water audit and better manage these water uses.

Water Losses: This is derived by subtracting authorized consumption from corrected system input volume. Water losses exist in two major classifications: apparent losses and real losses. Both are considered types of water loss. Apparent loss is valued at the customer retail rate because it had the opportunity to be sold. Real loss, however, is calculated at the variable production cost of water.

• **Apparent Losses—**These are "paper" losses that occur when water reaches a customer, but the volume is not accurately measured and/or recorded due to customer meter inaccuracy, systematic data handling discrepancies, or unauthorized consumption. Apparent loss is water that has been consumed but not paid for due to error in quantifying the volume of water. These losses cost water utilities revenue and understate the collective measure of customer consumption in the water utility's service area. Valued at the customer retail (revenue) rate, these losses are often very cost effective to recover.

• **Real Losses—**These are the "physical" losses, largely leakage, from the infrastructure: mains, valves, service lines, and tank overflows. Leakage occurrences are categorized as "reported" (visible) events or "unreported" (nonvisible—found only by active leak detection) events. Real losses occur prior to reaching customers and effectively force the water utility to treat and deliver more water than its customer population actually requires. These losses are typically valued at the variable production rate (costs for water treatment, pumping, or bulk water purchase); however, if the utility is experiencing a water shortage, then real losses may be valued at the customer retail rate because recovered leakage could be viewed as water that can be sold to customers.

Revenue Water: Revenue water consists of billed wholesale water exported and billed metered and unmetered water. These are usually the primary categories through which the utility can generate revenue.

Non-revenue Water: This term is the sum of apparent loss, real loss, and unbilled authorized consumption. Non-revenue water is clearly defined as all water for which no revenue is received.

2.0 STEPS OF WATER AUDIT

2.1 Water Supply and Usage Study

Water audit comprises of preparation of layout of water sources, distribution network, and service/delivery points to water users and return flow of waste or excess water. The layout should include locations and capacities of flow measurement devices installed at key points, dimensions of pipes and fittings in the water supply system, locations and particulars of flow control devices and history sheets of all measuring and control devices including pipes and fittings. A study of the availability of water sources and past consumption patterns for various sectors is necessary to understand the present water utilization and projecting future requirement. Data on development of sustainable source of water through rainwater harvesting and effluent recycling should also be taken into consideration.

2.2 Process Study

Flow measurement devices may be installed at all strategic points so that water losses from various components such as raw water source, conveyance system from raw water source to treatment plant, from treatment plant to treated water storage system, treated water storage system to distribution networks, individual users, etc. could be assessed at regular intervals. Such studies will also prove useful for future extension, renovation and modernization of the system. Water quality of the distribution system needs to be monitored regularly at strategic points to find out the level and nature of contaminants present in the supplied water. Depending on the types of application and degree of purity needed, the treatment system can be designed and developed. The water distribution system, leakage assessment etc. will form an integral part of this study.

2.3 System Audit

The current water usages and systems for water use under various sectors such as irrigation, industry and commerce, hydropower, domestic water supply, thermal power and others need to be studied to check their operational efficiency and level of maintenance. The scope for any modification or up-gradation will depend on the status of existing systems. Measurement methodology from the intake point of the system through various sub-systems to the ultimate user points needs to be verified periodically for its suitability, efficiency and accuracy. Bulk metering should be done at the source for zones, districts etc. and revenue metering for consumers. This will help in identifying the reaches of undue wastewater generation.

2.4 Discharge Analysis

The domestic wastewater, return flows from irrigation, and effluents from the industries need to be studied for conformity to environment standards, possibility of recovery of valuable by-products and the opportunity for recycling of waste water.

2.5 Water Audit Report

Adequate planning and standard procedures are necessary prior to undertaking the water audit of a system. A water audit can be accomplished on the basis of water allotted

for a service and water actually utilized for that service. After assessing the loss of water and the efficiency of the system, steps needed for utilization of recoverable water loss may be listed. A cost-benefit study for optimum recovery of water loss may be performed. A water audit report may, invariably, contain:

(a) Amount of water earmarked/made available to the service.
(b) Amount of water utilized both through metered and unmetered supplies.
(c) Water loss and efficiency of the system along with reasons for such losses.
(d) Suggested measures to check water loss and improve efficiency.

An effective water audit report may be purposeful in detection of leak in distribution system, taking timely action for plugging such leaks and thereby reducing conveyance losses of water and improving efficiency of the system. Water audit of the system should be undertaken at regular interval of time, at least on an annual basis.

3.0 IRRIGATION SECTOR

Irrigation is the major consumer of water, accounting for about 80 percent of the current level of total water utilization in the country. It is estimated that with increasing demand from other competing sectors, the availability of water for irrigation sector is likely to reduce progressively to about 70 percent in future. Irrigated agriculture is therefore, considered a thrust area for achieving maximum conservation in water use.

Water audit facilitates comparison between planned Irrigation System Performance (ISP) and actual ISP (ha/ M m3) realized on the project. This will provide information about loss of water in the system. Water audit thus helps in identifying the causes of low ISP & excessive losses in the system. Service Provider then can initiate the action for minimizing the losses and improving the ISP.

Water saving in irrigation sector is of paramount importance being the largest consumer of water. Methods like aligning cropping pattern with natural resource endowments, micro irrigation (drip, sprinkler, etc.), automated irrigation operation, evaporation-transpiration reduction, etc., should be encouraged and incentivized. Recycling of canal seepage water through conjunctive ground water use may also be considered.

3.1 Water Demand in irrigation sector,

Water demand is region specific depending upon the type of soil, cropping pattern/practices, climatic condition, etc. Irrigation water demand also depends upon the type of infrastructure, conveyance system, water application technique etc. Among various methods available for working out irrigation water demand, **Modified Penman Method*** is considered the most suitable and is recommended for assessing crop water demand.

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* "A Guide for estimating Irrigation Water Requirement" July 1984 of Water Management Division, Ministry of Water Resources, New Delhi

As a first step, crop evapotranspiration (Et Crop) is assessed. The crop water requirement can then be worked out, in consideration of percolation losses and other requirements like pre-sowing / land preparation, transplantation requirements etc., as applicable. The quantity of water actually used by the plants for their growth is termed as consumptive use. The Net Irrigation Requirement (NIR) is then worked out by deducting effective rainfall from the consumptive water use. The effective rainfall may meet only part of crop water demand. It may be insignificant in arid areas but may be a major portion in humid areas.

3.2 Irrigation Efficiencies

Even a marginal improvement in the efficiency of water use in irrigation sector will result in saving of substantial quantity of water which can be utilized either for extending the irrigated area or for diverting the saving to other sectors of water use.

3.2.1 Field Application Efficiency (Ef)

On application of water to fields, a part of it gets evaporated, another part goes as losses (run off, percolation loss, etc) and the remaining is used by the crops to meet evapotranspiration needs. Actual quantity of irrigation water required to be released at field head is called Field Irrigation Requirement (FIR). Field application efficiency (Ef) takes into consideration above losses in application of irrigation water and may be defined as ratio of Net Irrigation Requirement (NIR) over Field Irrigation Requirement (FIR) i.e. Ef =NIR/FIR The field application efficiencies considered for Irrigation Planning for ponded and non-ponded crops are,

(a) Ponded Crops 80% to 85%

(b) Non-ponded crops 65%

3.2.2 Conveyance Efficiency (Ec)

Conveyance Efficiency may be defined as a ratio of water released at the field head (FIR) to irrigation water needed to be released at the canal head. The quantity of water required to be released at the canal head is termed as Gross Irrigation Requirement (GIR). Therefore, Conveyance Efficiency (Ec) =FIR/GIR Depending upon the type of distribution system (lined, unlined, partially lined canal system) the following values for conveyance efficiency are taken for planning.

(a) For fully lined system 70% to 75%

(b) For partially lined system 65%

(c) For unlined canal system 60%

From the above relationship, Gross Irrigation Requirement (GIR) = FIR / Ec

The actual conveyance efficiency and actual conveyance loss can be worked out by taking measurement of the water released at the canal head (Gross Irrigation Requirement) and that at the field head (Field Irrigation Requirement). For more detail Guidelines for Computing the water use efficiency of the irrigation projects may be referred which are available on the CWC website.

3.3 Water Audit in Irrigation Sector

As one step ahead of performance evaluation studies and benchmarking of irrigation projects, water audit is required to be made applicable to all irrigation systems. The

measurement of water is essential for calculation of water losses during conveyance in canal and distribution network and also during application in the field. Some of the methods that can be used for measurement of actual quantity of water delivered are;

(a) Velocity Area Method
(b) Weir Method and
(c) Meter Flume Method.

Complete records of water withdrawn from the reservoir or the river system and of water that flows through the various branches, distributaries and other network channels and at outlets as well as water flowing through escapes are needed to be maintained. Simultaneously, record of rainfall, crops sown, area irrigated and depth of water provided are also required to be maintained. Actual conveyance and field application losses and efficiencies of an irrigation system can be calculated from such records.

Various proformae required for water audit in irrigation sector (as are in use by Govt. of Maharashtra) are given in **Annex-B**. Further details may be seen in the web site of Govt. of Maharashtra www.maharashtra.gov.in.

Analysis of the data collected as outlined in the performae will give the actual conveyance and field application efficiencies. These efficiencies are to be compared with the planned / achievable efficiencies to assess the scope for improvement. The corrective measures need to be taken accordingly.

3.3.1 Checking Water Account

State Government may enforce the field officers to submit the annual water accounts of all State sector irrigation projects under a circle in prescribed proformae by 14th August every year as being adopted by Govt. of Maharashtra. For effective implementation of the decision based on water audit analysis and timely publication of annual water audit report, a time-bound programme as mentioned below is framed & strictly adhered to.

On receipt of the water accounts, its scrutiny may be carried out in Water Audit Cells. While scrutinizing the water account of a project, emphasis shall be given on following points.

(i) Total available live storage is tallied with different water uses, evaporation losses, leakages, replenishment received in June and unutilised water at the end of irrigation year.
(ii) Season-wise availability and extent of water use.
(iii) Irrigation System Performance actual observed as compared to norms fixed by Government of Maharashtra.
(iv) Actual evaporation losses as compared to designed evaporation losses.
(v) Percentage of leakages through dam and its location, efforts taken by field staff to minimise or stop the leakages.
(vi) Actual season wise water use & area irrigated as compared to project planning / Preliminary Irrigation Programme

3.3.2 Inspection of Irrigation offices

To have a cross check over the data submitted in water account & to verify whether record about water storages, water use, different losses along with crop wise area measurements, revenue assessment/ revenue recovery are maintained up-to-date & in prescribed form, annual inspections of Irrigation offices is carried out each year. An annual inspection programme, for inspection of irrigation management divisions, shall be prepared and communicated to the field officers. According to this programme, inspections may be conducted. During such office inspections, to ascertain the validity of water account data submitted to Water Audit Cells the following records are to be checked.

