



CRBOM Small Publications Series No. 22

Water auditing in Maharashtra

by

B A Chivate

**Center for River Basin Organizations and Management,
Solo, Central Java, Indonesia**

May 2010

The '*Small Publications*' are intended for knowledge-sharing and dialogue. In some cases they may present facts, information and lessons learnt. In other cases, they provide news, opinions, ideas or open questions for discussion.

They express the opinions of the author(s) and not those of CRBOM.

They can be freely copied and disseminated.

Contributions are welcome, in English or in Bahasa Indonesia.

The author:

Er. B A Chivate,
Maharashtra Water Resources Development Centre, Aurangabad
bac_chivate@yahoo.co.in

CRBOM
Center for River Basin Organizations and Management,
Solo, Central Java, Indonesia
www.crbom.org
info@crbom.org

Contents

Acknowledgement	i
Location map	ii
Acronyms and abbreviations	iii
Glossary	iii
Summary	iv
1 Introduction	1
2 Maharashtra at a glance	1
3 Water auditing - what, why and how?	2
4 Approach	3
4.1 Guidelines for efficient and economical use of water	3
4.2 Coverage	3
4.3 Data flow	3
4.4 Indicators	4
4.5 Schedule	6
4.6 Inspection of irrigation offices	6
4.7 Dissemination of results	7
5 Observations	7
5.1 General	7
5.2 Water availability, water utilization and system performance	8
5.3 Recommendations based on the results	8
6 Conclusion	9
References	9

