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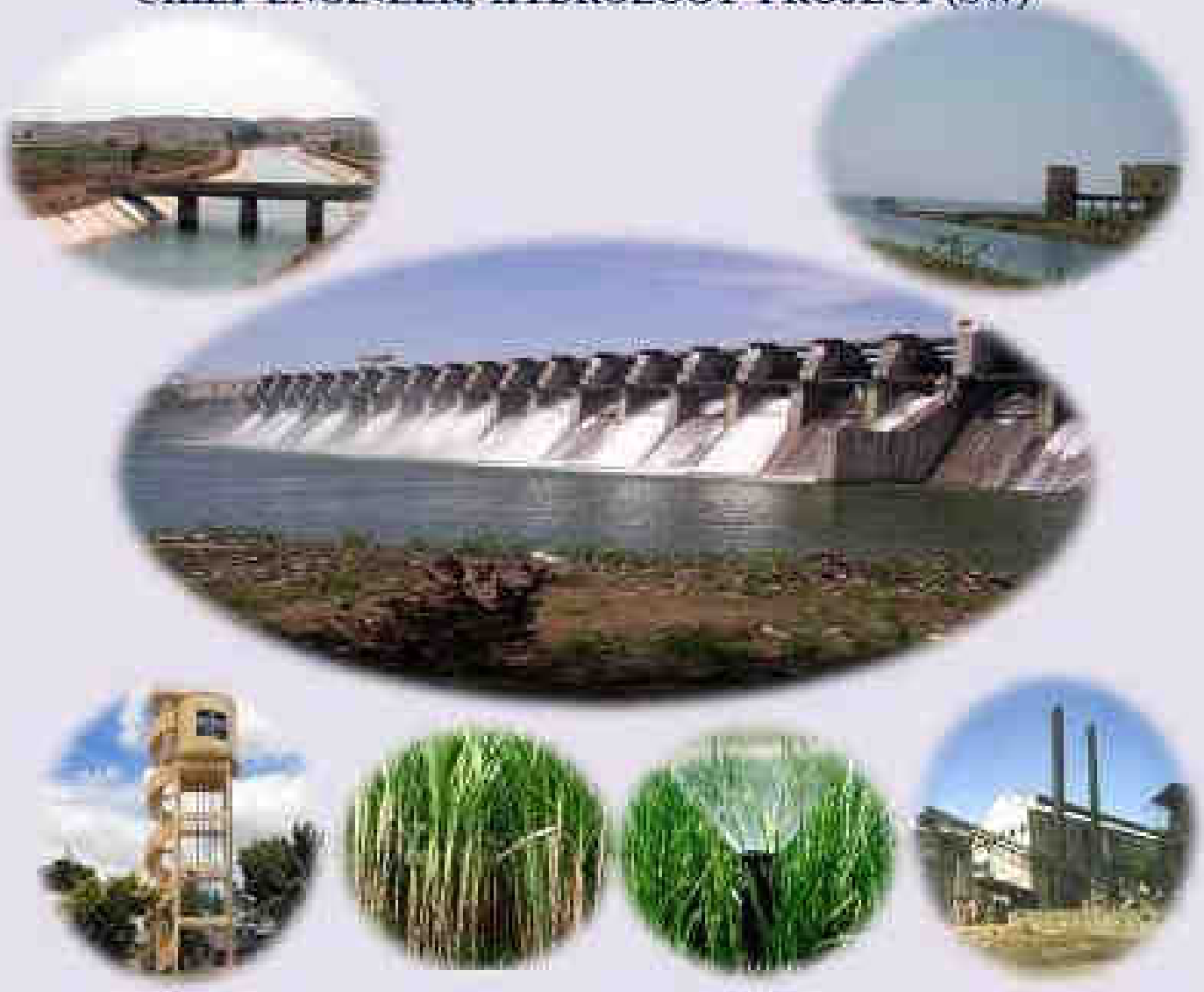
Govt. of Maharashtra

Water Resources Department

CHIEF ENGINEER, HYDROLOGY PROJECT (SW)



HYDROLOGY PROJECT DIVISION, AURANGABAD

PURPOSE DRIVEN STUDY (PDS)

Effect of Changing Water Allocation in Jayakwadi Project

Foreword

In Maharashtra state up to June 2010, more than 3000 dams are constructed mainly to cater water to 4.63 Million-hector land. Though the main objective of most of the projects is to supply water for Irrigation, due to increase in population, industrial growth and change in life style of people, more and more water is diverted for Non Irrigation purpose irrespective of provisions in sanctioned project report. Such diversion of water for Non-Irrigation is as per the State Water Policy adopted in 2003 by the State Government.

However, such change in water allocation at later stage of the project is likely to compel to curtail down the created irrigation potential of such projects to certain extent. Excessive interception of inflow on U/S of such projects, encroachment of silt in Live Storage and fringe Irrigation beyond the scope of project also leads to curtailment of irrigation potential. Such curtailment in irrigation potential not only affects the objective of project but also may create unrest among the cultivators in the command of the project. Jayakwadi project, which is 36 years old, is an example of the situation.

Jayakwadi project a largest project in Godavari Basin, constructed to supply water to 0.183 Mha. land is presently supplying 150 Mcum of water to Non Irrigation sector. To study the impact of such change in water allocation on social, economic, environmental, agricultural & Industrial aspects, a purpose driven study is taken under Hydrology Project.

The required data is collected from CADA Organisations, GSDA Pune, Industrial Department, Agricultural department, WALMI, MWRDC etc. for the said study.

The data collected from these departments and socio-economic survey through SACRED, a NGO at Aurangabad is organized, analysed with the help of Technical Advisor Mr. A R Suryawanshi and Dr. Sharad Bhogale.

I am sure this study along with the mitigation measures suggests in general to reinstate the project objectives on the background of change in water allocation will be useful to Jayakwadi as well as other such similar projects.

I offer my sincere thanks to all Departments, Organizations who spared all information required for this study. I am also thankful to Mr AR Suryawanshi, SACRED & Dr Sharad Bhogale for their contribution to this study.

Lastly, I am also thankful to Mr D D Bhide, Director General, DTHRS Nashik, for sparing his valuable time and suggestions on different aspects of the study.

I appreciate the efforts taken by Mr. V L Joshi Executive Engineer, Hydrology Project Division Aurangabad and his team for active participation and completing the study in schedule time.

(H. K. GOSAVI)
Chief Engineer

HYDROLOGY PROJECT DIVISION, AURANGABAD.

Team Associated with Purpose Driven Study (PDS)

Effect of Changing Water Allocation in Jayakwadi Project

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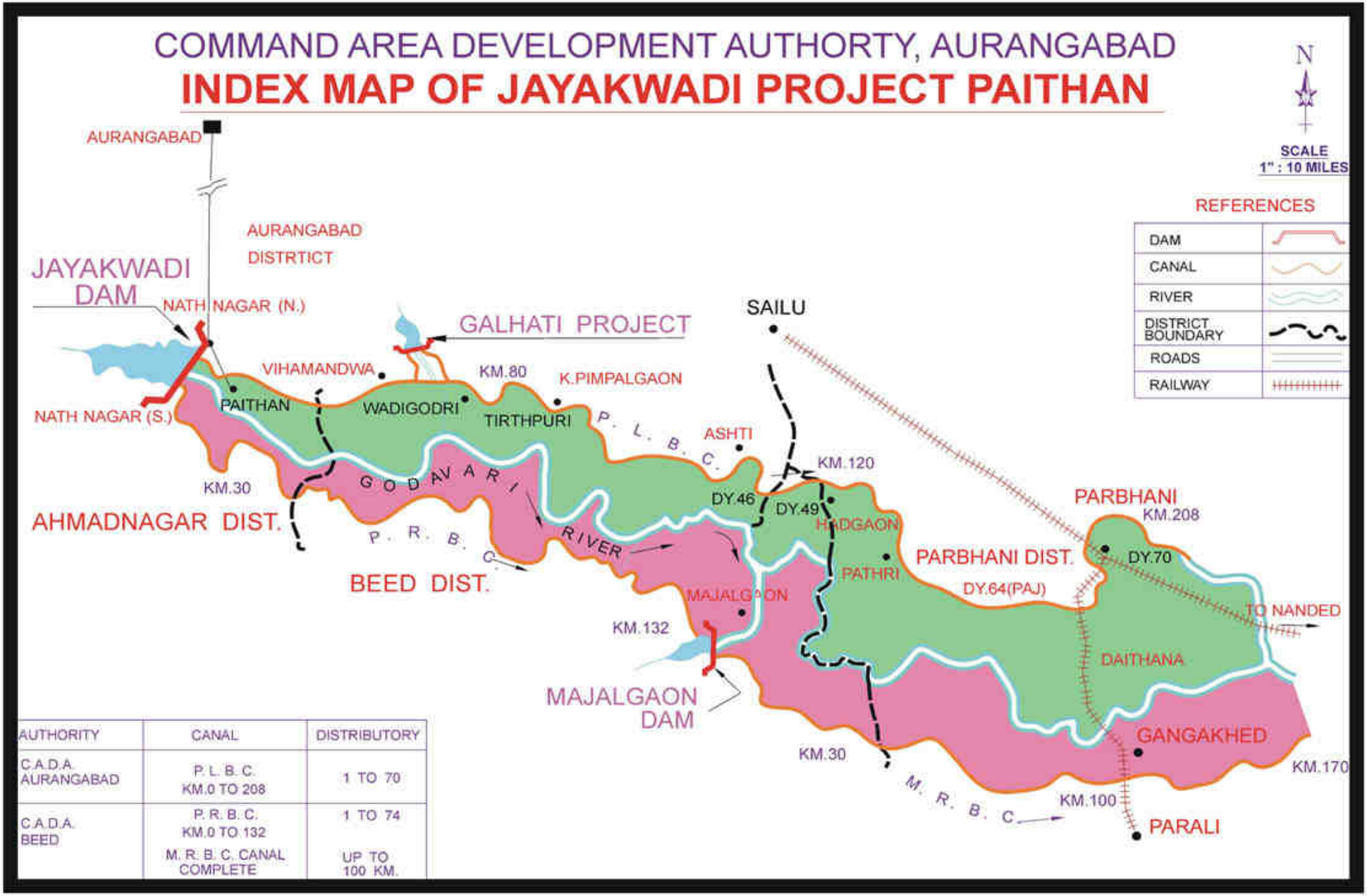
Location Map