(i) Daily lake level & water storage register.
(ii) Daily evaporation record register (Major & Medium projects)
(iii) Main Canal gauge register to evaluate water let out in canal for irrigation (daily, rotation-wise, season-wise)
(iv) Agency - wise non irrigation water use register.
(v) Register for leakages through dam.
(vi) Record of measurement of irrigated area
(vii) Crop-wise area assessed.
(viii) Revenue recovered

Revenue recovery being an important aspect of irrigation management, a review of revenue assessed, recovered, and balance at the end of the year is specially taken during such inspections. Preparation and sanction of Preliminary Irrigation Programme (PIP) before stipulated period, conducting meetings of canal advisory committee, timely and wide publicity to Public Notice, timely submission of rotation-wise water demands and water use by field offices to controlling authorities, daily gauging of discharges through distributaries/minors plays an important role in Irrigation Water Management of a project. Whether such procedure shall be followed or not is also verified by scrutinizing the relevant records during field office inspections. The lapses, deficiencies noted during the inspection are to be communicated to the concerned authorities for submitting relevant clarification and taking proper action for improvement in future.

3.3.3 Implementing Agencies

All State Governments should form Water Audit Cells under Monitoring Units in their Water Resources Departments. The Project Authorities will maintain the water account and Monitoring Unit of Irrigation/Water Resources Departments can be given the responsibility of carrying out the water audit. The number of projects to be audited by a Water Audit Cell may depend upon the size of the irrigation projects.

Government of Maharashtra has formed a 'Water Audit cell' to carry out water audit of more than 2000 projects and issued first report in this regard in March 2005. The reports published by Government of Maharashtra can be seen in the aforesaid web site www.maharashtra.gov.in.

It is advised that Water Audit exercise may be conducted annually by each State Government and the report may be placed before the standing committee for the Water Resources of the concerned state assembly.

3.4 Performance Indicators of Water Audit

The water audit method features a number of performance indicators that allow water utilities to reliably assess their water loss standing and track their performance. The performance indicators are designed specifically to

- track the water utility's progress on a year-to-year basis,
- set performance targets, and
- benchmark performance with other water utilities

Water Resources Department, Government of Maharashtra for water auditing of Major Irrigation Projects in its report of 2009-10 had used nine indicators, as mentioned below,

I. Water Availability in Reservoirs on 15th October

II. Percentage of Actual Evaporation to Live Storage

II (A) Percentage of Actual Evaporation to Projected Evaporation.

III. Target and Achievement of Irrigation Potential Utilisation

IV. Water Use Pattern

V. Irrigation System Performance (Canals)

VI. Percentage of Planned & Actual Non-Irrigation Use

VII. Percentage of Unutilized Water to Live Storage.

VIII. Conveyance efficiency of main Canals

IX. Actual cropping pattern

For Medium Irrigation Projects all above indicators except indicator number VIII & Indicator number II (A) were used for water auditing.

Looking at the number and availability of data, the analysis for Minor Irrigation Projects the following four indicators were used.

I. Water Availability in Tanks on 15th October.
II. Percentage of Actual Evaporation to Live Storage
III. Water Use Pattern
IV. Irrigation System Performance

4.0 DOMESTIC SECTOR

Domestic water is a basic need for human as well as livestock. The main objective of domestic water supply system is to provide safe and clean water in adequate quantity at reasonable cost to every household. For sustainability, the planning may be required at national level as a whole for policies and subsequently at state or region or at community levels. Lot of waste water is generated specially in urban areas. It is estimated that return flow from urban and rural uses is about 50% of supplies and pollute the very fresh water resources. It is expected that 85 percent of the return flow would go the surface water source and balance 15 percent to ground water source. There are considerable losses in the distribution system on account of leakages due to networks being old and poor maintenance in addition to lack of efforts towards conservation.

Urban water supply and sewage treatment schemes should be integrated and executed simultaneously. Water supply bills should include sewerage charges also.

4.1 Per Capita Water Requirement

The quantity of water required for domestic purposes depends mainly on habits, social status, climatic conditions and customs of the people. The per capita water requirement in urban areas is more than that in the rural areas. As per yardstick of the Union Ministry of Urban Development & Poverty Alleviation, water requirement for domestic purposes in urban areas is 40 litres per capita per day (lpcd) in case of supply through public stand posts and 70 lpcd in the case of supply through house service connections, where no sewerage system is existing or contemplated. Where sewerage system exists or contemplated, water supply would be 135 lpcd in the urban areas. In the case of metropolitan cities having population of more than 1 million, the domestic water supply would be 150 lpcd. Over and above the aforesaid demand, 15% losses may be allowed for determining the quantity of raw water required.

4.2 Transmission Losses

A study undertaken by the Ministry of Urban Development & Poverty Alleviation through NEERI, Nagpur has revealed that about 30 to 50% of the water produced and supplied in the cities goes as waste through leakages in the distribution system. About 80% of the aforesaid losses are estimated in the household connections due to worn out pipes etc. In view of this, the Ministry of Urban Development & Poverty Alleviation has emphasized the need for control of unaccounted supply of water (nonrevenue water) through leak detection programmes for identifying leakages and rectifying the same through suitable replacement of pipelines. A manual containing details of various aspects of O&M of water supply systems has been brought out by the Ministry of Urban Development & Poverty Alleviation recently.

4.3 Water Audit in Domestic Sector

In domestic water supply, water audit is considered very important, since treatment of water to bring it to drinking water standard costs a lot of money to the supplier. Water audit helps in determining the amount of water lost from a distribution system due to leakages etc. Water audit compares the amount of water supplied with the amount billed and accounts for the water loss.

4.3.1 Water Measurement

For the purpose of water audit, bulk metering system should be devised zone-wise, including group-consumer-wise in a system or a subsystem. This will facilitate identification of the reaches where actually the wastage of water is taking place. One can determine average daily water use by using one of the following two methods.

(a) Metered Water: In the case of metered water use, per capita per day consumption is to be obtained by dividing water usage by the number of days in the billing period and also by the number of residents of household.

(b) Unmetered Water: If water use is not metered, one must determine water use for each fixture. Flow rates for showers and faucets can be determined by using a container and stop watch to measure the amount of water discharged through the fittings in a minute. Toilet use per flush can be approximated by the capacity of the flushing tank. After determining the water use of each fixture, one will need to record the number of uses/ the length of time each fixture is used to determine average daily water use. Alternately, legitimate unmetered consumption can be worked out based on average domestic (metered) consumption per capita per day for consumers having similar water use habits plus an allowance for unmetered commercial consumption. A sample proforma for assessing water requirement for residential units is at Annex-C.

Distribution system characteristics vary and hence, each utility will have different challenges in performing the water audit. Each utility will need to decide how it can perform the audit accurately with the least cost. A worksheet should be developed, with a set study period. A study period should be set considering evaluation of the complete water system. Shorter periods might not give a complete picture of the water system, and longer periods can be difficult to manage. One year is recommended because 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. A set of model forms and instructions may be included that can be used if the utility does not choose to develop one. Records should be compiled and meters should be checked so that usages are recorded accurately. 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.

While making adjustments to metered amounts, all adjustments and how they were calculated should be properly documented. All records should reflect adjustments and

such adjustments should be verifiable. If adjustments are for significant amounts of water then necessary changes in the system should be made to eliminate need for such adjustments in the future. Adjustments could be known from the difference between storage in system at the beginning and that at the end of the study period. Some difficulty might be there in adjusting existing records to fit the study period. When meter-reading periods overlap, some adjustments will be necessary to represent the study period. Some flow records might have to be pro-rated so that all flow measurements reflect the same period. This should be done carefully to ensure the accuracy of the audit.

A preliminary audit should be undertaken to determine the amount of water loss. If water loss is significant, a more detailed study should be undertaken and accordingly measures should be taken to reduce the loss. A sample proforma for assessing water losses in domestic/industrial units is given as Annex-D.

In addition to the above, a more thorough or comprehensive audit would include the following:

(a) An inventory of meters.

(b) Analysis of water loss and methods to reduce the loss.

(c) Periodic checking for accuracy of meters.

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 supplement 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 implement 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.

4.4 Water Losses and Follow up

Water losses are losses in the distribution systems that are not due to authorized consumption. Water losses can be categorized as either apparent losses or real losses.

(a) Apparent Losses

Apparent losses are also referred to as commercial losses. This is because water that is lost in this way is water that could have been sold. Because of this, when doing financial calculations, this water should be priced at the retail rate. Examples of apparent losses include water theft, slow meters and billing issues. Specifically, apparent losses are comprised of:

1. **Unauthorized Consumption** – Typically, unauthorized consumption is considered

to be water theft. Examples include taking water illegally from fire hydrants, customer meter tampering, meter bypasses and illegal line taps. This value is low for most water systems. Unless the user has well validated data on unauthorized consumption, a value of 0.25% of the water produced from the users own sources can be used as a starting point for the audit.

2. Customer Meter Inaccuracies– Customer meters are quite accurate when they are new but as they age and they start to wear they begin to under-register. Meter inaccuracy can be further increased by water that is chemically aggressive. Customer meter inaccuracies are the apparent loss due to the collective under-registration of customer meters. Data should be entered as the percentage under-registration of billed& unbilled metered consumption. This percentage is often estimated. A value of 2.0% under-registration of billed metered consumption can be used as a starting point for the audit.

3. Systematic Data Handling Errors– These are errors that occur between when a meter is read and when a bill for that reading is sent to the customer. They are due to data handling and billing errors.

	Unauthorized Consumption
+	Customer Meter Inaccuracies
+	Systematic Data handling Errors
=	Apparent Losses

(b) Real Losses

Real losses are the water that is actually lost due to leaks. This leakage can occur as distribution and transmission leaks, storage leaks including overflow at water storage tanks and service connection piping leaks. All water systems have loss due to leakage. Preventing or repairing these leaks typically requires a water system to invest in a utility loss control program for the water system infrastructure.