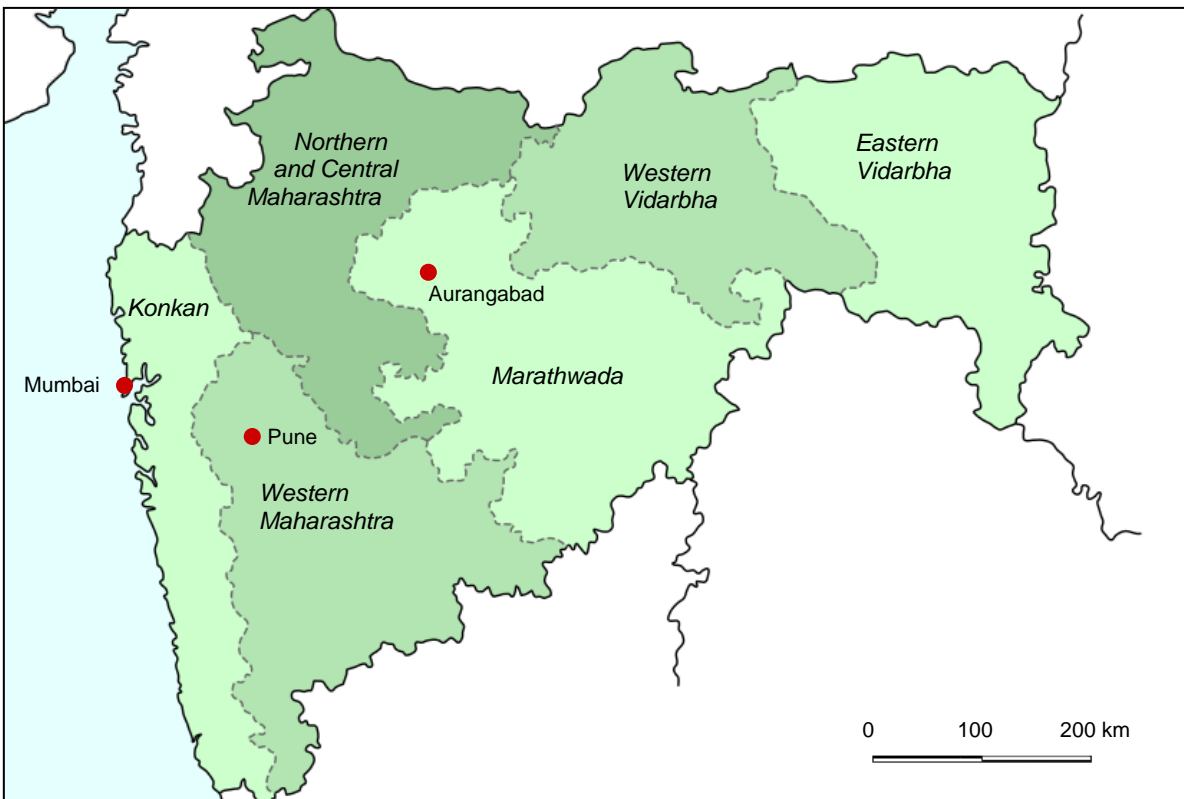
Appendices

1 Water uses in Maharashtra	10
2 Guidelines for water auditing	11

Acknowledgement

This paper is based on work conducted and reported by Office of the Chief Engineer, Maharashtra Water Resources Development Centre, Aurangabad; and Water Resources Department, Government of Maharashtra, Mumbai.

Location map



Acronyms and abbreviations

GOI:	The (central) Government of India
GOM:	The (state) Government of Maharashtra
ISP:	Irrigation system performance (ha per Mm ³)
O&M:	Operation and maintenance
Mha:	Million hectares; 1 Mha = 10,000 km ²
Mm ³ :	Million cubic metres
MWRD:	Maharashtra Water Resources Department
MWRDC:	Maharashtra Water Resources Development Centre
PIP:	Preliminary Irrigation Programme
WUA:	Water user association

Glossary

Dry season (in Maharashtra): November/December to March/April

Hot weather season (or pre-monsoon season) (in Maharashtra): March-April to May; the cropping season lasts to June/July

Irrigation potential: The area covered by irrigation infrastructure (whether used or not)

Irrigation potential utilization: The area where the irrigation infrastructure is actually used

Kharif (rainy) cropping season (in Maharashtra): June to November/December

KT weir (Kolhapur type weir): A type of weir used for in-stream storage in small rivers. It has gates that are opened during the monsoon and closed at the end of the monsoon

Monsoon (in Maharashtra): The southwest monsoon occurs in June-September, and the northeast monsoon in October-December

Non-irrigation water uses can be domestic and/or industrial

PIP (Preliminary Irrigation Programme): The annual plan for water availability and allocation for a specific irrigation scheme

Rabi (spring crop) (in Maharashtra): October/November to January/March

Wet season (in Maharashtra): June/July to September/November

Summary

Monitoring of irrigation systems can highly contribute to returns on the substantial investments in their construction, operation and maintenance.

Maharashtra has an area of 307,780 km², of which 225,000 km² is cultivable. 20 percent of the cultivable area is served by irrigation infrastructure.

The State applies water auditing (since 2003/04) and performance benchmarking of irrigation systems (since 2001/02).

The water auditing is based on between 10 and 4 indicators (depending on the size of the scheme), and is presently covering 2,110 schemes. The auditing provides a highly valuable guidance and directions at the scheme level, as well as at the national level of management.

Methodologies, findings and related observations are comprehensively reported and published on the Internet.

The present paper describes the water auditing and makes some observations on approach and benefits. Related benchmarking modalities are described in a separate paper.

1 Introduction

Irrigation is the major off-stream water user in many Asian river basins - the present allocation in Maharashtra is between 70 and 75 percent, which is less than the demand. Making good use of the available water is a critically important management task, and even more so when the resource is finite. Also, irrigation infrastructure is expensive, and the returns on the investments must be monitored and optimized.

In support of these good purposes, the government of Maharashtra has successfully implemented annual auditing of irrigation systems since 2003-04 as one of its sector improvement programmes.

The present paper describes the procedures and exemplifies the findings.

Maharashtra's equally successful benchmarking of irrigation systems is described in a separate paper (Chivate, May 2010).

2 Maharashtra at a glance

The area of Maharashtra is 307,780 km², of which 225,000 km² is cultivable. The population is around 115 million.

The State features a coastal plain, about 50-80 km across, in front of the Western Ghats. The Ghats form one of India's main watersheds. Inland of the Ghats is the Deccan plateau.

The State as of today came into existence in 1960. At the time, the increasing population was facing shortage of food grains, and there was a need to increase the agricultural production. Priority was given to agricultural development and to irrigation development with a high efficiency.