COMMAND AREA DEVELOPMENT AUTHORTY, AURANGABAD

INDEX MAP OF JAYAKWADI PROJECT PAITHAN



AUTHORITY	CANAL	DISTRIBUTORY
C.A.D.A. AURANGABAD	P. L. B. C. KM.0 TO 208	1 TO 70
C.A.D.A. BEED	P. R. B. C. KM.0 TO 132	1 TO 74
	M. R. B. C. CANAL COMPLETE	UP TO 100 KM.

CONTENTS

Abbreviations

CADA	Command Area Development Authority
CDO	Central Design Organisation
Cusecs	Cubic meter per second
DTHRS	Design, Training, Hydrology, Research & safety
GOI	Government of India
GOM	Government of Maharashtra
GSDA	Ground Water Survey & Development Agency
H.W.	Hot Weather
Ha	Hector
ID	Irrigation Department
MCM	Million Cubic meter
Mha	Million hector
MOWR	Ministry of Water Resources
MS	Maharashtra State
MWRDC	Maharashtra Water Resources Development Center
NGO	Non Government Organisation
PDS	Purpose Driven Study
PLBC	Paithan Left Bank Canal
PRBC	Paithan Right Bank Canal
S.E.	Superintending Engineer
SACRED	Society of Action in Creative Education & Development
SW	Surface Water
TMC	Thousand Million Cubic meter
U/S	Upstream Side
WALMI	Water and Land Management Institute
WRD	Water Resources Department

1. INTRODUCTION

1.1 The Ministry of Water Resources (MOWR) Govt. of India (GOI) is implementing Hydrology Project Phase II (HP II), which is follow up of the recently concluded Hydrology Project I. In vertical expansion component of HP I, there is a provision for Purpose Driven Studies (PDS). The study on "The effect of changing water allocation in Jayakwadi Project (Nathsagar), Paithan, Dist. Aurangabad. (Maharashtra)" is one of such studies.

1.2 Initially, Jayakwadi Project is planned mainly for Irrigation purpose in Marathwada Region of Maharashtra. Because of increase in population, urbanization and industrial development in and adjoining command area of Jayakwadi Project, some quantity of water is being diverted for such non- irrigation purposes. This has affected the agriculture, irrigation, socio-economic and environmental systems to some extent. This type of situation is occurring in most of the irrigation projects in the State. It is therefore necessary and useful to study the impact of changing water allocation on the performance of the project. The outcome of this study will help for better planning and management of available water resources.

1.3 Outline of the Study:

Following aspects are included in the Study

- Review of previous studies
- Review of Hydrology
- Review of water planning and allocation to various sectors
- Impact of changing water allocation on Agriculture system, Irrigation system, Socio-Economic System, Environmental System and Industrial Development.
- Performance evaluation with respect to adjoining project
- Forecasting future demands
- Mitigation and Demand Management measures
- Developing guidelines for future planning and allocation

1.4 Approach and Methodology:

The Study is mainly based on analysis of Secondary data available with Water Resources and other concerned Departments and agencies except Socio-Economic System for which data on sample basis was collected for impact analysis. All the data primary as well as secondary data was collected by the concerned officers/staff of the Hydrology Project with the help of hired staff for field work of socio-economic survey.

The consultant provided necessary technical guidance to Hydrology Project authorities with respect to data requirement, data collection, storage and analysis of data/information and report writing as envisaged in the PDS.

The Objective, approach, methodology, data formats and outcome for each aspect of the study is given in subsequent chapters.

2 Jayakwadi Project at a glance

Jayakwadi is a Major Project on the river Godavari. The head works are located near Paithan town, Taluka Paithan, Dist. Aurangabad; It was mainly planned for Irrigation purpose. It has command area on both the sides of Godavari River. The location map and Index plan is enclosed. The salient features of the Project as envisaged in Project Planning are as given below.

- Catchment Area : 21750 Sq.kms. (8400 Sq.Miles)
- Gross Storage : 2909 Mm^3 (10272 Mcft)
- Live Storage : 2171 Mm^3
- Type of Dam : Earthen
- Length of Dam : 10.20 kms.
- Maximum height of dam above River Bed : 37 meters (120 ft.)
- Area under submergence : 35000 Ha.

- **Details of canal and command Area**

Particulars	**Paithan Left Bank Canal**	**Paithan Right Bank Canal**	**Total**
(i) Length (Kms)	208	132	
(ii) Gross Command Area (Ha.)	203958	59900	263858
(iii) Culturable Command Area (Ha)	183562	53910	237472
(iv) Irrigable Command Area (Ha.)	141640	41682	183322
(v) Max. Discharge (Cumec)	100.8	63.71	
(vi) Lining	Full Length	Full Length	

- **District wise distribution of ICA (Ha) :**

District	**Paithan Left Bank Canal**	**Paithan Right Bank Canal**	**Total**
Aurangabad	7620	1432	9052
Jalna	36580	-	36580
Parbhani	97440	-	97440
Ahmednagar	-	2290	2290
Beed	-	37960	37960
Total :	141640	41682	183322

- **Designed Crop Pattern :**

Crop	%	Total Area (Ha)
Rice	10	18332
Jawar [K]	12	21999
Wheat	25	45830
Jawar [R]	15	27498
Gram	5	9166
Cotton	25	45830
Chili & other	3	5500
Groundnut (Hw)	3	5500
Sugarcane	3	5500
Other perennials	1.5	2750
Total :	102.5	187905

- Commencement of the Project: Oct. 1965
- Year of first impoundment: 1974
- Year of commencement of Irrigation: 1976
- Power Generation: 12 MW (Reversible Turbine)
- Soils in the command: Deep vertisols (Black Cotton Soil)
- Major crop grown: Sugarcane, cotton, wheat, Rabi Jawar, HW Groundnut.
- Climate: Semi – arid
- Average rainfall in command: 660 mm to 950 mm
- Proposed diversion to Majalgaon Project: 350 Mm^3

  (As per original design)
- Management Organizations: CADA, Aurangabad

  CADA, Beed
  C.E. & Chief CADA, Aurangabad

3. Review of Previous Studies

3.1 The objective of this chapter is to take review of similar previous Studies to make use in present study.

3.2 The review of following Studies is taken and presented in Table 3.1.

1. The Socio-Economic Survey of Jayakwadi and Purna Command Area, Marathwada Agricultural University, Parbhani (M.S), 1981.

2. Note on Review of created irrigation potential of Jayakwadi Project **:-** Chief Engineer and Chief Administrator, Irrigation (CAD) Department., Aurangabad July 1995.

3. Jayakwadi Project: - A blessing for Marathwada region by Shri.M.R.Dighe, C.E & Administrator, CADA Aurangabad, Article published in CBIP's Irrigation & Power Journal, June 1995.

4. Jayakwadi Irrigation Project: Socio-Economic Follow-up Survey by Marathwada Agricultural University, Parbhani (M.S.), 1996.