	Water Losses
–	Apparent Losses
=	Real Losses

Non-Revenue Water (NRW)

Non-revenue water is water that is not billed and for which no payment is received. Non-revenue water can be the result of authorized consumption and from water losses, both apparent and real.

	Water Losses
+	Unbilled Metered
+	Unbilled Unmetered
=	Non Revenue Water

Among the benefits of NRW control initiatives are:

1. Reducing operating losses and improving revenue collection
2. Minimising unscheduled water supply disruption through water pressure control measures and close supervision of quality of work and materials
3. Increasing the efficiency of water supply distribution system management
4. Improving asset management and water supply network systems and their components through the use of latest hardware and software technology
5. Performing water audit as a tool for checking the overall performance of water supply activities
6. Determining capital expenditures.

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.

A worksheet for Water Audit, similar to an accounting spreadsheet, should be developed. Such an exercise makes the computations clear and simple and allows the utility to balance water supplied with water used. For balancing water in and out of the distribution system, the worksheet should list and account for various water usages. Worksheet may have adequate details of the distribution system. A more detailed worksheet will provide better understanding of the water usage and could be a useful tool for the service provider. For this purpose the worksheet used by Texas Water Development Board "Water Loss Audit Manual for Texas Utilities" may be used and the website http://www.twdb.texas.gov/publications/brochures/conservation/doc/WaterLossManual_2008.pdf may be referred.

5.0 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.

Growing population and rising standard of living of people are pushing up demand for quality industrial products at phenomenal pace. Thus the industrial requirement for water is increasing day by day. 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.

5.1 Water Consumption Trend in Industries

Indian industry is currently excessively dependent on fresh water and tends to dump its untreated waste into the rivers and groundwater. Overall, the water footprint of Indian industry is too high, which is bringing industry into conflict with other parts of the economy and society. There is huge scope for reducing the industrial water footprint and this can be done through technologies and investments, which have a very short payback period. Coal-based thermal power plants need massive amounts of water, both for cooling and ash disposal. In case of coastal power plants, the water requirement is normally met from the sea, but for inland TPPs, water is a far more critical issue.

The first step in this direction will be to make comprehensive water audits a recurring feature of industrial activity so that we know what is being used by the industrial sector at present and so that changes can be monitored and the most cost-effective basket of water efficiency technologies and processes designed and implemented to reduce water demand and increase industrial value added per unit of water consumed. We must make it mandatory for companies to include every year in their annual report, details of their water footprint for the year. Simultaneously, we must develop benchmarks for specific water use in different industries and would ensure their application in the grant of clearances for industrial projects.

5.2 Wastewater from Industrial Sources

In pace with the rise in industrial water requirement, wastewater from industries is also going up continuously. Discharge of effluents from the industries to water bodies pollutes enormously larger quantity of fresh water. Thus apart from taking measures for saving of water in industrial sector, apparently, there is a need for serious efforts to treat industrial effluents before their discharge to water bodies.

Out of the 192,804 MW with environmental clearance, about 138,000 MW or 72% are inland. TERI has estimated that in 1999–2001 out of a total of about 83,000 million litres per day (MLD) of water discharged by all the industries in India, about 66,700 MLD (~80 per cent) is cooling water discharge from thermal power plants. CSE puts the figure closer to 90%. During the same period, it was estimated that for every MW of power produced, Indian thermal power plants consumed about 8 times more water than those in developed nations. This is mainly attributed to the once-through cooling system (open loop system). Cooling towers and ash handling are the major water consuming areas and account for about 70 per cent of the water use within the plant. Comprehensive water audits conducted by TERI at some of India's largest thermal power plants revealed immense scope of water savings in the cooling towers, and ash handling systems. Once-through systems are becoming uncommon in the world. However, in India, many plants still operate the once-through cooling system. A rough estimate suggests that by converting all the thermal power plants in India to closed-cycle cooling systems, about 65,000 MLD of fresh water can be saved. The payback period for the proposed wastewater treatment and recycling system is less than 3 years. From a national perspective, where a large number of power plants other than NTPC still function on the

once-through cooling system, there is considerable scope to improve water-use efficiency and conserve water resources.

5.2.1 Estimation of Wastewater Generation

It is difficult to assess wastewater generation from industries on the basis of average generation of wastewater per product unit, mainly due to large variations in volume of wastewater generation per product unit. However owing to various constraints, present estimation of industrial wastewater is based on average generation of wastewater per unit product.

The volume of wastewater and concentration of various pollutants in industrial discharge vary depending on manufacturing processes and other factors such as housekeeping, reuse, technology, etc. Even for a given manufacturing process, the amount of wastewater generation depends on several factors, for instance:

(a) House- keeping practices;

(b) Extent of process control;

(c) Product quality requirements including packaging;

(d) Management systems & initiatives;

Housekeeping practices refer to simple measures such as arresting leaks from pipes, stopping of unnecessary overflows from the vessels, improving material handling procedures to reduce losses. Poor housekeeping results in significant generation of wastewater. Process control includes setting up of process parameters to optimum levels leading to best possible yields and minimum wastage of water. Product quality requirements refer to commercial specifications, which may vary depending on market. Achieving better quality generally requires additional processing and improved raw materials and thus may generate more wastes. The management systems include entire sequence of raw material processing, technology and production of finished product.

The total wastewater generated from all major industrial sources is 82446 million litres per day (MLD), which includes 68977 MLD of cooling water from thermal power plants. Out of the remaining 13469 MLD of wastewater, thermal power plants generate another 3242 MLD as boiler blow down water and waste-water from ash disposal. Process water and cooling water constitute 16% and 84% respectively of industrial waste water generation in India. Large & Medium Industries and Small Scale Industries generate 62% and 38% of Industrial Waste water (Process Water) respectively.

The following table shows industrial wastewater (process water) under various categories of industries.

SI. No.	Category of Industry	Waste Water generation in %age
1	Thermal Power Plants	24
2	Pulp and Paper	14
3	Engineering	32
4	Textile (Cotton	13
5	Steel	8
6	Others	9

The emphasis on curtailing wastage in handling and improvement in operation processes through better management can lead to minimization of wastes. Since all these factors vary from industry to industry and unit to unit, it is very difficult to precisely estimate the exact volume of wastewater. However, based on experience an average volume per unit product for a particular product can always be assessed.

5.2.2 Estimation of Water Pollution Load

The liquid waste generated by industrial sector can be classified into four categories as presented in the following table.

Classification of Industrial Discharge according to Nature of Pollutants

Nature of pollutants	Type of industries
Organic pollution	Distillery, Sugar, Tannery, Pulp and Paper Dairy, Coke-oven, Refinery and Food industry
Dissolved solids	Chemical industry, Fertilizer, Pharmaceutical, Pesticides
Toxic chemicals	Electroplating, Coke-oven, Tannery, Chemical industry, Pesticides, Pharmaceuticals, H-acid, G-acid plants, Dye and Dye intermediates
Cooling water	Thermal Power Plants, Cable, Rolling Mills, PVC and plastic mounting

Under small-scale category, the significant polluting industries are electroplating industries. The control of pollution from electroplating industries is not very effective as many of these industries are located in congested residential areas where land is not available for treatment of wastewater.

From pollution point of view, the major pollution in terms of organic load is generated from distilleries followed by paper mills. Since the distilleries generate highly concentrated wastewater, it is not easy to treat such wastewater. Despite the efforts on treatment of distillery waste, the targeted effluent quality is not achieved. The paper and board mills also generate heavy organic pollution load. A large number of paper mills are in small-scale sector, making it again difficult to manage the effluents, creating heavy pollution in many areas.

The industries generating chemical pollution can be divided into two categories-

a) those which generate high total dissolved solids (TDS) bearing wastes e.g. pharmaceuticals, rayon fibres, chemicals, caustic soda, soap and detergents, smelters' wastes, etc,
b) those which generate toxic wastes e.g. pesticides, smelters' wastes, inorganic chemicals, organic chemicals, steel plants, pharmaceuticals and tanneries' discharges, etc.

5.2.3 Recycling and 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.

5.3 Water Audit in Industries

Water Audit is a "Systematic Approach of Identifying, Measuring, Monitoring and Reducing the Water Consumption by various activities in an Industry". 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.

As one of the large users of this precious resource, industry has an important responsibility to practice water audit. Industries can realize many benefits from the practice of water audit. By reducing consumption of water, industries will not only effect saving but also protect the environment. Industrial effluents constitute a major source of polluted water and contain different kinds of toxic pollutants. Treatment of industrial waste water is necessary to lower the concentration of toxic pollutants to permissible limits. With the quality of water becoming poor, availability of fresh water is being scarce and statutory environmental regulations becoming more stringent, optimization in use of water calls for a closer monitoring by industrial sector. 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.

Industries in water short regions may be allowed to either withdraw only the makeup water or should have an obligation to return treated effluent to a specified standard back to the hydrologic system. Tendencies to unnecessarily use more water within the plant to avoid treatment or to pollute ground water need to be prevented.

Subsidies and incentives should be implemented to encourage recovery of industrial pollutants and recycling / reuse, which are otherwise capital intensive

Water audit is to be carried out annually. All industries should introduce water audit as a regular activity. Many industrial units have taken up such studies from economic point of view for improvement in efficiency (including improvement in efficiency of water use) and exploring possible areas of cost-savings. While carrying water audit following points may be considered;

(a) 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.

(b) 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.

(c) 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.

A sample proforma for assessing water losses in domestic/industrial units is given as Annex-D.

5.4 Research and Development

While water audit is a common and accepted practice internationally, it has started drawing the attention in India, recently. With water becoming more and more a valuable resource with every passing year, the need for water audit is bound to get increasing attention. The research efforts in industrial sector for water audit are required with orientation towards the following-

(a) Appropriation of technology to ensure efficient use of cooling and processed water;
(b) Development of pollution control mechanism;
(c) Development of appropriate cost effective technologies for treatment of wastewater for reuse;
(d) Development of cost effective technologies Thermal Power Plants for recycling of water;

6.0 WATER RATE

6.1 Rationalization of Water Rates

In several states the water rates have not been revised for a long time. Consequently the revenue collection is too meager to maintain the irrigation system. Thus, there is a dire need for rationalization of water rates so as to meet the expenditure on account of O&M of the system.