A major challenge facing the Water Resources Department of the Government of Maharashtra is to assure that the area served by irrigation infrastructure is actually cultivated. This requires efficient utilization of the available water, and the Water Resources Department has concentrated its efforts in that direction.

Numerous irrigation projects have been constructed in Maharashtra to tap the water resources of the state. An irrigation potential to the tune of 4.5 Mha has been created (by mid 2008) through 71 major, 243 medium and 2,940 minor state sector irrigation schemes.¹ During the last five years the irrigation potential utilization status has increased from 1.7 Mha to 2.7 Mha.

¹ Major: More than 10,000 ha; minor: Less than 2,000 ha

3 Water auditing - what, why and how?

Water auditing is a systematic and scientific examination of the water accounts of a project, conducted as a well-informed and critical examination by an independent organization.

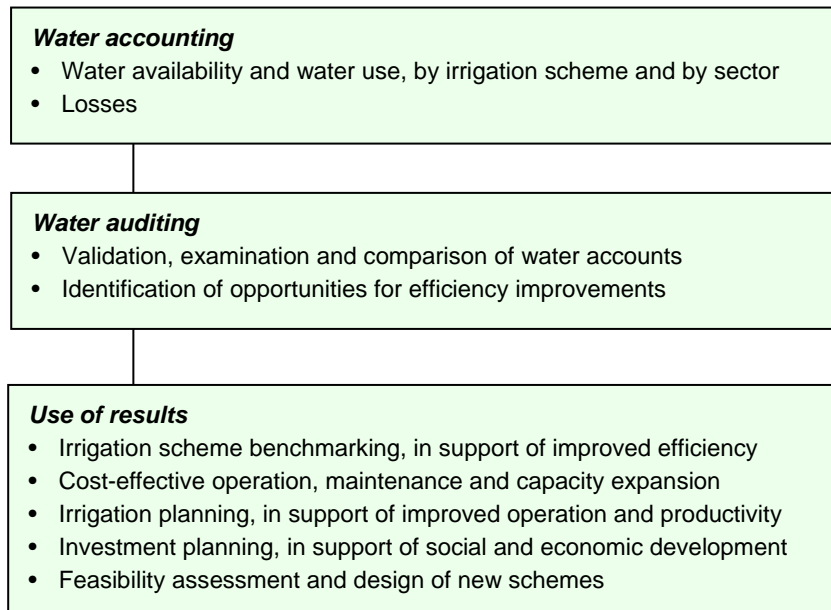
A water audit determines the amount of water used in different sectors, losses from the distribution system due to leakages, and the costs related to the losses. A comprehensive water audit provides a detailed profile of the distribution system and the water uses, thereby facilitating effective management of resources and an improved reliability.

It also provides knowledge about the present performance of the system in support of decisions on expansion.

Water auditing is based on water accounting and provides, in turn, the basis for benchmarking of irrigation systems, as well as well-informed operational irrigation planning and strategic investment planning.²

Water auditing thus helps in identifying the causes of low performance and excessive losses. The service provider can then initiate appropriate action for improvement.

Figure 1: Water accounting and water auditing



4 Approach

Maharashtra was the first state in India to include water auditing in its State Water Policy and has practised water auditing since 2003-04.

4.1 Guidelines for efficient and economical use of water

In December 2005, the Central Water Commission, Ministry of Water Resources, GOI & The Central Ground Water Board issued guidelines for water auditing. These guidelines are only indicative and cover a broad spectrum. Every state is required to prepare its own guidelines considering its particular conditions and requirements.

Accordingly, from time to time, the Government of Maharashtra issues guidelines for efficient and economical use of water for irrigation. A list of such guidelines is attached as Appendix 2.

The guidelines provide consistency and transparency to the process. This assures valid comparisons between schemes and over time, and facilitates the understanding of the results.

4.2 Coverage

The number of audited schemes are as follows:

Year	No. of schemes
2003-04	1,229
2004-05	1,624
2005-06	1,957
2006-07	1,971
2007-08	2,007
2008-09	2,110

During 2008-09, water audits were made of 53 major projects (with 74 reservoirs), 194 medium projects (with 196 reservoirs), and 1,863 State sector minor projects.