5. Irrigation Water Management Component of Pilot Water Resources Studies of Godavari basin up to Paithan Dam **:-** Water and Land Management Institute (WALMI), Aurangabad, M.S, Feb-1997.

6 Report of II Maharashtra Water and Irrigation Commission, June-1999.

7 Regional Imbalance of Water Resources Development in Maharashtra: - Shri.Y.R.Jadhav, Retired Superintending Engineer, I.D,GOM, Dec-2007, (Marathi Publication).

8 Study of projects receiving yield less than 50% of storage capacity – A case study of Jayakwadi Project **:-** S.E, Command Area Development Authority (CADA), Aurangabad, I.D., GOM ,2008.

3.3 The outcome / conclusions of all these Studies are used in further analysis and presentation of this study. However, the overall outcome of these studies in brief is given below.

- Excess u/s interception of water on U/S of Jayakwadi project resulting into reduction in the inflow to this project.
- Considerable Reduction in the actual irrigation potential.
- Cropping pattern must be diluted.
- Pollution of Godavari river around big cities like Aurangabad.
- Inequitable distribution of water available in the basin.
- Further interception of water on U/S side should be stopped immediately.
- Augmentation of supply of water in the basin through inter basin transfer of water is essential.
- Total cropping intensity increased from 146% to 177% from 1981 to 1996.
- 100% adoption of High yielding Varieties of crops.
- Overall output – input ratio in crop production increased from 1.65 to 1.73 during 1981 to 1996.
- Net Agricultural Income increased from Rs.3328 to 12639 per ha. from 1981 to 1996.
- Employment to landless laborers increased by 18% from 1981 to 1996
- Further Scope in increasing agricultural production if all inputs including water are supplied in time & in required quantities.
- Benefits other than agriculture like fish production, drinking water supply, Industrial water supply, flood protection, employment generation, Tourism is substantial.

Table 3.1 Review of Previous Studies.						
Sr. No.	**Agency**	**Title of the Study**	**year**	**Study Aspects**	**Outcome / conclusion in brief**	**Remarks/Reference**
1	Marathwada Agricultural University, Parbhani (Maharashtra), Deptt.of Agri.Economics & Statistics.	The Socio Economic Survey of Jayakwadi and Purna Command Area .	1981	• To Study the present infrastructure facilities available at village level • To Study the process of changes in the farm assets and capital formation in agriculture • To examine the requirement of all types of inputs. • To Study cost of cultivation. • To assess the extent of adoption of high yielding Varieties. • To Study the extent of water utilization for different crops. • To Study the pattern of family consumption. • To Study the employment opportunities.	1. The Value of land increased by 56.51% . 2. The number and Value of farm buildings and farm machinery increased. 3. The number of per farm bullocks increased from 4.6 to 5.58. 4. The Value of the dwelling house including the repairs and additional constructions increased by 21.13% 5. The area under irrigated Hybrid Jowar, Wheat and Paddy increased. 6. Average intensity of cropping was 150.62% However there is vide fluctuation in area allocation under different crops indicating that cropping pattern in Jayakwadi is not yet stabilized. 7. Per family consumption expenditure was Rs.2593. Consumption of wheat and paddy was increasing. 8. The proportion of area under High Yielding Varieties of cotton, Jowar and Wheat increased over a period of Study. 9. Per hectare use of manures and fertilizers was much lower than the recommended doses. 10. Input – output ratio for different crops. Rabi Jowar – 1:1.63, Wheat – 1:1.22, Cotton – 1:2.07. 11. Net Income Rs 3596 per ha. 12. Per ha productivity: Hy Jawar – 24.35 Quintle 13. Proportion of borrowing members decreased. 14. Average employment**:** 251 days for male, 200 days for female and 91 days for children (per annum) 15. A systematic scheduling & Irrigation water matching with periodic water requirement is necessary	Ref: The report of the Socio-Economic Survey of Jayakwadi and Purna command areas by K.D.Rajmane, S.P. Kalyankar and T.G.Satpute, Deptt. Of Agri. Economics and statistics, Marathwada Agricultural University, Parbhani, 1981.

Sr. No.	Agency	Title of the Study	year	Study Aspects	Outcome / conclusion in brief	Remarks/Reference
2	Chief Engineer & Chief Administrator, Irrigation (C.A.D.) Dep't. Aurangabad. (I.D,Gom)	Review of created Irrigation Potential of Jayakwadi Project (PLBC +PRBC)	July, 1995	• Actual availability of water at Jayakwadi dam site • Review of irrigation potential created and actual utilization. • Review of carryover, diversion to Majalgaon Project, Sanction of additional water for Non – Irrigation purposes and Lift Irrigation Schemes.	1. It is necessary to stop further interception of water on U/S side of Jayakwadi. 2. Simulation study based on 1955 – 1985 yield series estimates 75% dependable net yield as 1678 Mm^3. However actual net yield (75% dependable) received from 1975 to 1995 is 1446 Mm^3 (Planned utilization on both the canals as per revised project report of 1985 is 2058 Mm^3) The 50% yield based on this simulation study is 2013 Mm^3. Therefore whether the project is to be operated on 50% dependable yield or otherwise is to be decided at Govt. level. 3. Considering the reduced availability of water at Jayakwadi the diversion of 350 Mm^3 of water to Majalgaon Project as proposed in project planning is not possible. 4 As per Govt. directives, 55 Mm^3 of water from Jayakwadi reservoir is allocated for Thermal Power Station at Parali. This power station is far away from Jayakwadi reservoir and hence it is not proper to carry this water to such a long distance Alternatively water to this power station may be taken from Majalgaon Project. 5. The project planning provides 382 Mm^3 of water as carryover storage. However considering the reduced availability of water, it proposed to reduce this carryover as 150 Mm^3. 6. There is widespread opposition by the beneficiary farmers to divert more water for Non – Irrigation purposes. 7. No further sanction should be given for lift irrigation schemes on Jayakwadi reservoir as well as on canal. 8. The frequency and actual period of rotations will have to be decided based on actual carrying capacity of both the canals (The actual carrying capacity of PLBC and PRBC is 2300 cusecs and 850 cusecs respectively against designed capacity of 3556 and 2248 cusecs respectively.	Ref: Report submitted to Govt. in July 1995.

Sr. No.	Agency	Title of the Study	year	Study Aspects	Outcome / conclusion in brief	Remarks/Reference
3	Shri M.R. Dighe. Chief Engineer & Administrator, CADA, Aurangabad.(M.S)	Jayakwadi Project – A Blessing for Marathwada Region.	1995	To assess economic & other benefits of Jayakwadi Project.	1. Total agricultural production increased steadily from 8.31 crores to 56.53 crores during 1990 – 91 to 1993 – 94. The per ha increase in production from irrigated area is Rs 11836. 2. Fish production is Rs 130 lakhs /year contemplated in project report. 3. Drinking water supply to Aurangabad city & other Town & Villages equivalent to Rs 376 lakhs/year of agriculture benefits. 4. 1135 industries including 4 Sugar factories with a total annual production of Rs 1400 crores have developed during 1980 to 1990 due to water supply from Jayakwadi Project Water Supply to industries equivalent of Rs 338 lakhs/ year based on agriculture benefits is being made. 5. Indirect benefits are flood protection, employment generation (400 lakh man days/year), Tourism (3000 tourists/day)	Article published in CBIP'S Irrigation and Power Journal, Maharashtra special Issue Apr-June, 1995.