Instead of uniform water rate for all sectors of water use, there may be different water rates for different sectors of water use in consideration of priority of water allocation

advocated in the National Water Policy. Water rate for domestic water use may be minimum, followed by water rates for irrigation, power and industrial sectors in ascending order. Even in one sector of water use, various slabs of water rate may be decided to effort economy in water use. For instance in the case of domestic water use, a standard rate may be fixed for domestic water consumption as per prescribed norms. In the event of consumption per capita per month being less than the prescribed norms, a concession may be offered as an incentive to the consumers. Similarly, for higher levels of monthly water consumption different enhanced rate slabs may be thought of as is being practiced in energy sector to discourage misuse of water and effect water saving. Introduction of such a slab system of water rate in irrigation sector, apart from effecting water saving, may be considered as a deterrent for over-watering in head and middle reaches and thus may be helpful in equitable distribution of water between head, middle and tail reaches of an irrigation command. Such an idea may be extended to power and industrial sectors of water use as well. With such an approach of water rate, apart from saving in water use, discharge rate of industrial effluents is also expected to fall. Detailing of slab rate system for water use may be finalized at State level.

The following important aspects related to water pricing as per National Water Policy 2012 shall be used as guiding principle.

- Pricing of water should ensure its efficient use and reward conservation. Equitable access to water for all and its fair pricing, for drinking and other uses such as sanitation, agricultural and industrial, should be arrived at through independent statutory Water Regulatory Authority (WRA), set up by each State, after wide ranging consultation with all stakeholders.
- In order to meet equity, efficiency and economic principles, the water charges should preferably / as a rule be determined on volumetric basis. Such charges should be reviewed periodically.
- Recycle and reuse of water, after treatment to specified standards, should also be incentivized through a properly planned tariff system.
- The principle of differential pricing may be retained for the pre-emptive uses of water for drinking and sanitation; and high priority allocation for ensuring food security and supporting livelihood for the poor. Available water, after meeting the above needs, should increasingly be subjected to allocation and pricing on economic principles so that water is not wasted in unnecessary uses and could be utilized more gainfully.
- Water Users Associations (WUAs) should be given statutory powers to collect and retain a portion of water charges, manage the volumetric quantum of water allotted to them and maintain the distribution system in their jurisdiction. WUAs should be given the freedom to fix rates subject to floor rates determined by WRAs.
- The over-drawal of groundwater should be minimized by regulating the use of electricity for its extraction. Separate electric feeders for pumping ground water for agricultural use should be considered.

CHAPTER –II
WATER CONSERVATION

1.0 INTRODUCTION

Rapid industrialisation and urbanization coupled with continuous decline in per capita water availability is putting a lot of pressure on the available water resources in the country. As per report of standing sub-Committee for assessment of availability and requirements of water for diverse uses in the country (August, 2000) the future water requirements for meeting the demands of various sections in the country for the year 2025 and 2050 have been estimated to be 1093 BCM and 1447 BCM respectively. The increasing gap between water availability and demand highlights the need for conservation of water. The National Water Policy 2012 also lays stress on conservation of water. It has been stipulated that efficiency of utilization in all the diverse uses of water should be optimised and an awareness of water as a scarce resources should be fostered.

There is a need for water conservation, not only to restore the fast deteriorating eco-system of the country but also to meet the inevitable emergency of shortage even for drinking and domestic water in near future. The following points are to be pondered upon to plan strategies to meet the crisis:-

1. Water is a finite resource and cannot be replaced/ duplicated.
2. Water resources are theoretically "renewable" through hydrological cycle. However, what is renewable is only the quantity, but pollution, contamination, climate change, temporal and seasonal variations have affected the water quality and reduced the amount of "usable water".
3. Only 2.7% of the water on earth is fresh.
4. As per Ministry of Rural Development, 182 districts (972 blocks) comprising an area of 7,45,914 sq.km have been covered under ‘Drought Prone Areas Programme’.
5. About 310 blocks in the country are over-exploited where ground water is withdrawn more than its replenishment from rainfall.
6. The ground water levels have declined by more than 4 meters in 40 districts of 16 states in the country during last decade.
7. Rainfall is highly unevenly distributed over time and space in various parts of the country.
8. About 87.2 Billion Cubic Metre (BCM) of surplus monsoon runoff is available in 20 river basins of the country, out of which 21.4 BCM can be recharged to ground water reservoirs.
9. Increased demand in coastal areas is threatening the fresh water aquifers with seawater intrusion.
10. In inland saline areas, the fresh water is becoming saline due to excessive withdrawal of ground water.
11. Water conservation practices in urban areas can reduce the demand as much as by one third, in addition to minimizing pollution of surface and ground water resources.

12. Watershed programmes tended to concentrate on harvesting rainwater through surface structures. There is a need to look at surface and ground water holistically and prepare a conjunctive use plan.

1.1 Action Plan for Water Conservation

1.1.1 Conservation of Surface Water Resources

A large number of dams have been constructed in the country to store rainwater. At the end of XII Plan, 4877 large dams creating live storage capacity of 253.38 BCM have been constructed and 313 large projects are ongoing, which will add another 50.96 BCM on completion.

All efforts have to be made to fully utilize the monsoon runoff and store rainwater at all probable storage sites. In addition to creating new storages it is essential to renovate the existing tanks and water bodies by desilting and repairs. The revival of traditional water storage techniques and structures should also be given due priority.

The Scheme for Repair, Renovation and Restoration (RRR) of Water Bodies during the XII Plan has been approved by Government of India and the new Guidelines were circulated to all the State Governments. Under the scheme, about 10,000 water bodies having a Culturable Command Area (CCA) of 6.235 lakh hectare at a cost of Rs. 10,000 crore would be covered. Out of 10,000 water bodies, 9,000 water bodies will be in rural areas and balance 1,000 water bodies will be in urban areas.

1.1.2 Conservation of Ground Water Resources

Groundwater is an important component of hydrological cycle. It supports the springs in hilly regions and the river flow of all peninsular rivers during the non-monsoon period. For sustainability of ground water resources it is necessary to arrest the ground water outflows by

(a) Construction of sub-surface dams
(b) Watershed management.
(c) Treatment of upstream areas for development of springs
(d) Skimming of freshwater outflows in coastal areas and islands.

1.1.3 Rainwater Harvesting

Rainwater harvesting is the technique of collection and storage of rainwater at the surface or in sub-surface aquifers, before it is lost as surface runoff. Ground water augmentation through diversion of rainfall to sub-surface reservoirs, by various artificial recharge techniques, has special relevance in India where due to terrain conditions most of the rain water is lost as flash floods and local streams remain dry for most part of the year. Central Ground Water Board has identified an area of about 4.5 lakhs sq. km in the country, which shows a declining trend in ground water levels and needs urgent attention to meet the growing needs for irrigation, industry and domestic purpose. It is estimated that in these identified areas of water scarcity, about 36.1 BCM of surplus monsoon surface runoff is available which can be fruitfully utilized to augment the ground water

resources. A twin strategy of adopting simple artificial recharge techniques in rural areas like Percolation Tanks, Check dams, Recharge Shafts, Dugwell Recharge and Sub-surface dykes and adopting Roof top rainwater harvesting in urban areas, can go a long way in redeeming the worsening situation of shortage of groundwater. About 2.25 lakhs artificial recharge structures in rural areas and about 37 lakhs Rooftop rainwater harvesting structures in the cities are feasible. The design and viability of various low cost structures have been demonstrated by CGWB by undertaking 174 schemes throughout the country under the Central Sector Scheme "Study of Ground water Recharge". Rainwater harvesting has to be taken up in a big way to solve the crisis of water scarcity.

Uncovered areas, particularly in urban and semi-urban localities, are continuously diminishing due to phenomenal pace of industrialization and urbanization and massive use of concrete all around in the country. This phenomenon is constantly causing reduced scope for percolation of rain waters to the ground during monsoon and thus perpetual reduction in ground water recharge year after year. With a view to offset this loss in recharge of groundwater there is apparent need for making roof rainwater harvesting mandatory, either through legislation or by promulgating ordinance, for every public as well as private new and existing buildings in urban and semi-urban areas within specified time frame. Apart from this, harvesting of surface runoff in open areas, both public and private, may also need to be encouraged. Some of the benefits of rainwater harvesting are as follows:

i. Increases water availability.
ii. Checks the declining water table
iii. Improves the quality of ground water through the dilution of fluoride, nitrate and salinity.
iv. Prevents soil erosion and flooding especially in urban areas.
v. Is environmentally friendly.

1.1.4 Protection of Water Quality

The rapid increase in the density of human population in certain pockets of the country as a result of urbanisation and industrialization is making adverse impact on the quality of both surface and ground water. Demand for water is increasing on one hand and on the other hand the quantity of "utilizable water resources" is decreasing due to human intervention in the form of pollution of fresh water. Thus the protection of existing water resources from pollution is a very vital aspect of water conservation.

1.1.5 Cleaning up of Polluted Rivers, Lakes and Water Bodies

Rivers, lakes and ponds and other water bodies are the main sources of water on which civilization grows and develops. Water bodies get polluted as a result of human interference and unplanned developmental activities. The main reason for pollution is discharge of untreated domestic and municipal waste and also the industrial waste. The

cleaning up of these water bodies is of utmost importance to provide water supply to the population on the one hand and on the other hand to maintain the environment to the desired level. The action points in this regard are as follows:-

1. To control and check the flow of pollution to the rivers, lakes and ponds through appropriate measures/action.
2. Treatment of effluent up to the appropriate standard before discharging into the rivers.
3. Proper maintenance and uninterrupted operation of the sewage treatment plant
4. System of incentive and dis-incentive for discharging pollutants / untreated waste into the rivers.
5. Adopting remedial measures in the particular river stretch where the problem is acute;
6. Adopting appropriate technology for removal of pollution from lakes and reservoirs
7. Declaring particular site/location as water heritage site and adoption by different organizations / departments for maintaining the same to the desired standard.

On account of continuous discharge of industrial effluents in water bodies like rivers, canals, lakes, ponds etc and contamination of ground water aquifers with pullulated waters, these water bodies at places have become polluted to an enormous extent and apparently huge financial resources are needed for decontaminating them. This suggests for taking stringent measures like imposition of huge penalty for abusing such water bodies, cancellation of license or permission for operation of water polluting industrial units. Pollution Control Boards at Central and State levels may be provided legal powers through legislation to deal with such delinquent agencies and industrial units. Sensitizing general public and involvement of non-governmental organizations with requisite experience and interest in implementation of legislation for control of pollution of water bodies may also prove useful and effective. Media has also a very vital role to enact by way of highlighting lapses on the part of individuals and industrial units. Traditionally, in India, rivers are revered as Goddess. With time, such a feeling has started diluting. People, particularly young generation, may be inculcated to bestow respect to rivers and other water bodies to strengthen this traditional belief of sacred status of rivers and streams and maintain their aesthetic values through mass awareness.