The distribution of projects according to water availability is as follows:

Table 1: Classification of irrigation schemes according to water availability

Plan group	Water availability	Major	Medium	Minor	Total
	<i>m³/ha</i>				
Highly deficit	Below 1,500	01	35	352	388
Deficit	1,501-3,000	12	65	595	672
Normal	3,001-8,000	25	48	556	629
Surplus	8,001-12,000	03	28	146	177
Abundant	Above 12,000	12	18	214	244
Total		53	194	1863	2110

4.3 Data flow

A total of 9 proformas are used for the records of water accounting. Proforma 1 to 5 are applied by section offices and sub-division offices. These are then compiled in division offices for individual irrigation schemes.

On the basis of these records the annual water accounts are prepared: ³

- Proforma 6 (A): Annual water account, reservoirs
 Proforma 6 (B): Annual water use, area irrigated & ISP
 Proforma 6 (C): Annual irrigated area by crop and by water source (canal, reservoir, lift, river, wells)
 Proforma 6 (D): Water account of KT weirs
 Proforma 7: Water account of minor irrigation schemes

4.4 Indicators

A distinction is made between major, medium and minor projects.

Indicators used in 2008-09 are shown in the table below.

Table 2: Indicators used for auditing (2008-09)

No.	Indicator	Application		
		Major projects	Medium projects	Minor projects
I.	Water availability in reservoirs/tanks 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 utilization	√	√	
IV.	Water use pattern	√	√	√
V.	Irrigation system performance (for canals)	√	√	√
VI.	Percentage of planned and actual non-irrigation use	√	√	
VII.	Percentage of unutilized water to live storage	√	√	
VIII.	Conveyance efficiency of main canals	√		
IX.	Actual cropping pattern	√	√	

Indicator I: Water availability in reservoirs on 15 October

The availability of water in the reservoirs depends on the rainfall, upstream storages, and watershed development works. Moreover, for major reservoirs, which perform as flood control measures also, some storage capacity must be retained for flood retention.

Indicator II: Percentage of actual evaporation to live storage on 15 October

The evaporation in Maharashtra is high due to a hot and arid climate. The evaporation further depends on the shape (notably the depth) of the reservoir.

Indicator III: Target and actual irrigation potential utilization

The water availability for irrigation during a particular year depends on the actual inflow to the reservoir; non-irrigation allocations; silt accumulation in the reservoir; etc. For optimum and economical use of water, a Preliminary Irrigation Programme (PIP) is

³

Government circular dated 14.09.2005

prepared with provisions for non-irrigation uses and assumptions on evaporation losses. The area that can be irrigated with the available storage is decided in the PIP. Many projects see a reduced availability of water for irrigation due to increased non-irrigation uses. Naturally it becomes important to see whether at least the area targeted in the PIP is actually irrigated or not. If the achievement is on the lower side, the causes must be determined in support of improved planning and/or improved performance.

Indicator IV: Water use pattern

The major projects in the State are constructed as multipurpose projects. As per Maharashtra State Water Policy 2003, water supplies for domestic purpose and industries take priority above irrigation. Due to growing population, urbanization and industrialization, the demand for water for non-irrigation uses is increasing. Due to lowering of ground water table, many rural water supply schemes are also being planned with reservoirs as their raw water source.

Secondly, the actual cropping pattern can very well be different from the forecast.

Monitoring of the actual water use pattern in different projects provides insight in the demands of the different uses.

Indicator V: Irrigation system performance (ISP) (for canals)

A distinction is made between supplies from canals and supplies from wells because these have different management implications.

In Maharashtra, irrigation uses 70 to 75 percent of the available water. The State's water resources are scarce, and efficient use of water is essential in all sectors. A main objective of water accounting and auditing is to see that the water in the reservoirs is used efficiently. The Government have decided norms (in terms of ha/Mm³) for Irrigation System Performance (ISP) in the rabi and the hot weather season. So far, there are no norms for the kharif season and for lift irrigation, but still, it is necessary to observe the actual performance in the field.