Sr. No.	Agency	Title of the Study	year	Study Aspects	Outcome / conclusion in brief	Remarks/Reference
4	Marathwada Agricultural University, Parbhani (M.S)	Jayakwadi Irrigation Project. Socio–Economic Follow–up Survey.	1996	• To know, the impact of irrigation on the infrastructure facilities • To study the changes in farm assets and capital formation. • To evaluate the changes in agricultural inputs. • To examine the changes in cropping pattern. • To Study the economics of crop cultivation. • To estimate the changes in the extent of adoption of high yielding varieties. • To Study the impact of water utilization for different crops. • To know the present consumption pattern and impact of irrigation on consumption expenditure • To Know the changes in the extent of employment opportunities. • To Know of irrigation on Socio – Economic conditions of SC/ST farmers.	1. Considerable increase in the assets of farm buildings, farm machinery, modern implements. 2. Food grain area declined to 66% from 77% and area under cash crops & horticulture crops was increased by 5% and 2% respectively. The emergence of summer Groundnut and Sunflower was predominant. 3. Cropping intensity increased from 146 to 177%. 4. The Utilization of irrigation was increased to 46.6% from 18.84%. 5. No Significant change in consumption pattern. 6. 100% adoption of high yielding varieties in case of cotton, wheat, Sugarcane and Summer Groundnut and more than 90% in case of Rabi Jowar & Bajara. 7. The use of manures & fertilizers increased in case of cash crops but declined in food grain crops. 8. Input – output ratio: Rabi Jowar 1:1.83, Bajara 1:1.53, Pulses 1:2.42, Safflower 1:1.87, Sugarcane 1:1.68, Cotton 1:1.66. Overall input – output ratio was 1;1.73 as against. 1:1.65 of previous one. 9. Significant increase in yield of all crops except wheat. 10. Net Income increased from Rs 3328 to 12639. 11. Overall employment of landless laborers was increased by about 18% over the previous period. 12. Positive impact of irrigation on economy of SC/ST farmers e.g. cropping intensity was 184% against 176% of general category farmers. 13. There is further scope to increase productivity of all crops through timely agricultural operations, use of appropriate inputs in time and optimum utilization of irrigation water.	Ref: Report of the Socio-Economic follow-up Survey of Jayakwadi Irrigation Project, by K.D.Rajmane, P.R.Waghmare and D.N.Hedgire, Deptt of AgriConomics .Marathwada Agricultural University. Parbhani. 1996.

Sr. No.	Agency	Title of the Study	year	Study Aspects	Outcome / conclusion in brief	Remarks/Reference
5	Water and Land Management Institute (WALMI) Aurangabad. (M.S.).	Irrigation Water Management component of Pilot Water Resources studies of Godavari Basin upto Paithan Dam.	1997	• Suggesting appropriate cropping pattern in study area. • Estimating Net Irrigation Requirement (NIR) by Modified Penman method for the suggested cropping pattern. • Estimating Irrigation Demands (on half monthly basis). • Irrigation Water Allocation for post man-soon period i.e. Model irrigation allocation plan (PIP). • Irrigation scheduling i.e. to determine frequency of irrigation under diversified cropping pattern and rotational Water Supply (RWS). • Operation Schedule of main canal.	1. 107% Canal irrigation cropping pattern is suggested against 102.5% proposed in design by reducing proportion of high water consuming crops like paddy, wheat, Banana, L.S. Cotton and increasing proportion of low water requirement crops like sunflower, Soya bean, Rabi Jowar, Gram, Safflower, Lucerne etc. 2. Crop wise net irrigation requirement (NIR) by modified Penman method (half monthly basis and total for the Crop period). 3, Irrigation demands on half monthly basis considering actual 75% dependable yield restricting non-irrigation requirements & lift irrigation requirements to present sanctioned Volume, overall efficiency as 40% against actual efficiency of 30%, and proposed cropping pattern. The ICA estimated on this basis works out to 1,16,528 ha against 1,83,322 ha proposed in project design. 4. Model Preliminary Irrigation Program using LOTUS 1-2-3 spread sheet software with case study of Major irrigation project (Mula) is given. 5. Irrigation scheduling i.e. frequency of irrigation based on soil – Crop – climate database and RWS is proposed as follows.Rabi:21 days (against 14 days proposed in design)HW: 14 days. 6. Operation schedule of Paithan Left Bank Canal considering capacity of main canal in different reaches, capacity of each off take from main canal, running time of each off take based on its ICA, proposed crops and their NIR, conveyance efficiency.	Report of WALMI Aurangabad, February 1997 (D.P. 6,54,130, 138,194,272,281,286)

Sr. No.	Agency	Title of the Study	year	Study Aspects	Outcome / conclusion in brief	Remarks/Reference
6	Maharashtra Water and Irrigation Commission.	Report of Maharashtra Water and Irrigation Commission (Upper and Lower Godavari)	June 1999	• Engineering, Agriculture, Socio – Economic, Environment etc.	1. The Variability of yield in the catchment up to Paithan (Jayakwadi) dam is very large i.e. about 30%. 2. Storages in the catchment area including Paithan dam may be planned on less than 50% dependability so that water available in good years is carried over to Scarcity years. 3. Water resources development in the whole basin (Upper and Lower Godavari) should be planned based on river basin approach and not based on individual project in isolation. 4. There is Scope for diverting water from western flowing river to Godavari basin. 5. Development of Aurangabad City and industrial area around it is polluting Godavari river including ground water. 6. Evaporation rate in lower Godavari basin (including Paithan Reservoir) is high and hence measures to minimize evaporation losses from reservoir as well as command area should be adopted. 7. Water use in this basin should not result in to water logging and will give maximum benefit per unit of available water. 8. High water requirement crops like Sugarcane and Banana should be discouraged and increase area under kharif and Rabi Seasonal.	Ref: Maharashtra Water and Irrigation Commission's Reports of Upper and Lower Godavari Sub-basin.
7	Shri Y.R.Jadhav, Retired Superintending Engineer, I.D, GOM.	Regional Imbalance of Water Resources Development in Maharashtra (Marathi)	Dec., 2007.	• To find out regional enhance in Water Resources Development (WRD) in the State of Maharashtra • To Study impact of regional imbalance in WRD.	1. Estimated 75% dependable yield up to Jayakwadi dam is 196 TMC and reservation for projects U/S of Jayakwadi is 111.63 TMC. However considering completed on going and proposed Schemes on U/S side, which include State as well as local sector Schemes, the total planned water use on U/S side is 196 TMC. This shows that Jayakwadi project may not receive water at all in future. 2. It will be difficult in future to Satisfy non – irrigation demands alone and what to talk about irrigation. 3. At present Irrigation potential has been reduced to 30 to 35%. 4. In order to improve upon the present detrimental impact, it is necessary to distribute the available water in the basin equitably to all the projects based on the system adopted for Pravara Sub-basin. 5. Ground water development may be done at Government cost by establishing separate corporation for this region.	Ref: Marathi Publication by Shri Y.R. Jadhav. Dec.2007 (pp 82 to 92)

Sr. No.	Agency	Title of the Study	year	Study Aspects	Outcome / conclusion in brief	Remarks/Reference
8	S. E, Command Area Development Authority, Aurangabad, (I.D.,GOM)	Study of Projects receiving yield less than 50% of storage capacity, A case Study of Jayakwadi Project.	2008	• Comparisons of actual yield with designed storage capacity of Jayakwadi reservoir. • Estimated total yield in the catchment and net yield at dam site during project planning and actual status. • Present Status of water utilization in the catchment area.	1. Comparison of net yield at dam site (75% dependable) simulation study cone by CDO): 980 Mm^3. Yield based on actual: 908 Mm^3. Yield series of 33 years: 908 Mm^3. (If all the projects in catchment area are completed, actual yield at Paithan will be much less than 908 Mm^3.) 2. Present planned utilization on upstream side is 4427 Mm^3.against 3270 Mm^3. assumed during project planning. Thus Resulting into excess diversion of 1157 Mm^3. (4427 – 3270=1157) 3. In low rainfall years, the storages on U/S side get filled 100%, however storage at Paithan remains up to 40% only. 4. The actual storage in the Paithan reservoir between 75 % to 100 % was available for 13 years only out of 33 years. 5. Further interception of water including local sector schemes on U/S side should be stopped. 6. Water should not be diverted through canals in rainy season on U/S side till Paithan reservoir receives water as per reservoir operation policy. 7. Equitable sharing of shortages in all the reservoirs in the catchment area. 8. Additional water should be made available in this basin by inter basin transfer for mitigating shortage of Jayakwadi Project.	Ref: Study report of S.E., CADA, Aurangabad. 2008.

4 Review of Hydrology

4.1 The Objective of this chapter is to take review of Hydrological studies of Jayakwadi Project done at various points of time by different agencies and to compare the yield estimations. In addition, the actual yield received in the reservoir, actual dependability and effect of upstream interceptions on the yield is also studied. The outcome is presented in subsequent paragraphs.

4.2.1 Yield estimates by various agencies

Following agencies estimated the availability of water at Jayakwadi Project Site from time to time.

(1) 1964 - Original Project Report prepared by Irrigation Project Investigation Wing of Irrigation Department, Government of Maharashtra.

(2) 1985 – Revised Project Report prepared by Jayakwadi Project Circle, Aurangabad, Irrigation Department, Government of Maharashtra.

(3) 1989 & 1990 – World Bank, Central Water Commission and Irrigation Department, Government of Maharashtra.

(4) 1994 – Central Designs Organisation, Irrigation Department, Government of Maharashtra.

(5) 1998 – Water and Power Consultancy Services (India) Ltd. (WAPCOS) New Delhi.

(6) 1999 – Maharashtra Water and Irrigation Commission.

(7) 2001 – Central Designs Organisation, Irrigation Department, Government of Maharashtra.