1.1.6 Ground Water Protection

Ground water resources are getting polluted at an alarming pace due to lack of proper wastewater and sewerage disposal system in urban areas. The application of excessive fertilizers in agriculture sector and disposal of hazardous effluents from the industries are putting great strain on availability of fresh water. The action points to safeguard the water bodies may be as follows:-

1. Use of organic fertilizers should be encouraged to protect ground water from pollution due to excessive use of chemical fertilizers. Ground water vulnerable zones may be identified by preparing vulnerability maps for physical, chemical and biological contaminants for the whole country.

2. Notification on banning industries, landfills and disposal sites of industrial effluents and sewerage, which are hazardous to ground water aquifer systems.

3. Devising ground water solute transport model for contaminants plume migration studies.

4. Research and Development studies for corrective action techniques on polluted aquifers.

1.1.7 Water Conservation Practices

Water conservation can be accomplished broadly by:-

A. Water Resources Development Structures
B. Efficient Water use practices
C. Catchment Area Treatment

A) Water Resources Development Structures

Watershed programme could lead to overall development of villages. If the land and water resources are properly managed at the village itself, it will help to improve the agricultural production, livestock development etc. There is considerable scope for developing the water resources in the watersheds by construction of percolation tanks, ponds in the gully beds, reservoirs, check dams, nala bunding, submergence tanks, gully plugging, wells, tube wells, silt retention structures, farm ponds etc. Usefulness of various structures in this regard is discussed below:-

i) Small Reservoirs

Construction of small reservoirs in the watersheds of Relmajra (Punjab), Sukhomajri (Haryana), Wagarwadi of Maharashtra, Kothakota and Veeravanka in Andhra Pradesh, Ramnagar of Udhampur (Jammu and Kashmir) to store excess runoff in the beds of the torrents to control flash floods, recharge ground water, save the land downstream from erosion have been a great success. At some watersheds, the water could be stored in rainy season and utilized in the drought year thus providing irrigation to wheat. One of the serious problems being faced by Punjab and Haryana is the receding water table in shallow tube wells, recharge of ground water is extremely essential in this situation. For these purpose small reservoirs in the hilly areas even if they had not stored water for irrigation will be of immense help to the population.

ii) Percolation Embankment

For water development and reducing the runoff, many percolation embankments are constructed to harvest water from their catchments. These embankments provided very effective for controlling flash floods and probably recharging ground water and saving large areas of cultivated land from flooding and gully formation.

iii) Diversion Drain

Diversion drain to divert water from hilly areas is an important component of watershed management. Though at many places, the terrain was such that diversion drains would have proved useful but these were constructed at a few places. In all these places watershed diversion drains provide useful in controlling runoff of water from hilly areas and avoiding flooding of the cultivated area**.**

iv) Gully Plug

It is observed that gully plugs have been taken up at a number of places viz, Badhkhera in Rajasthan, Salaiyar in Tamil Nadu, Aganpur- Bhagwasi in Punjab, Umsiang and Middle Rongre in Meghalaya, Upper Swarna Rekha in Jharkahnd with the objective of stabilizing the gullies and increasing the recharge of ground water. These were effective only when well designed and a series of these were constructed at appropriate intervals.

v) Submergence Bunds

This is a unique practice particularly in Bundelkhand zone of MP and UP. In this case, water from large area is retained by constructing big dikes or dams at lower elevation to submerge large areas upstream. The main objective of this bund is to recharge profile in relatively high water holding capacity soils so that the success of rabi crops is assured.

vi) Check Dams

Check Dams across the gullies of nala bundies have been constructed at many watersheds to harvest and store excess runoff of water and reused the same for raising the crops either in rainy season itself or in the post rainy season. Spillways are generally provided. These structures proved useful in providing direct irrigation or in recharging the ground water and other soil conservation measures resulted in increasing number of tube wells and dug wells.

vii) Percolation Tanks

Harvest and storage of excess runoff of water in the low rainfall areas helps in recharging of the ground water and as such the tanks are termed as percolation tanks.

viii) Farm Ponds

These were constructed in few places, mainly in the very dry areas. These proved to be useful for providing drinking water and water for live stock in the watersheds like Badhkhera in Rajasthan, Bajni in Madhya Pradesh. At some watershed farm ponds has been used to raise the vegetable crops using the stored water.

ix) Nala Bundies

Nala bundies is a variation of small reservoirs but help in recharging the ground water.This has been successfully adopted in Wagarwadi watershed of Maharashtra. This programme will be particularly useful in areas of relatively high rainfall where crop suffers from excess water and other moisture stress. These natural nalas can serve both as drainage and irrigation channel.

x) Submergence Tank

In submergence tanks, the rain water is stored from every field by constructing big dykes across the drain lines.

xi) Dug out ponds/Tanks

The dugout ponds/ tanks have been used for recharge of ground water and for direct irrigation. This programme helps mainly farmers who own relatively small holdings.

B) Efficient Water Use Practices

India faced with the problems both of drought and floods often at the same location. The distribution of rainfall is so variable with respect to time and space that its management would require considerable effort. The efficient water use practices play an

important role in water conservation in a particular area. Some of the practices adopted for water conservation are discussed here below:

i) Application of water by Sprinkler and Drip Irrigation Methods

In order to conserve water, sprinkler irrigation is the best method to use on soils that have steep slopes, undulating or irregular topography and on soils that are too shallow to level. It is difficult, however, to sprinkle irrigate if water intake rate of soils is less than 4mm/hr. Drip irrigation method is a more recent type of pressurized irrigation method which is widely practiced in the developed countries and is being introduced in arid and semi-arid zones where water scarcity is major problem, compared to the sprinkler irrigation method, the drip methods operate on much lower line pressure, thus providing or saving in energy requirement. A recent approach is mixing of fertiliser with the irrigation water which is then delivered to the crops/plants through drip irrigation and has been termed as fertigation. This is an efficient method of delivering fertiliser and water to the plant with minimum wastage. A detailed note on drip and sprinkler system is given at Annexure-I

ii) Miscellaneous in-situ moisture conservation Practices

Present research has shown that the best possibility of moisture conservation lies in controlling the portion of the precipitation that normally runs off from land. Effecting the prolonged detention of surface water on the land, increases the amount of water entering the soil. The effective methods in dry farming areas are:-

a) Contour cultivation
b) Formation of basins, furrows, random tie ridges, broad based ridges and furrows.
c) Crop ploughing in both red and black soils when the rainfall is less than 750mm.
d) Formation of drainage channel in black soil areas

iii) Intelligent Irrigation Scheduling:

Performance of an irrigation system is judged by the level of water control it offers and the rehabilitation/modernisation apart, efficient management operation and management of the system is the key. Irrigating crops in the command, strictly conforming to the required frequency and duration has potential of enhancing water use efficiency in irrigation sector.

iv) Optimal utilisation of ground water- conjunctive use

In conjunctive situations, gravity canals when integrated with micro-irrigation, recharge aquifer, uniform water spread in much larger area the command and avoids ground water pumping involving heavier cost and thereby improve overall on-farm energy balance as also raises the water-table.

v) Minimisation of losses due to evaporation

For crop irrigation, optimum water efficiency means minimising losses due to evaporation, runoff while maximising production. Evaporation losses can be minimised by making the reservoir deep or by using chemicals which reduce the rate of evaporation.

C) Catchment Area Treatment

The Centrally Sponsored Programme of Soil Conservation in the Catchments of River Valley Project &Flood Prone River (RVP&FPR) is being implemented through Micro Management of Agriculture (MMA) since November 2000. The main objectives of the programme are:-

I. Prevention of land degradation by adoption of a multi-disciplinary integrated approach of soil conservation &watershed management in catchment areas.

II. Improvement of land capability and moisture regime in the watersheds.
III. Promotion of land use to match land capability.
IV. Prevention of soil loss from the catchments to reduce siltation of multipurpose reservoirs.
V. Afforestation.

Presently this programme is being implemented in 60 catchments all over the country. In this programmes all type of lands viz, agriculture, waste and forest are treated in an integrated manner with suitable packages of treatment viz Construction of Contour Vegetative Hedge, Contour Graded Bunding, Horticulture Plantation, Staggered Trenching, Sowing and planting of plant, Pasture Development and Drainage Line Treatment. The Evaluation studies revealed that watershed inventions have been found very effective in prevention of land degradation and water conservation. The main findings were:-

i) Increase in agricultural yield
ii) Increase in cropping intensity
iii) Reduction in sediment production rate
iv) Reduction in peak rate of runoff
v) Increase in groundwater recharge

2.0 ACTION POINTS FOR WATER CONSERVATION

An important component of water conservation involves minimizing water losses, prevention of water wastage and increasing efficiency in water use. "Resource saved is resource created" should be kept uppermost in mind. The action points towards water conservation in different sectors of water use are listed below:

2.1 Irrigation Sector

Important action points towards water conservation in the irrigation sector are as follows:

1. Performance improvement of irrigation system and water utilization;
2. Proper and timely system maintenance;
3. Rehabilitation and restoration of damaged /and silted canal systems to enable them to carry designed discharge;
4. Selective lining of canal and distribution systems, on techno economic consideration, to reduce seepage losses;
5. Restoration / provision of appropriate control structures in the canal system with efficient and reliable mechanism;
6. Conjunctive use of surface and ground water to be resorted to, specially in the areas where there is threat to water logging;
7. Adopting drip and sprinkler systems of irrigation for crops, where such systems are suitable;
8. Adopting low cost innovative water saving technology;
9. Renovation and modernization of existing irrigation systems;

10. Preparation of a realistic and scientific system operation plan keeping in view the availability of water and crop water requirements;
11. Execution of operation plan with reliable and adequate water measuring structures.
12. Revision of cropping pattern in the event of change in water availability;
13. Utilisation of return flow of irrigation water through appropriate planning;
14. Imparting trainings to farmers about consequences of using excess water for irrigation;
15. Rationalization of water rate to make the system self-sustainable;
16. Formation of Water Users Associations and transfer of management to them;
17. Promoting multiple use of water;
18. Introducing night irrigation practice to minimize evaporation loss;
19. In arid regions crops having longer root such as linseed, berseem, lucerne guar, gini grass, etc may be grown as they can sustain in dry hot weather;
20. Assuring timely and optimum irrigation for minimizing water loss and water-logging;
21. Introducing rotational cropping pattern for balancing fertility of soil and natural control of pests;
22. Modern effective and reliable communication systems may be installed at all strategic locations in the irrigation command and mobile communication systems may also be provided to personnel involved with running and maintenance of systems. Such an arrangement will help in quick transmission of messages and this in turn will help in great deal in effecting saving of water by way of taking timely action in plugging canal breaches, undertaking repair of systems and also in canal operation particularly when water supply is needed to be stopped due to sudden adequate rainfall in the particular areas of the command.
23. With a view to control over irrigation to the fields on account of un-gated water delivery systems, all important outlets should be equipped with flow control mechanism to optimize irrigation water supply.
24. As far as possible with a view to make best use of soil nutrients and water holding capacity of soils, mixed cropping such as cotton with groundnut, sugarcane with black gram or green gram or soyabean may be practised.
25. It has been experienced that with scientific use of mulching in irrigated agriculture, moisture retention capacity of soil can be increased to the extent of 50 per cent and this in turn may increase yield up to 75 per cent.