Indicator VI: Ratio between planned and actual non-irrigation uses

Keeping in view the priorities for different uses and the reasons for a growing demand for non-irrigation uses, it is necessary to monitor the deviations from projected allocations for different sectors. This provides information about trends in support of decisions on reallocation, if required.

Indicator VII: Ratio between unutilized water and live storage on 15 October

The only source of water for the State is rainfall. About 88 percent of the rainfall is received from June to September and 12 percent after October. Thus, the water in the reservoirs should be fully used before 30 June every year. This indicator shows whether there is any unutilized quantity (excluding carry-over⁴) in the reservoirs, and if it so, what are the reasons, in support of remedial measures.

Indicator VIII: Conveyance efficiency of main canals

The conveyance efficiency of canals is determined by leakages from the canals and seepage through the embankments. Knowledge about the rates is important for appropriate planning and operation, as well as decisions on improvements where this is relevant.

⁴

Carry-over: Water retained for the incoming irrigation year; or retained for future use, such as drinking water; or water required for standing crops and/or perennial crops

Indicator IX: Actual cropping pattern

The cropping pattern is always dynamic. It changes with the water availability, but is also influenced by market prices for alternative agricultural products (which may in turn have different irrigation needs). This indicator provides information about developments in this respect.

4.5 Schedule

In its circular dated 26 June 2003, the Government of Maharashtra has instructed the project authorities to submit annual water accounts of all state irrigation projects in the prescribed format by 14 August every year. The following schedule is strictly adhered to.

Table 3: Schedule for annual water audit

	Particular	Scheduled date
1	Submission of water accounts to MWRDC office by concerned irrigation circles	14 August
2	Communication of remarks on water accounts to concerned irrigation circles by MWRDC	31 October
3	Compliance of remarks on water accounts by irrigation circles	30 November
4	Consolidation of water account data of different projects and preparation of draft Water Audit Report by MWRDC	15 January
5	Approval to the Water Audit Report by GOM	20 February
6	Publication of Water Audit Report	22 March (World Water Day)

The water accounts are scrutinized upon receipt, with emphasis to the following points:

- i) Total available live storage is tallied with different water uses, evaporation losses, leakages, and replenishment (received in June) and unutilized water at the end of irrigation year
- ii) Water availability and water use, by season
- iii) Irrigation System Performance actually observed as compared to GOM norms
- iv) Actual evaporation losses as compared to designed evaporation losses
- v) Percentage of leakages through a dam and efforts taken by field staff to minimize or stop the leakages
- vi) Actual seasonal water use and area irrigated as compared to project planning/ Preliminary Irrigation Programme

4.6 Inspection of irrigation offices

Annual inspections of irrigation offices are carried out in order to validate the data, and to assure that the various records are kept continuously and in the prescribed format. This is done according to an annual inspection programme that is communicated to the field officers.

During such inspections, the following records are normally checked:

- i) Daily lake level and water storage
- ii) Daily evaporation (major & medium projects)
- iii) Main canal gauge (to evaluate water supplied for irrigation via the canal) (daily, rotation-wise, season-wise)

- iv) Non irrigation water uses, by agency
- v) Leakages through dam
- vi) Measured irrigated area
- vii) Crop distribution
- 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.

Other aspects to consider include the timely preparation of the Preliminary Irrigation Programme (PIP); conducting meetings of the canal advisory committee; timely and broad publication; timely submission of rotation-wise water demands (proformas I and IA) and water use (Proformas III and IIIA) by the field offices to the controlling authorities; and daily gauging of discharges. Lapses and deficiencies noted during the inspection are communicated to the concerned Executive Engineer under intimation to the concerned Superintending Engineer, prompting clarification and in support of proper action for improvement.

In order to streamline the work, a Water Audit Manual is presently under consideration for approval.

4.7 Dissemination of results

Auditing results, together with the applied methodologies and related observations, are reported in detail, and are disseminated directly to the users, as well as on the Internet.

5 Observations

This chapter provides a summary of general and specific observations made during auditing of the annual water accounts 2008-09.