The details of Studies done by above mentioned agencies are presented in Table 4.1. The abstract of the same is given below.

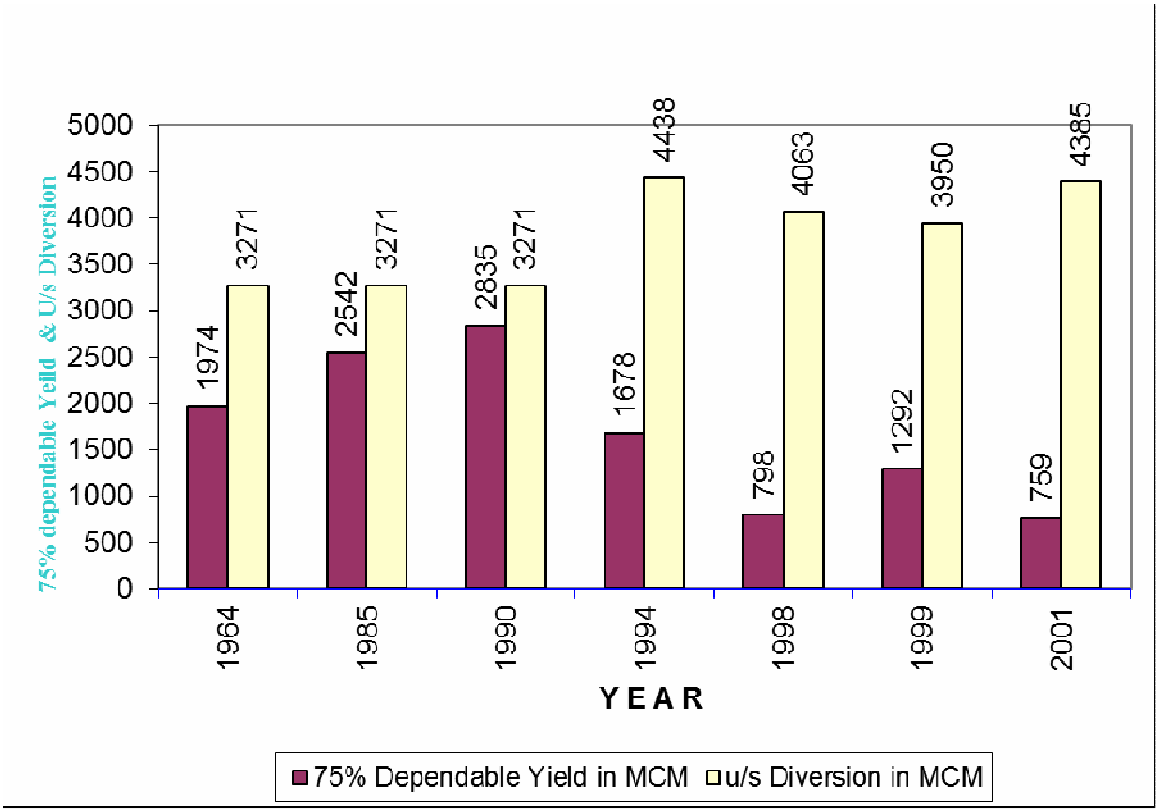
Jayakwadi Project

Abstract of Yield Estimates

Sr.No.	Year of Study	Rainfall series	Run off series	Methodology	U/S utilisation considered	75% dependable yield at Dam Site
1	1964 (Original Project Report)	48 Years (1914 to 1962)	48 Years (1914 to 1962)	Partly by actual runoff & partly by Strange's table	3271 MCM 115.5 TMC	1974 MCM 69.71 TMC
2	1985 (Revised Project Report)	51 Years (1927 to 1977)	10 Years (1968 to 1977)	Rainfall-Runoff co-relation	3271 MCM 115.5 TMC	2542 MCM 90 TMC
3	1989 +1990 (WB + CWC+ID GoM)	31 Years (1955 to 1985)	18Years (1968 o 1985)	Rainfall-Runoff co-relation	3271 MCM 115.5 TMC	2835 MCM 100.1 TMC
4	1994 (CDO, ID GoM)	31 Years	18 Years	Rainfall-Runoff co-relation	4438 MCM 156.7 TMC	1678 MCM 59.27 TMC
5	1998 (WAPCOS)	30 Years	19 Years	Rainfall-Runoff co-relation	4063 MCM 143 TMC	798 MCM 28 TMC
6	1999 (MWSIC)	Not Available	Not Available	Not Available	3950 MCM 139.48 TMC	1292 MCM 45.62 TMC
7	2001 (CDO,ID GoM)	31 Years (1955 to 1985)	31 Years (1955 to 1985)	Rainfall-Runoff co-relation	4385 MCM 154.8 TMC	759 MCM 26.8 TMC

It is seen from the above analysis and comparison that the yield estimates have been revised from time to time taking in to consideration the latest rainfall-runoff series and adopting latest methodology i.e. establishing rainfall-runoff co-relation.

Histogram Showing Year of Study vs. 75% dependable Yield & u/s Utilisation



The range of 75% dependable yield at Jayakwadi dam site as estimated at various points of time is given below.

- Maximum 75% dependable yield : 2835 MCM (100.1 TMC)
- Minimum 75% dependable yield : 759 MCM (26.8 TMC)

The proposed utilisation of Jayakwadi Project as per project planning is given below.

Design Stage	75% dependable net yield at Dam Site	Proposed Utilisation for Jayakwadi (PLBC+PRBC)	Proposed Utilisation including carryover and diversion to Majalgaon Project	Ref:
Original (1964)	1974 MCM 69.71 TMC	1988 MCM 70.22 TMC	2720 MCM 96.07 TMC	Comprehensive note of CDO, 1998, P.27 & 28
Revised (1985)	2542 MCM 90 TMC	2058 MCM 72.69 TMC	2790 MCM 98.54 TMC	Comprehensive note of CDO, 1998, P.54 & 55

The latest yield estimate as per 2001 study (which is lowest among the studies carried out by different agencies at different time point) is 759 MCM (26.8 TMC) which is about 30% of yield estimated during Revision of the Project in the year 1985.

Table 4.1

Yield Estimates by Various Organizations

Sr. No.	Organization	Year of Study	Rainfall series details	Run off series details	Methodology	Assumptions	U/s Utilisation	Estimated yield at % dependability				Remarks
								Average	50%	75%	90%	
	1	2	3	4	5	6	6	7	8	9	10	11
1	Irrigation Project Investigation Wing of Irrigation Department, Government of Maharashtra (Original Project Report)	1964	* 48 Year series (1914 to 1962) * 24 rain gauge Stations	*Runoff of 48 Years (1914 to 1962) at Nandur-Madhme-shwar weir, Ozar weir, Nandur-Borgaon River Gauging Site.· *Strange's yield series for free catchment.	*Net Annual Yield downstream of Weirs & River gauging site deducing upstream diversions was considered *the entire Yield from free catchment based on Strange's method was considered. * 4 % regeneration flow from u/s utilization was considered.	*Free Catchment is considered as "Good" for estimating yield by Strange's method.· *Post monsoon flow is assumed as 10 % of monsoon flow for free catchment.	3271 MCM 115.5 TMC	3520 MCM 124.3 TMC	3292 MCM 116.25 TMC	1974 MCM 69.71 TMC	1340 MCM 47.3 TMC	Ref: Comprehensive note on Hydrological & simulation studies, CDO, Jan 1998, P.19-41

Sr. No.	Organization	Year of Study	Rainfall series details	Run off series details	Methodology	Assumptions	U/s Utilisation	Estimated yield at % dependability				Remarks
								Average	50%	75%	90%	
	1	**2**	**3**	**4**	**5**	**6**	**6**	**7**	**8**	**9**	**10**	**11**
2	Jayakwadi Project Circle, Aurangabad, Irrigation Department, Government of Maharashtra. (Revised Project Report)	1985	* 51 Year series (1927 to 1977) * 24 rain-gauge Stations	River gauge data from 1968 to 1977 (10 Years) at Paithan Dam Site.	*Rainfall-Runoff co-relation established using 10 years runoff series. *Runoff series for 51 years (1927-1977) generated using R & R equation. * Upstream utilization by Major & Medium Projects added to estimate virgin yield. * R&R relationship is Y=0.6255x-6.0508, where Y is runoff in Inches & x is weighted rainfall in inches. * 75% regeneration flow from u/s utilization is considered.	Post monsoon flow of 8 % considered.	3271 MCM 115.5 TMC	4122 MCM 145.6 TMC	4123 MCM 145.6 TMC	2542 MCM 90 TMC	1726 MCM 61 TMC	Ref: Revised Project Report of Jayakwadi Feb. 1985 (Jayakwadi Project Circle, Aurangabad) P. 33 to 40