2.2 Domestic & Municipal Sector

Important action points for water conservation in domestic and municipal sector are as under:-

1. Action towards reduction of losses in conveyance;
2. Management of supply through proper meter as per rational demand;
3. Intermittent domestic water supply may be adopted to check its wasteful use.
4. Realization of appropriate water charges so that the system can be sustainable and wastage is reduced;
5. Creation of awareness to make attitudinal changes;
6. Evolving norms for water use for various activities and designing of optimum water supply system accordingly;

7. (a) Modification in design of accessories such as flushing system, tap etc. to reduce water requirement to optimal level;
   (b) Wherever necessary, BIS code may be revised;
8. (a) Possibility for recycling and reuse of water for purposes like gardening, flushing to toilets, etc. may be explored;
   (b) Wastewater of certain categories can be reused for other activities as per feasibility;
9. Optimum quantity of water required for waste disposal to be worked out;
10. In public buildings the taps etc. can be fitted with sensors to reduce water losses;

2.3 Industrial Sector

Important action points for water conservation in industrial sector are given below:-

1. Setting-up of norms for water budgeting;
2. Modernization of industrial process to reduce water requirement;
3. Recycling water with a re-circulating cooling system can greatly reduce water use by using the same water to perform several cooling operations;
4. 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 24 traditional chemical treatment and should be considered as an option for increasing water savings in a cooling tower.
5. The use of de-ionized water in reusing can be reduced without affecting production quality by eliminating some plenum flushes, converting from a continuous flow to an intermittent flow system and improving control on the use.
6. The reuse of de-ionized water may also be considered for other uses because it may still be better than supplied municipal water.
7. The wastewater should be considered for use for gardening etc.
8. Proper processing of effluents by industrial units to adhere to the norms for disposal;
9. Rational pricing of industrial water requirement to ensure consciousness / action for adopting water saving technologies;

3.0 REGULATORY MECHANISM FOR WATER CONSERVATION

Groundwater is an unregulated resource in our country with no price tag. The cost of construction of a groundwater abstraction structure is the only investment. Unrestricted withdrawal in many areas has resulted in decline of groundwater levels. Supply side management of water resources is very important for conserving this vital resource for a balanced use. An effective way is through energy pricing restriction on supply and providing incentives to help in conservation of water. Action plan, in this regard, may include the following:-

1. Rationalizing pricing policy of water in urban and rural areas. Industries should be discouraged to exploit ground water with high price slabs.

2. Restriction on new construction of ground water structures in all the over exploited and dark blocks of the country;
3. Metering of all ground water abstraction structures;
4. Controlled supply of electricity and downsizing of pump capacity in rural areas;
5. Regulating the water trading or selling;
6. Providing incentives for adoption of rainwater harvesting;
7. Modification in building bye-laws in urban areas to make it mandatory to adopt rainwater harvesting. Action has been initiated by Delhi, Andhra Pradesh, Gujarat, Haryana, Karnataka, Kerala, Maharashtra, Rajasthan, Tamil Nadu and Uttar Pradesh in this respect. Other States are required to take initiatives in this regard.

4.0 MASS AWARENESS

Water conservation is a key challenge, which requires public participation. Mass awareness on the need for water conservation and providing common tips to effectively participate in this important mission is need of the time. The simple information on typical use of water for domestic purpose and how to save water under this sector, as given below, may help in creating awareness.

Typical Use of Water

Drinking	4%
Drinking Cooking & other kitchen uses	8%
Personal hygienic	29%
Washing clothes	10%
Toilets flushing	39%
House cleaning/gardening etc.	10%

Saving of Water

What we do	**What should be done**	**Saving of water**
Bathing with Shower 100 litre	Bathing with Bucket 18 litre	82 litre
Bathing with running water 40 litre	Bathing with Bucket 18 litre	22 litre
Using old style flush in Latrines 20 litre	Using new style flush 6 litre	14 litre
Shaving with running water 10 litre	Shaving by taking water in mug 1 litre	9 Litre
Brushing teeth with running water 10 litre	Brushing teeth by taking water in mug 1 litre	9 Litre
Washing clothes with running water 116 litre	Washing clothes with bucket 36 litre	80 litre
Washing Car with running water 100 litre	Washing car with wet cloth 18 litre	82 litre
Washing floor with running water (15'x 10') 50 litre	Washing floor with wet cloth 10 litre	40 litre (per 150 sq.ft. area)
Washing hands with running tap 10 litre.	Washing hands with mug 0.5 litre	9.5 litre

Electronic and print media, posters, stickers, handbills, etc may be used liberally to inculcate sense of responsibility and belongingness for precious natural resource water among various sections of society. Small documentary films, in regional languages, on importance of water and techniques to be adopted for water saving and water conservation may be telecast periodically from regional television channels to create awareness among countrymen particularly people living in rural areas.

4.1 Tips for Conserving Water for Domestic and Municipal Use

- Timely Detection and repair of all leaks;
- Turning off water tap while brushing teeth;
- Use of mug rather than running water for shaving;
- Avoiding / minimising use of shower/bath tub in bathroom;
- Turning off faucets while soaping and rinsing clothes;
- Avoiding use of extra detergent in washing clothes;
- Using automatic washing machine only when it is fully loaded;
- Avoiding use of running water while hand-washing;
- Avoiding use of running water for releasing ice tray ahead of time from freezer;
- Using smaller drinking glasses to avoid wastage;
- Using over flow stop valve in the overhead tanks to check over flow of water;
- Turning off the main valve of water while going outdoor;
- Avoiding use of hose for washing floors; Use of broom may be preferred;
- Minimizing water used in cooling equipment by following manufacturer's recommendations;
- Watering of lawn or garden during the coolest part of the day (early morning or late evening hours) when temperature and wind speed are the lowest. This reduces losses from evaporation.
- Avoiding use of excess fertilizers for lawns in view of the fact that application of fertilizer increases the requirement of water in addition to polluting the groundwater.
- Planting of native and/or drought tolerant grasses, ground covers, shrubs and trees. Once established, they do not need to be watered as frequently and they usually survive a dry period without much watering.
- Grouping of plants based on water needs while planting them;
- Turning off water tap a little before watering time so as to use full water available in hose;
- Avoiding over watering of lawns. A good rain eliminates the need for watering for more than a week.
- Setting sprinklers to water the lawn or garden only, not the street or sidewalk;
- Avoiding installation or use of ornamental water features unless they recycle the water and avoiding running them during drought or hot weather;
- Installation of high-pressure, low-volume nozzles on spray washers;
- Replacement of high-volume hoses with high-pressure, low-volume cleaning systems;
- Equipping spring loaded shutoff nozzles on hoses;

- Installation of float-controlled valve on the make-up line, closing filling line during operation, provision of surge tanks for each system to avoid overflow;
- Adjusting flow in sprays and other lines to meet minimum requirements;
- Washing vehicles less often, or using commercial car wash that recycles water;

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. This may be made mandatory. Similarly, water harvesting through storming of water runoff including rainwater harvesting in all new building on plots of 100 sq. m and above may be made mandatory.

4.2 Tips for Conserving Water for Industrial Use

- Using fogging nozzles to cool product;
- Installing in-line strainers on all spray headers; regular inspection of nozzles for clogging;
- Adjusting pump cooling and water flushing to the minimum required level;
- Determining whether discharge from any one operation can be substituted for fresh water supply to another operation;
- Choosing conveying systems that use water efficiently;
- Handling waste materials in a dry mode wherever possible;
- Replacing high-volume hoses with high-pressure, low-volume cleaning systems;
- Replacing worn-out equipments with water-saving models;
- Equipping all hoses with spring loaded shutoff nozzles – it should be ensured that these nozzles are not removed;

- Instructing employees to use hoses sparingly and only when necessary;
- Turning off all flows during shutdowns unless flows are essential for cleanup - using solenoid valves to stop the flow of water when production stops (the valves could be activated by tying them to drive motor controls);
- Adjusting flow in sprays and other lines to meet minimum requirements;
- Sweeping and shovelling may be practiced instead of hosing down the floors;
- Making an inventory of all cleaning equipments, such as hoses in the plant - determining how often equipments are used and whether they are water-efficient;
- Washing cars, truck and bus fleets less often;
- Cleaning driveways, loading docks, parking areas or sidewalks with water may be avoided - using sweepers and vacuums may be considered;
- Avoiding runoff and making sure that sprinklers cover just the lawn or garden, not sidewalks, driveways, or gutters;
- Watering on windy days may be avoided as far as practicable;

It is imperative that users from all sectors of water use, stakeholders including state and central governments, agencies, institutions, organizations, non-governmental organizations, municipalities, village panchayats, public sector undertakings and other such bodies directly or indirectly involved in planning, development and maintenance of

water resources projects and providing services to the users, may need to be involved for making integrated and continuous efforts for creating mass awareness towards importance of saving and conservation of water, and duties and responsibilities of individuals as well as of organizations and institutions towards judicious and optimal use of water.