5.1 General

- 1 There was a wide variation in the actual evaporation as compared tot the projected evaporation.
- 2 The actual irrigation water use of many projects was higher than planned. Among the reasons are lack or nonfunctioning of flow meters, and unmeasured silt storage.
The total annual actual irrigated area of major and medium projects was higher than planned (113 %), but the achievement of some projects was below 50% of the target.
- 3 For some schemes, the Irrigation System Performance in the Rabbi season was below 60% of the state norms.
- 4 For several schemes, the Irrigation System Performance in the hot weather season was satisfactory as compared to state norms, while on other schemes, there was a scope for improvement.
- 5 For some schemes, the conveyance efficiency (of canals) was not satisfactory. It is suggested that the project authority should identify the reasons and take suitable action for improvement.

- 6 For minor schemes, leakages were high (18% of live storage). The evaporation losses were 24%, so the total losses were 42%.

5.2 Water availability, water utilization and system performance

At state level, an actual live storage of 21,810 Mm³ was available on October 2008 (against a design live storage of 28,108 Mm³). Of this, 15,913 Mm³ was used for irrigation and 3,780 Mm³ for other uses.

The storages in the reservoirs are listed below.

Table 4: Capacity utilization of storage reservoirs on 15 October 2008

Storage	Major schemes	Medium schemes	Minor schemes
<i>Percent</i>	<i>No.</i>	<i>No.</i>	<i>No.</i>
80 to 100	34	101	1,002
50 to 80	04	26	261
Below 50	15	67	600

The total evaporation losses were 14% of live storage for major projects, 23% for medium projects, and 24% for minor projects, with a state average of 16% (or 3,580 Mm³).

The annual average Irrigation System Performance was 101 ha/Mm³ for major and medium schemes.

The total unutilized storage as compared to 15th October 2008 live storage was 5%.

Please refer to Appendix 1 for a summary of water availability and water use, as determined during the annual water audits.

5.3 Recommendations based on the results

Principles for water accounting and auditing were described in a GOM circular dated 16 Jun 03. Since then, important lessons have been learned, not only regarding the state's irrigation management in general, but also about the accounting and auditing routines. Some suggestions are made below.

- Evaporation data can be improved by better measurements and conversion routines. Where meters are yet to be installed, data from a station within the same climatological zone can be used as an interim arrangement.
- Flow data can be improved by calibration of the meters.
- Siltation should be monitored, particularly for major projects that are more than 15 years old.
- Better data for non-irrigation uses and lift irrigation schemes can be provided by increased use of water meters (based on water meters), in support of improved data for the over-all water allocation.
- There is a scope for scheme-level action plans for improved water efficiencies and reduced losses.
- Attention is required to achieve full utilization of the available water.

6 Conclusion

Water accounting and auditing have been conducted in Maharashtra since 2003-04 and is presently covering more than 2,000 irrigation schemes. A comprehensive and highly valuable knowledge has been produced and is steadily expanding.

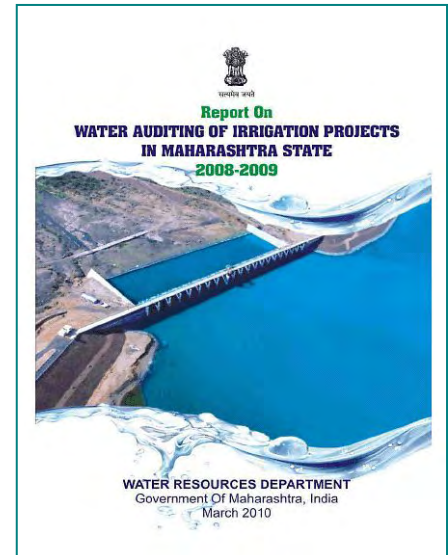
Systematic, transparent and well documented water auditing is highly supporting the basis for planning, operation and maintenance of the State's irrigation schemes in many ways:

- Valid, site-specific and timely information is produced about water availability, storage and distribution losses, not only to the direct benefit of the involved schemes, but also in support of feasibility studies and design of expansions and new schemes
- The actual water availability, demand and allocation are being routinely compared with projected or assumed values, hereby providing feedback for better planning and better operation, which in turn contribute to a better predictability of water allocations
- Specific needs of improvements and upgrading are timely identified, often together with indications on what to do; and
- A well-informed monitoring and documentation is provided in support of the state's continuous efforts towards efficient and beneficial utilization of its finite water resources