Sr. No.	Organization	Year of Study	Rainfall series details	Run off series details	Methodology	Assumptions	U/s Utilisation	Estimated yield at % dependability				Remarks
								Average	50%	75%	90%	
	1	**2**	**3**	**4**	**5**	**6**	**6**	**7**	**8**	**9**	**10**	**11**
3	World Bank, Central Water Commission and Irrigation Department, Government of Maharashtra.	1989 and 1990	Weighted average rainfall series of 24 rain gauge stations from 1955-56 to1985-86 (31 years)	(i) 1968-69 to 1985-86 (18 years) Jayakwadi Reservoir data. (ii) CWC's Kaygaon Toka R.G. data for 1968-69 to 1974-75.	*Rainfall-Runoff co-relation developed for 1968-69 to 1985-86 considering monthly rainfall & inflows, u/s utilisation. * Runoff series back extended to 1955-56.	*Post monsoon flow as 10 % *Regeneration flow as 10% of u/s utilization.	3271 MCM 115.5 TMC	3383 MCM 119.46 TMC	3435 MCM 121.3 TMC	2835 MCM 100.1 TMC	1864 MCM 65.82 TMC	Ref: Comprehensive note on Hydrology & Simulation studies for Jayakwadi – Majalgaon Project, Central Design Organisation, Nasik (I.D.GOM) Jan. 1998 P. 66 to 91

Sr. No.	Organization	Year of Study	Rainfall series details	Run off series details	Methodology	Assumptions	U/s Utilisation	Estimated yield at % dependability				Remarks
								Average	50%	75%	90%	
	1	**2**	**3**	**4**	**5**	**6**	**6**	**7**	**8**	**9**	**10**	**11**
4	Central Designs Organisation, Irrigation Department, Government of Maharashtra.	1994	Rainfall data of 100 rain gauge stations for 31 years. Isohyetal map is prepared to demarcate ghat & non ghat catchment area.	(i) 1968-69 to 1985-86 (18 years) Jayakwadi Reservoir data. (ii) CWC's Kaygaon Toka R.G. data for 1968-69 to 1974-75.	* Virgin series of 1990 considered. * Ghat belt catchment Area and non ghat catchment area demarcated based on Isohytal map.	*Post monsoon flow as 10 % *Regeneration flow as 10% of u/s utilization.	4438 MCM 156.7 TMC (including Major , Medium, Minor, K.T. Weirs, L.I. Schemes	2130 MCM 75.2 TMC	2003 MCM 70.72 TMC	1678 MCM 59.27 TMC	1295 MCM 45.73 TMC	Ref: Jayakwadi – Majalgaon Project, water availability & simulation studies, Central Designs Organisation, Nasik (I.D.GOM) July 1994 P. 9 to 17 & 41
5	Water and Power Consultancy Services (India) Ltd. WAPCOS New Delhi.	1998	30 Years (1964-65 to 1993-94) for 50 rain gauge stations	19 years (1975 to 1993) inflow at Paithan Dam, 1976-1993 inflow in major Projects on u/s & 1982-1993 inflow in Medium Projects on u/s	Rainfall – Runoff co-relation.	Return flow of 10 % of Irrigation releases.	Maximum 4063 MCM 143 TMC (1976) & Minimum 1573 MCM (1986) Annex.6 P.173			798 MCM 28 TMC (Appendix. VII P. 2)		Ref: Pilot Water Resources Study of Godavari Basin up to Paithan Dam- Final Report Vol. II, March 1998 by WAPCOS

Sr. No.	Organization	Year of Study	Rainfall series details	Run off series details	Methodology	Assumptions	U/s Utilisation	Estimated yield at % dependability				Remarks
								Average	50%	75%	90%	
	1	2	3	4	5	6	6	7	8	9	10	11
6	Maharashtra Water and Irrigation Commission	1999	No Separate analysis was done but estimate is based on Central Designs Organisations Studies.				3950 MCM 139.48 TMC (Mula + Pravara 1730 MCM and other 2220 MCM	3317 MCM 117.13 TMC	2767 MCM 97.7 TMC	1292 MCM 45.62 TMC	Not Available	Ref: Maharashtra Water and Irrigation Commission's Report 1999. (Upper Godavari Report P. 44 to 47)
7	Central Designs Organisation, Irrigation Department, Government of Maharashtra.	Nov. 2001	31 Years latest rainfall series from 1955 to 1985	Runoff series for 31 years (1955 to 1985) considering month wise inflows in u/s storage & Jayakwadi Storage.	Rainfall - Runoff co-relation.	*Post monsoon flow as 10 % *Regeneration flow as 10% of u/s diversion.	4385 MCM 154.8 TMC (including Minor,& Local Sector Schemes)	1627 MCM 57.45 TMC	1514 MCM 53.46 TMC	759 MCM 26.8 TMC	257 MCM 9.08 TMC	Ref: Jayakwadi – Majalgaon Project, water availability & simulation studies, Cenral Designs Organisation, Nasik (I.D.GOM) Nov.2001 P. 5, 6, 17

4.2.2 Actual Yield Received

Actual yield received in Jayakwadi reservoir from 1975 to 2010 is given in Table 4.2. The analysis of this 36-year series reveals following facts.

(i) Actual 75% dependable yield = 802 Mm^3 which is about 30% of yield estimated during revision of project in the year 1985.

(ii) Average yield is 2456 Mm^3 which tallies with 75% dependable yield estimated in revised project report (1985). Though 75% dependable yield is 30% of yield estimated in Revised Project Report (1985), if year wise actual yield and planned utilization is considered for 36 years series, the comparison of actual availability of yield and planned utilization as given below in the table.

Planned utilization including kharif irrigation of Jayakwadi proper i.e. PLBC & PRBC as per original project report (1964) is 1988 Mm^3.

% of actual yield with respect to planned utilization on (PLBC + PRBC) including kharif.	**No. of Years (out of 36)**
75% and above	23 (64% years)
50% to 74%	3 (8% years)
30% to 49%	5 (14% years)
Less than 30%	5 (14% years)
Total:	**36**

Above analysis shows that for 26 years out of 36 years (i.e.72% years) actual yield received was more than 50 % of planned utilization and for 23 years (64%years) out of 36years, yield received is more than 75 % of planned utilization.

(iii) Considering the soil property of command area to retain soil moisture for a prolonged period and trend of post monsoon rain showers in the command, in general there is no water demand for irrigation in kharif season. Therefore, if planned utilization in Rabi & H.W. season only (excluding kharif) is considered (1741 Mm^3) and compared with actual yield received, it reveals following facts.

% of actual yield with respect to planned utilization in Rabi & H.W. season on PLBC & PRBC (excluding kharif.)	**No. of Years (out of 36)**
75% and above	25 (70% years)
50% to 74%	1 (3% years)
30% to 49%	7 (20% years)
Less than 30%	3 (7% years)
Total:	**36**

It shows that for 25 years out of 36 (70% years) actual yield received is more than 75% of planned utilization in Rabi & H.W. Season.

The graphical presentation of actual yield and planned utilization is shown in Fig.4.1.

This analysis shows that as for as planned Rabi & HW utilization is concerned, for more than 70% years there was no shortage of water. Even if water storage of 150 Mm^3 maximum up till now, is diverted for non-irrigation purposes, Prima facie it appears that, it shall not have any effect on the irrigation potential.

4.2.3 Effects of upstream Utilisation:

The details of upstream utilization are given in tables as indicated below.

Table 4.3: Major and Medium Projects

Table 4.4: Minor Irrigation Projects (State Sector)

Table 4.5: Local Sector Schemes (up to 250 ha.)