4.3. Water Users' Association (WUA) and Legal Empowerment

Water Users' Association, though relatively a new concept in the country but is prevalent in some states in irrigation sector. It is considered that involvement of farmers in water management will facilitate equitable and judicious allocation of irrigation waters among farmers of head, middle and tail reaches and improves collection of water charges from users. It is felt that with improvement in collection of water charges, irrigation projects may not languish for maintenance for want of funds and in this way overall efficiency of irrigation systems will improve. This will help saving of water and optimum utilization of water.

Such a concept i.e. involvement of Users in the distribution and management process may also be extended in domestic and industrial sectors of water use. It has been observed that in adverse situation of water supply to domestic sector, when supply is not adequate to meet demand, some residents use water pumps in water supply lines to boost supplies in their dwellings and thereby causing hardship to other residents of the locality. Illegal tapping of water from supply lines or lifting water of canals are also prevalent at places. It has also been observed that inhabitants, in general, are less sensitive to leakage or water loss from the system. Similarly in case of industrial sector, it is not very uncommon to discharge untreated or partially treated industrial effluents in water bodies like rivers, lakes, ponds, canals etc. including ground water aquifers. Water Users Associations in domestic and industrial sectors of water use may address these issues and may help in conservation of water and control pollution of water bodies from industrial pollutants. Water Users Associations may be duly empowered through legislation or promulgation of ordinance to punish errant water users.

Annex-A

Summary of Recommendations of National Workshop for Water Audit and Water Conservation Organized at New Delhi on 30th January 2004

Water is a precious natural resource. Its limited availability and increasing demand prompted for drafting 'Guidelines for Water Audit and Water Conservation'. These were deliberated upon in a national level workshop organized at New Delhi in January, 2004, jointly by Central Water Commission and Central Ground Water Board. Senior level officers from various States, Central Ministries and NGOs attended the workshop. Recommendations emerged in the seminar are as given below:

I. Water Audit

(i) Water audit is an important management tool for effective conservation of water. Broadly water audit should be conducted categorically in two systems, resource audit or supply side audit and the other one as consumption audit on demand side. All efforts should be made for improvement of not only water use efficiency and distribution system, but also on the efficient development and management of the source of water.

(ii) It has been strongly advocated that the water audit system needs to be framed and incorporated in every significant water resources project as a routine exercise during operation and maintenance of the project by the project authorities. A separate cell may be constituted for this purpose. This is as per suggestion of Govt. of Maharashtra. They have established a separate Chief Engineer's Office for this purpose.

(iii) The periodicity of water audit and its report may be determined in advance at the commencement of commissioning the project by the project authority and the concerned Governments and appropriate provision of fund may be made for its implementation. In general, it may be carried out annually.

(iv) The recommendations in the water audit report for corrective measures of the system may be considered on priority for implementation by the competent authority. All efforts should also be made to provide all technical and financial provisions in a time bound manner.

(v) The irrigation sector utilizes about 83% of water as a major stakeholder. Due to the thrust on account of rapid urbanization and modernization, the demands for domestic and industrial uses are progressively increasing, thus creating a situation of competing of demands from value added sectors of water use and threatening irrigation sector even in maintaining current level of water use whereas more water is needed for growing more to meet the demand of growing population. A systematic comprehensive water audit will be very useful in bringing out the trend of changes on demand and supply scenario which will help in deciding the methodology for improving the efficiency of the system by adopting conjunctive use of surface and ground water, application of modern irrigation techniques including drip and sprinkler irrigation wherever feasible and other improvised agricultural devices in addition to development of wasteland and waterlogged areas.

(vi) Due to over exploitation of ground water, the water table at vulnerable places like thickly populated urban areas are depleting at very fast rate. Private tube wells are mushrooming

without control, to meet the growing demand. Industries should be discouraged to exploit ground water on their own. As far as possible supplies to industries should be from surface water and if ground water supply is considered essential, it should be managed by a Government Agency. There is general apathy towards conjunctive use of ground water and surface water. Specific water audit needs to be conducted on regular basis for realistic assessment of ground realities and initiating remedial measures under the umbrella of holistic approach.

(vii) Pollution level of fresh surface water and ground water resources are alarmingly increasing due to excessive use of pesticides and fertilizers in agriculture and discharge of untreated waste by industries and sewage disposal leading to health hazards and scarcity of fresh water. Water audit from this angle needs to be conducted strategically and periodically. The existing laws regarding pollution control need to be strictly observed by not only imposing penalties but also restricting the polluters.

(viii) To prevent wastage of water, pricing of water for irrigation, domestic and industrial uses needs to be revised and updated periodically so that subsidy is phased out as quickly as possible and at least operation and maintenance cost is recovered for sustainability of the system. Further, gradually the pricing of water at flat rate system needs to be replaced by actual cost rate by volume. The differential pricing system should also be suitably introduced keeping in view the socio-economic aspects of the people and the region in addition to their life style and ethnic background.

(ix) Benchmarking system of various suitable parameters for all sectors of water use may be developed and introduced for optimizing and enhancing the efficiency of the system. It is an effective tool for water audit and measurement of relative performance and suggests ameliorative measures for performance improvement.

(x) To identify source of water loss due to leakage, the approach of bulk metering system should be installed at various well defined macro and micro systems like various zones, districts, towns, colonies and even large group-consumers to single unit consumers so that water audit can be effectively conducted.

II. Water Conservation

(i) Water Conservation is prime and challenging concern. Numerous types of water conservation techniques are available in the country. The scientists constantly innovate the new techniques, but there is a gap on the application of the appropriate technologies, which needs to be removed. Due to lack of proper operation and maintenance in irrigation, industry and domestic water distribution system, there is huge loss of water. Hence it is emphasized to improve the O&M system.

(ii)For developing the water resources, age-old traditional water conservation methods need to be judiciously adopted in conjunction with the latest modern conservation technology. Keeping this in view, rain water harvesting, revival of traditional water storages, check dams and other similar structures need to be adopted. Building byelaws should be suitably modified to introduce mandatory roof top rain water harvesting.

(iii) In order to conserve precious fresh water, recycling of waste water may be incorporated wherever feasible. Dual water supply system, one for treated wastewater and the other for fresh water may be introduced so that treated waste water can be used for secondary purposes such as toilets flushing, gardening, agriculture and selective industries etc. New urban colonies, big hotels industries and other similar establishments should have mandatory dual water supply systems.

(iv) Cropping pattern and crops water requirement varies from time to time due to the dynamic socio-economic condition of the people and the region in addition to geo-morphological, climatic and metrological changes. Hence, for effective management, appropriate base line data for water demand under different situations needs to be brought out for optimum crop water management and field activities considering effective rainfall in different physiological stages.

(v)Night irrigation practice may be introduced to minimize evaporation loss thus conserving irrigation water. Timely and need based irrigation should be done to minimize loss of water. Further, for boosting productivity, rotational cropping pattern may be introduced for balancing fertility of soil and natural pest control.

(vi) Various water savings devices are being developed under various ongoing R&D Programmes. These devices may be suitably adopted in the system.

(vii)Strategic mass awareness campaign should be conducted regularly to cover all stakeholders, including service providers and consumers, for water conservation in irrigation, domestic and industrial sectors. Special attention must be given so that the fruits of the campaign must reach the children, housewives and farmers effectively.

Annex-B

Various proformae as being used by Government of Maharashtra for carrying out Water Audit in Irrigation Sector

Proforma-I

Water Demand

Name of Project/Canal Section

Irrigation Year Sub-Division

Name of Section	Area expected to be irrigated			Projected consumption ha/Mcum	Requirement of water for section Mcum	Remarks
	Seasonal ha	Perennial ha	Total ha			
1	2	3	4	5	6	7

Note: The requirement of water shall be calculated from the projected consumption values of ha/Mcum (in Col. 5) or as per the directives issued by the Govt. from time to time.

Proforma-II

Water Indent

Name of Project/Canal Section

Irrigation Year Sub-Division:

Type of irrigation	Area expected to be irrigated			Projected consumption ha/Mcum	Requirement of water for section Mcum	Remarks
	Seasonal ha	Perennial ha	Total ha			
1	2	3	4	5	6	7
A) Flow Irrigation 1. Direct Outlet 2. Minors 3. Distributaries 4. Others						
Total (A)						
B) Lift Irrigation 1. Reservoir 2. Canal 3. River/Nalla 4. Well						
Total (B)						
Total (A+B)						

Note: The requirement of water shall be calculated from the projected consumption values of ha/Mcum (in Col. 5) or as per the directives issued by the Govt. from time to time.

Section Officer

------- Section

Proforma-III

Daily Discharge Drawn by Various Sections

Name of Project/Canal Section

Irrigation Year Sub-Division:

(Discharge in Cumec)

Date	Discharge drawn at head of subdivision	Discharge drawn by various sections of a sub-division				Utilisation of Water				Remarks
		Sect. 1	Sect. 2	Sect. 3	Sect. 4	For irrigation use	For non irrigation use	Let into tail tank or escape	Total (Col. 7 to 9)	
1	2	3	4	5	6	7	8	9	10	11

Sub-Divisional Engineer ……..Sub-Division

Proforma-IV

Discharge Drawn at Various locations of canal

Name of Project/Canal Section

Irrigation Year Sub-Division:

Date	Time	Reservoir			Pickup weir		Discharge let out in Right/Left Bank Canal		Discharge at various locations in cumec				For non irrigation use	Tail/feeder tank			Discharge of Channel off-taking from tail/ feeder tank
		R.L.	Storage	Discharge released	Gauge	Storage	Gauge	Discharge	Gauge @ RD	Gauge @ RD	Gauge @ RD	Gauge @ RD		Discharge of Tail Canal	Depth	Storage	
		m	Mcum	cumec	m	Mcum	m	Cumec	Cumec	Cumec	Cumec	Cumec	Cumec	Cumec	m	Mcum	Cumec
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Note: Separate sheets for Left and Right bank canal to be used.

Sectional Officer

Proforma-V

Water Used and Area Irrigated (Sub Division)

Name of Project/Canal — Section
Irrigation Year — Sub division:

Name of Section	Type of Irrigation	Water used by Section		Area Irrigated				Area irrigated ha/ Mcum (8/4)	Remarks
		Day cumec	Mcum	Seasonal	Perennial	Others	Total		
1	2	3	4	5	6	7	8	9	10
	Flow Irrigation								
	1. Direct Outlet on main canal								
	2. Distributaries/Branch								
	3. Minors								
	4. Others								
	Total (A)								
	B) Lift Irrigation								
	1. Reservoir								
	2. Canal								
	3. River								
	4. Well								
	Total (B)								
	Grand Total (A+B)								

Note: Separate sheet to be used for each section under the Sub-Division.