References

(All references are available on the Internet)

- Chivate, B A (May 10): Irrigation performance benchmarking in Maharashtra. CRBOM Small Publications Series no. 23. Center for River Basin Organizations and Management, Solo, Central Java, Indonesia
- Chivate, B A (Dec 09): Benchmarking of irrigation projects in Maharashtra, India - a case study. IE(I) Journal, Agricultural Series, Volume 90, published by the Institution of Engineers (India)
- MWRD (Mar 10a): Report on water auditing of irrigation projects in Maharashtra State 2008-09. Published annually by Water Resources Department, Government of Maharashtra, Mantralaya, Mumbai
- MWRD (Mar 10b): Report on benchmarking of irrigation projects in Maharashtra State 2008-09. Published annually by Water Resources Department, Government of Maharashtra, Mantralaya, Mumbai



Appendix 1: Water uses in Maharashtra

Source: MWRD (Mar 10a)

The table below provides an extract of the annual water audits.

Irrigation year	Designed storage	Actual storage on 15 October	Water use for irrigation	Water use for non-irrigation	Total water use	Potential created	Potential utilized	Potential utilized including wells	ISP on canal flow	ISP including wells
	<i>Mm3</i>	<i>Mm3</i>	<i>Percent</i>	<i>Percent</i>	<i>Mm3</i>	<i>Mha</i>	<i>Mha</i>	<i>Mha</i>	<i>ha/Mm3</i>	<i>ha/Mm3</i>
2000-01	26,748	18,947	78%	22%	17,433	3.706	1.30	1.76	96	130
2001-02	28,062	18,717	76%	24%	16,326	3.769	1.25	1.71	101	138
2002-03	28,715	18,936	75%	25%	17,201	3.812	1.32	1.84	102	142
2003-04	28,840	16,941	69%	31%	15,369	3.863	1.24	1.69	118	159
2004-05	28,889	18,298	69%	31%	15,463	3.913	1.26	1.70	119	160
2005-06	29,110	24,860	74%	26%	18,616	4.003	1.62	2.22	118	162
2006-07	29,531	27,309	65%	35%	25,404	4.132	1.84	2.68	110	161
2007-08	29,116	25,489	75%	25%	26,435	4.331	1.90	2.77	116	168
2008-09	33,071	24,803	73%	27%	25,366	4.486	1.83	2.73	99	148

ISP: Irrigation system performance

Appendix 2: Guidelines for water auditing

Source: GOM resolutions dated 14 Mar 88, 2 Nov 88, 7 Mar 01, 5 Dec 01, 21 Nov 02 and 20 May 04

- i) Irrigating maximum possible lands with available discharges
- ii) Adopting rotational water supply
- iii) Keeping flow period to the minimum possible by letting maximum possible discharge in canal to minimize the transit losses
- iv) Encourage night irrigation
- v) Encourage farmer's participation in irrigation planning and implementation through canal advisory committees and village meetings
- vi) Keeping rotation-wise and seasonal water accounts for watching the water efficiency
- vii) Setting up evaporimeters at every project bigger than 1000 ha, for correct assessment of evaporation
- viii) Providing measuring devices on canals wherever necessary
- ix) The responsibility of giving water account of minor projects rests with the concerned Sub Divisional Engineer and Executive Engineer, and with the Executive Engineer & Superintending Engineer in case of major and medium projects
- x) The norms for Irrigation System Performance in the rabi and hot weather season are decided as 150 ha/Mm³ and 110 ha/Mm³ respectively
- xi) Percentage checking of cropped area by Executive Engineer, Sub-Divisional Engineer and Section Officer for assuring 100 percent assessment of irrigated area
- xii) Norms for quota of water for lift irrigation on reservoirs and canals
- xiii) Agreement for water supply for non-irrigation water use (by electronic meter) and assessment of water revenue

**Center for River Basin Organizations and Management,
Solo, Central Java, Indonesia
www.crbom.org, info@crbom.org**