Table 4.6: Watershed Development Schemes

Table 4.7: Status of Ground Water Development

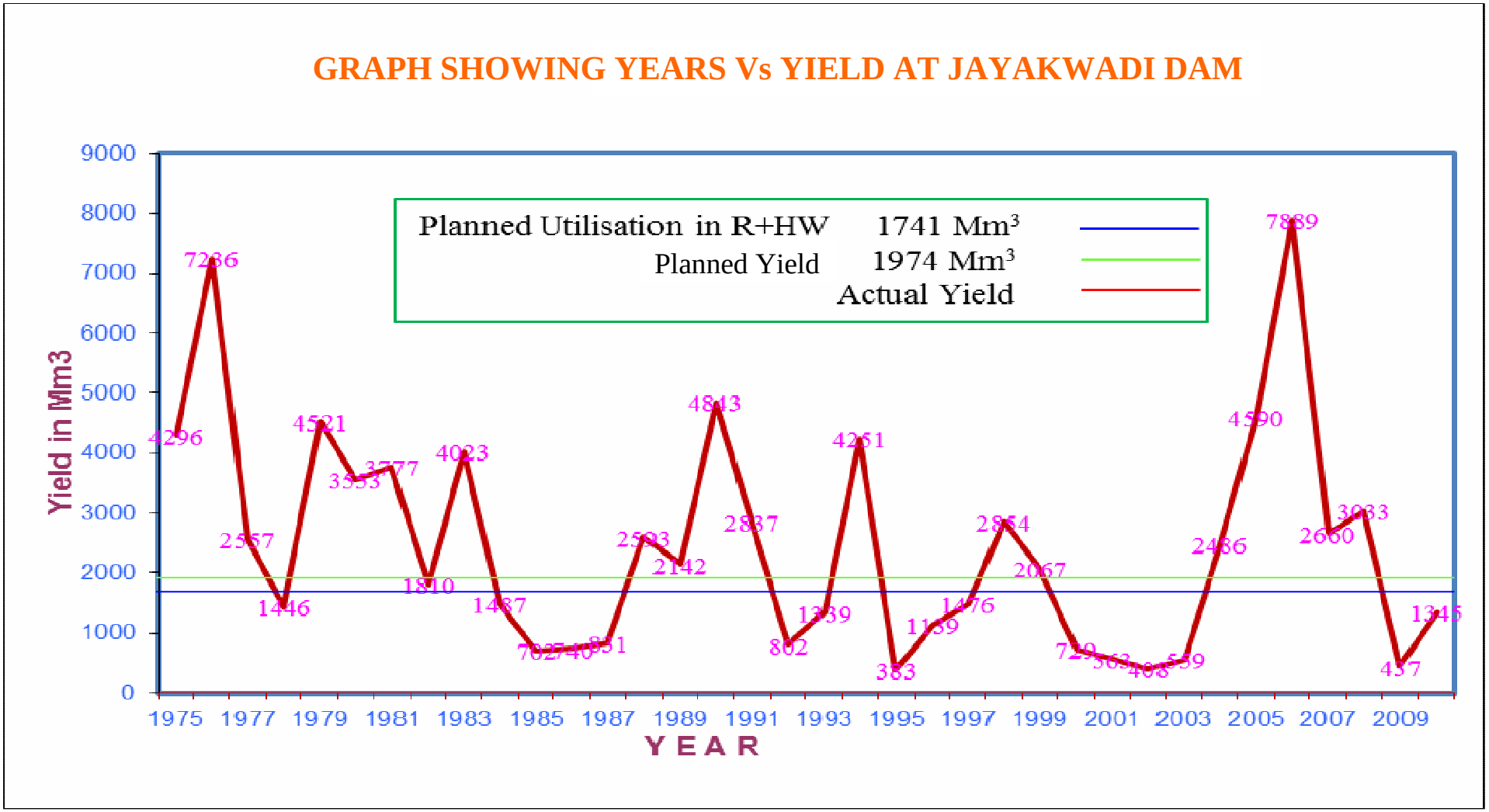

GRAPH SHOWING YEARS Vs YIELD AT JAYAKWADI DAM
Planned Utilisation in R+HW 1741 Mm³
Planned Yield 1974 Mm³
Actual Yield
Yield in Mm3
YEAR
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009
4296
7286
2567
1446
4521
3553
3777
1810
4023
1487
782
740
851
2583
2142
4813
2837
802
1339
4251
383
1139
1476
2854
2067
729
562
408
539
2486
4590
7889
2660
3083
457
1345

Fig. 4.1

The present practice of yield estimation at a particular point does not take into account the water interception/detention through local sector schemes and watershed development schemes. However as the water demands at local level are increasing, more and more such small-scale water interception/detention schemes are being constructed. As the numbers of such schemes are increasing day-by-day, the volume of water diverted/detained by them is considerable. This also reduces the net inflow received at particular project site, In case of Jayakwadi Project the total u/s interception in a normal year through all projects/schemes is given below. It is based on the details given in Table 4.3 to 4.7.

U/S Utilisation

Category	**Utilisation (Mm^3)**	**Reference**
1) Major & Medium Projects	3000	Table 4.3
2) Minor Projects (State Sector)	452	Table 4.4
3) Local Sector Schemes	709	Table 4.5
4) Water shed Development Schemes	65	Table 4.6
Total:	**4226**	

The Vargin runoff estimated during project design (1985) is as given below.

Dependability	**Virgin Runoff Mm^3**	**Total u/s Diversion Mm^3**	**Net yield available at Jayakwadi Mm^3**
75%	5566	4226	1340
50%	6634	4226	2408

As per approved project report of Jayakwadi, (1985), planned upstream reservation is 3271 Mm^3 (115.5 TMC). However present planned upstream diversion including on-going as well as small schemes is 4226 Mm^3. This indicates that there is more interception of water on U/s side. If ongoing schemes are completed, Jayakwadi may receive less yield as compared to 75% dependable yield contemplated in the project report. Water availability at 50% dependability is 2408 Mm^3, which matches with the originally planned utilization.

4.3 Conclusion:

a. Yield estimates have been revised from time to time considering latest rainfall – runoff series and adopting latest methodology. The latest study of 2001 estimates net 75% dependable yield at Jayakwadi site as 759 Mm^3 against originally planned yield of 1974 Mm^3 in the year 1964.

b. Actual yield received in Jayakwadi reservoir from 1975 to 2010 gives 75% dependable yield as 802 Mm^3.

   Although actual total yield received in the reservoir is less than the planned, whatever yield-received year wise is adequate to meet 75% demands of planned irrigation utilization in Rabi and HW season for 70% years.

c. The main reason for receiving less yield in Jayakwadi is excessive interception of water on upstream i.e. 4226 Mm^3 against 3271 Mm^3 assumed in project planning.

d. The contribution of volume of water diverted due to local sector and watershed development scheme towards reduction in the yield is considerable i.e. 774 Mm^3 which is about 40% of planned yield of 1974 Mm^3. Such extraction is not considered at present during hydrological yield estimation.

e. The future schemes in catchment area shall not be taken up in order to safeguard the investment in Jayakwadi to some extent.

f. All major, medium, minor and small schemes in the catchment of Jayakwadi project should be redesigned based on 75% dependability and water use on U/s be restricted.

g. The principle of river basin planning and management as stipulated in state water policy by sharing shortages shall be implemented seriously.

h. Ground water extraction in catchment area is about 1975 Mm^3 for 2008 which is far more than the regeneration flow assumed in project planning (regeneration assumed is 7.5% i.e. about 200 Mm^3). This type of situation exists in almost all parts of the state. Therefore, regeneration flow may not be considered while planning the storages hereafter.

Table 4.2
Actual Yield received
(From 1975 to 2010)

Sr.No	Year	Yield received (Mm^3)	% w.r.t. Planned yield of 1974 (Mm^3)	% w.r.t. Planned utilisation for Yayakwadi (PLBC & PRBC) i.e. 1988 including Kharif (Mm^3)	% w.r.t. Planned utilisation in Rabi & HW season on Jayakwadi (PLBC & PRBC) i.e. 17410 Mm3 Utilisation in Kharif for *(1988 - 247 Mm^3)	Descending order	
						Year	Yield in Mm^3
1	2	3	4	5	6	7	8
1	1975	4296	218	216	247	2006	7889
2	1976	7236	367	364	416	1976	7236
3	1977	2557	130	129	147	1990	4843
4	1978	1446	73	73	83	2005	4590
5	1979	4521	229	227	260	1979	4521
6	1980	3553	180	179	204	1975	4296
7	1981	3777	191	190	217	1994	4251
8	1982	1810	92	91	104	1983	4023
9	1983	4023	204	202	231	1981	3777
10	1984	1487	75	75	85	1980	3553
11	1985	702	36	35	40	2008	3033
12	1986	740	37	37	43	1998	2854
13	1987	831	42	42	48	1991	2837
14	1988	2593	131	130	149	2007	2660
15	1989	2142	109	108	123	1988	2593
16	1990	4843	245	244	278	1977	2557
17	1991	2837	144	143	163	2004	2486
18	1992	802	41	40	46	1989	2142
19	1993	1339	68	67	77	1999	2067
20	1994	4251	215	214	244	1982	1810
21	1995	383	19	19	22	1984	1487
22	1996	1139	58	57	65	1997	1476
23	1997	1476	75	74	85	1978	1446
24	1998	2854	145	144	164	2010	1345
25	1999	2067	105	104	119	1993	1339
26	2000	729	37	37	42	1996	1139
27	2001	563	29	28	32	1987	831
28	2002	408	21	21	23	1992	802
29	2003	559	28	28	32	1986	740
30	2004	2486	126	125	143	2000	729
31	2005	4590	233	231	264	1985	702
32	2006	7889	400	397	453	2001	563
33	2007	2660	135	134	153	2003	559
34	2008	3033	154	153	174	2009	437
35	2009	437	22	22	25	2002	408
36	2010	1345	68	68	77	1995	383
Aver-age:		**2456**					