Sub-Divisional Engineer ……..
Sub-Division

Proforma-VI

Water Used and Area Irrigated (Section)

Name of Project/Canal
Irrigation Year

Section
Sub division:

(Area in ha)

Type of Irrigation	Water used by Section		Area Irrigated				Area irrigated ha/ Mcum (7/3)	Remarks
	Day cumec	Mcum	Seasonal	Perennial	Others	Total		
1	2	3	4	5	6	7	8	9
Flow Irrigation								
1. Direct Outlet on main canal								
2. Distributaries/Branch								
3. Minors								
4. Others*								
Total (A)								
B) Lift Irrigation								
1. Reservoir								
2. Canal								
3. River								
4. Well								
Total (B)								
Grand Total (A+B)								

*Includes irrigation on percolation.

Sectional Officer
……. Section

Proforma-VII

Discharge letout through scouring sluices or escapes (Sub Division)

Name of Project/Canal — Sub division :

Irrigation Year — Division

Item	Section 1	Section 2	Section 3	Section 4	Section 5	Remarks
1	2	3	4	5	6	7
1) Date & time of opening						
2) Date & time of closing						
3) Duration in days						
4) Discharge in cumec						
5) Day cumec let out (3x4)						
6) Quantity in Mcum						
7) Total quantity let out from all sluices/escapes (Mcum)						
8) Total quantity used as obtained from column 4 of proforma III (Mcum)						
9) Percentage of wastage (item 6x100)/ item 7						

Sub-Divisional Engineer

……..Sub-Division

Proforma-VIII

Discharge letout through scouring sluices of escapes (Section)

Name of Project/Canal — Section

Irrigation Year — Sub division:

Unit : mm

Item	Location of scouring sluice or escape			Remarks
	R.D.	R.D.	R.D.	
1	2	3	4	5
1) Date & time of opening				
2) Date & time of closing				
3) Duration in days				
4) Discharge in cumec				
5) Day cumec let out (3x4)				
6) Quantity in Mcum				
7) Total quantity let out from all sluices/escapes (Mcum)				
8) Total quantity used as obtained from column 4 of proforma III (Mcum)				
9) Percentage of wastage (item 6x100)/ item 7				

Proforma - IX

Rainfall/Evaporation (Sub Division)

Name of Project/Canal
Irrigation Year

Sub division:
Division

Unit : mm

	Recording Station					
	Rainfall	Evaporation	Rainfall	Evaporation	Rainfall	Evaporation

Note: Rainfall data of nearest rain gauge station or meteorological laboratory should be recorded.

Sub-Divisional Engineer
……..Sub-Division

Proforma - X

Rainfall/Evaporation (Section)

Name of Project/Canal
Irrigation Year

Sub division:
Division

Unit : mm

	Recording Station					
	Rainfall	Evaporation	Rainfall	Evaporation	Rainfall	Evaporation

Note: Rainfall data of nearest rain gauge station or meteorological laboratory should be recorded.

Section Officer
…….Section

Proforma XI

Annual Water Account for Major and Medium Projects

Water Year: Name of Circle: Name of Division:	

Project No….

District Taluka Sub-basin No. Name of project Type of Project (Major/Medium)
1. Designed storage a. Gross b. Live c. Carry over
2. Maximum Live Storage observed in the year **3. Actual live storage as on attained** a. 1st July b. 15th October c. 1st March 4. Water remained unutilized by 30th June 5. Replenishment received in June
6. Reasons for unutilisation
7. Projected Water use in Mcum for …… **a. Irrigation** 1. Kharif 2. Rabi 3. Hot weather 4. Perennial **b. Non Irrigation** 1. Industries 2. Domestic c. Evaporation
Total (7a+7b+7c)
8. Lifts 9. Evaporation Losses 10. Leakages through dam
11. Water drawn at canal head for irrigation in Mcum for….. a. Kharif b. Rabi c. Hot weather
Total (11a+11b+11c)

12. Water lifted from reservoir (Mcum) **a. Irrigation** **b. Non Irrigation** 1. Industries 2. Domestic
Total (12a+12b) in Mcum
13. Water released through escapes 14. Evaporation from reservoir 15. Water lost through leakages from dam a. Quantity b. Percentage
16. Total utilisation + Losses (11+12+13+14+15) in Mcum
17. Area Irrigated in ha. **a. By flow irrigation** 1. Kharif 2. Rabi 3. Hot weather
Total 17a(1+2+3)
b. By lift irrigation
Total 17(a) + 17(b)
18. Area irrigated on Wells/Rivers/Drains in influence area
19. Water use efficiency (ha/Mcum): Col. 17 (a+b) + Col. 18 /Col. 16
20. Remarks:

Proforma XII

Annual Water Account for Minor Irrigation Projects Water Year:

Water Year:
Name of Circle:
Name of Division:

Project No….

District Taluka Sub-basin No. Name of project
1. Designed storage a. Gross b. Live **2. Maximum Live Storage observed in the year**
4. Water drawn at canal head for irrigation in Mcum for …… a. Kharif b. Rabi c. Hot weather
Total (4a+4b+4c)
5. Lifts 6. Evaporation Losses 7. Leakages through dam
8. Total (3+4+5+6+7)
9. Actual Area Irrigated for…….. a. Kharif b. Rabi c. Hot weather
Total Area Irrigated (9a+9b+9c)
10. Non irrigation use 11. Water remained unutilized on 30th June 12. Water use efficiency (ha/Mcum) – (Col. 9/ Col. 8)
13. Remarks

Name of Circle: Name of Division: Project No…. District Taluka Sub-basin No. Name of project 1. Designed

Proforma XIII

Water Auditing

I Records

1. Project wise/Village wise/Outlet wise GCA/CCA/ICA Register
2. Water Application Register
3. Month wise Water Use
4. Gauge Register
5. Register of Note Books
6. Panchnama Register
7. Register of Complaints
8. Plantation Register
9. Register of Non-irrigation use

II Water use

1. Reasons for difference, if any, in water demand and use
2. Method of measuring the quantity of water

III Measurement of crop area

1. Whether Programme of Crop Measurement is approved by EE
2. Whether date of first watering intimated to the measurer?
3. Whether measurements are checked by the SO, DE and EE
4. Area of unauthorized Irrigation, if any

IV Assessment & recovery

1. Season wise assessment of area irrigated
2. Whether area assessed & entries in note books are checked
3. Whether rates are checked by competent authority

V Water Account

1. Whether water account is maintained in prescribed proforma
2. Whether water use efficiency (Ha/Mcum) is assessed properly?

VI Lift Irrigation

1. Mode of measurement of water
2. Register of sanctions of lifts
3. Whether deposit amount is recovered from all schemes
4. How many schemes could not function in prescribed time limit? What action is taken in this respect
5. Whether all functioning schemes are having their agreements?
6. Whether register of details of lifts is maintained?
7. Whether register of details of lifts on notified rivers/nallas is maintained?

VII Conjunctive use of water

1. Whether register of wells in the jurisdiction of section is maintained?
2. Whether entry of newly dug wells is taken in it?
3. Whether area under well irrigation is recorded?

VIII Water Users Associations (WUAs)

1. Whether the WUAs provide water to non-members?
2. Whether WUAs' accounts are audited timely?
3. Whether year-wise entries of grants are maintained?
4. Whethers elections of WUAs are held timely

IX Maintenance & Repairs

1. Whether pre and post monsoon inspections of canal are carried out? Whether any major defect is observed? What corrective measures are suggested?
2. Action taken for maintenance & repairs of canals and all the control structures

X Miscellaneous
1. Details of Public Notices
2. Abstract of water applications
3. Register of rainfall and evaporation
4. Register of losses due to natural calamities
5. Whether Irrigated area is checked by the EE during inspection? and how much?
6. Whether and unauthorized irrigation was observed? What action is taken?
7. Whether diaries (10 days) are submitted by the canal inspectors?
8. Whether office inspection of canal inspectors is done by the section officer?
9. Whether revenue from fruit bearing trees is collected regularly?
10. Whether Notice board is available?
11. Whether copy of Irrigation Act is available in section office?
12. Whether details of standing crops are submitted?
13. Measures being taken for enhancing Government revenue
14. Whether any water logged/salt affected area is observed?
15. Measures adopted for promoting modern methods of irrigation
16. Trainings, Demonstrations, Study tours conducted
17. Whether surprise checks are made for the accounts of Section/Sub Division

Annex- C

DOMESTIC WATER AUDIT

Assessment of water requirement for residential Units

Number of persons / user in the residential unit =

SI No.	Fixture	Measurement of Water Uses per Residential Unit					
		Rate of Discharge (litre / min)	Average Duration of Use (min)	Average Quantity per Use (litre)	No. of Uses (No.)	Total Daily Use (litre)	Per Capita Daily Water Use (litre)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Kitchen faucet						
2	Utility faucet-1						
3	Utility faucet-2						
4	Bathroom faucet-1						
5	Bathroom faucet-2						
6	Bathroom faucet-3						
7	Other faucet-1						
8	Other faucet-2						
9	Shower-1						
10	Shower-2						
11	Shower-3						
12	Toilet-1						
13	Toilet-2						
14	Toilet-3						
15	Washing Machine						
16	Dish washer						
17	Others						
TOTAL							

Annex-D

DOMESTIC AND INDUSTRIAL WATER AUDIT

Assessment of Water Losses in industrial/domestic units

Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
WATER DELIVERED													
1. Total Water Supply to Distribution System													
2. Adjustments to Water Delivery													
3. Net Water Produced													
WATER USED													
4. Metered Water Supplied													
Residential													
Commercial													
Industrial													
Institutional													
Other													
Total													
5. Billed Unmetered Sales													
6. Unbilled Authorized Consumption													
Water Main Lines Flushing													
Sewer/Storm Drain Flushing													
Parks/Playgrounds/Swimming Pools													
Golf Courses													
Cemeteries													
Road													
Medians													
Schools													
Training/Fire Fighting													
Construction													
Storage Tank													
Sewer Plant													
Total													
7. Apparent Water Losses													
Water Meter Malfunction													
Theft													
Other													
Total													
8. Real Water Losses													
Leaks													
Storage Overflow													
Other													
Total													
9. Net Loss of Unmeasured Water													
10. Percentage of Loss of Unmeasured Water													