90%	33rd	559	Mm^3
75%	28th	802	Mm^3
60%	22nd	1476	Mm^3
50%	18.5th	2105	Mm^3
Avg.		2456	Mm^3

*Utilisation in Kharif 247 Mm^3

Table 4.3

Details of Major and Medium Projects on U/S of Jayakwadi Project

Particulars	Sr.No.	Project	Category	Live Storage Mm3	Planned Utilisation Mm3
1	2	3	4	5	6
(A) Completed	1	Bhandardara	Major	304.1	413.66
	2	Mula	Major	608.89	656.56
	3	Darna	Major	202.42	202.44
	4	Gangapur	Major	159.42	203.76
	5	Palkhed	Major	21.24	55.9
	6	Waghad	Major	72.23	43.35
	7	Kranjwan	Major	152.08	150.94
	8	Punegaon	Major	17.57	17.57
	9	Ozarkhed	Major	60.32	60.32
	10	Tisgaon	Major	12.76	12.76
	11	Mukane	Major	204.98	214.16
	12	Kadwa Project	Major	52.91	52.91
			TOTAL:	**1868.92**	**2084.33**
	1	Adhala	Medium	27.6	25.06
	2	Mandohol	Medium	8.78	8.87
	3	Bhojapur	Medium	10.21	10.21
	4	Alandi	Medium	27.47	27.47
	5	Ambadi	Medium	9.42	12.76
	6	Dheku	Medium	12.15	17.7
	7	Kolhi	Medium	3.23	3.99
	8	Bordahegaon	Medium	11.47	17.06
	9	Narangi	Medium	11.49	14.63
	10	Tembhapuri	Medium	19.26	25.17
	11	Bramhgavan L I S	Medium	27.46	27.46
	12	Devgaon Rangari	Medium	9.65	10.41
			TOTAL:	**178.19**	**200.79**
(B) On going	1	Upper Pravara (Nilvande-2)	Major	228.75	313.46
	(a)	Wambori Irr. Canal	Major	0	19.26
	(b)	Bhagada Irr. Canal	Major	0	1.7
	2	NMC Project	Major		
	(a)	Bhavali	Major	40.79	46.73
	(b)	Waki	Major	70.57	70.57
	(c)	Bham	Major	69.39	75.05
			TOTAL:	**409.5**	**526.77**
	1	Tajnapur LIS	Medium	0	45.77
	2	Gautami Godavari Project	Medium	53.34	53.34
	3	Kashyapi Project	Medium	52.43	52.43
	4	Shivana Takali	Medium	36.45	36.455
			TOTAL:	**142.22**	**187.995**
(C) Future	1	Nil	Nil	Nil	Nil
		TOTAL (A+B+C)		**2598.83**	**2999.76**

Planned utilisation of completed and on going projects is 2999.76 Say 3000 Mm3

Table 4.4

Details of Minor Irrigation Project on U/s of Jayakwadi Project (including LIS,KT weirs, Storage schemes) (State Sector Projects)

Total No. of Projects	Total Live Storage, Mm^3	Planned Utilisation, Mm^3
(a) Completed (154)	286.43	308.44
(b) Ongoing(30)	123.54	143.06
(c) Future (75)	227.74	246.97
TOTAL (a+b+c)	**637.71**	**698.47**

ABSTRACT

(i) Planned utilization including future schemes = 698 Mm^3

(ii) Planned utilization excluding future schemes. = 452 Mm^3

Table 4.5
Details of Local Sector Scheme on U/s (00 - 100 ha & 101 - 250 ha)
(as on 01/04/2009, Ref. Local Sector Booklet)

Sr.No.	District	Category	Total No. of Schemes		Total Storage in Mm^3		Tank Type
			0-100	101-250	0-100	101-250	
1	2		3	4	5	6	7
1	Nashik	Completed	3	38	2.41	53.22	Minor Tank
		Ongoing	1	5	0.53	8.01	
		Future	0	33			
2	Ahmadnagar	Completed	1	27	0.56	114.44	
		Ongoing	0	1	0	0.28	
		Future	0	12			
3	Aurangabad	Completed	43	29	12.26	28.14	
		Ongoing	1	2	1.92	1.47	
		Future	0	20			
1	Nashik	Completed	840	1	42.13	1.73	K.T.W.
		Ongoing	206	1	6.65	0.62	
		Future	0	6			
2	Ahmadnagar	Completed	28	28	5.12	8.77	
		Ongoing	6	8	1.67	7.13	
		Future	8	7			
3	Aurangabad	Completed	549	13	49.86	12.8	
		Ongoing	101	1	10.25	1.13	
		Future	200	20			
1	Nashik	Completed	9				LIS
		Ongoing	21	1	0		
		Future	0	0	0	0	
2	Ahmadnagar	Completed	7	0	0	0	
		Ongoing	11	3			
		Future	0	1			
3	Aurangabad	Completed	6	2			
		Ongoing	0	0	0	0	
		Future	0	0	0	0	
1	Nashik	Completed	1385	0	220.78	0	P.T.
		Ongoing	140	0	27.77		
		Future	100	0	0		
2	Ahmadnagar	Completed	1821	1	300.85	0.45	
		Ongoing	14	0	2.55		
		Future	20	0			
3	Aurangabad	Completed	2086	0	256.42	0	
		Ongoing	99	0	9.79		
		Future	80	0			
1	Nashik	Completed	1005	0	59.42		Village Tank
		Ongoing	390	0	19.31		
		Future	130	0			
2	Ahmadnagar	Completed	578	0	30.23		
		Ongoing	4	0	0.22		
		Future					
3	Aurangabad	Completed	160	0	7.24		
		Ongoing		39	2.88		
		Future		0	0		
	TOTAL				**1153.5**	**238**	

Total Storage for whole Nashik, Ahmednagar and Aurangabad District (1153+238 = 1391) 1391

Proportionate storage for a catchment area of Jayakwadi Project falling in
these three District (51%) 1391 x 0.51 = 709

Table 4.6

Details of Watershed Development on U/s

District	Total Area of Watersheds in the catchment (ha)	Area treated under Watershed* Development Schemes (ha)
Nashik	5,12,500	1,02,500
Ahmednagar	7,67,200	1,53,440
Aurangabad	2,22,400	66,720
TOTAL		**3,22,660**

* Figures shown in col. 3 belongs to year 2007

As per norms given in Technical Manual on Watershed Development, MOA, GOI, the water harvesting/conservation through different types of treatment is as given below.

CCT = 180 to 200 m^3/ha

Contour Bunds = 450 m^3/ha

Forest & Pasture = 225 m^3/ha

Considering minimum water harvest of 200 m^3/ha of treated area, the present total approximate water diversion through treatment of 3,22,660,ha is

3,22,660 ha x 200 200 m^3/ha = 65 Mm^3

Table 4.7

Status of Groundwater Development in Catchment of Jayakwadi Project

Year	Groundwater use Mm^3
1998	889
1995	921
2004	1062
2008	1975

Source (Reports of G.S.D.A. GOM)

5 Review of Water Planning

5.1 Introduction:

The review of water planning and allocation for different canals and purposes is taken in this chapter. The Jayakwadi Project was originally formulated in the year 1964 and subsequently revised in the year 1985. The summary of water planning and allocation is presented in this chapter. Similarly the actual water allocation for various purposes, year wise, since inception of the project is also presented. The data made available by CAD authority, Aurangabad is used for this purpose.

5.2 Water planning in project design.

The details of water planning and allocation as per 1985 report are as given bellow.

- Gross Storage : 2909 Mm^3
- Live Storage : 2171 Mm^3
- Carryover Storage : 382 Mm^3 (17% of live storage)
- Annual Evaporation : 665 Mm^3
- Evaporation after monsoon: 451 Mm^3
- Utilization at canal head :

  PLBC: 1076 Mm^3

  PRBC: 318 Mm^3

  1394 Mm^3

  (Kharif 248 Mm^3 + Rabi 895 Mm^3 + HW 251 Mm^3)
- Non Irrigation use: Nil
- Utilisation for Irrigation on Reservoir Lift: Nil
- Diversion for Majalgaon Project
  In good Years: 350 Mm^3
- Efficiency:
  - Conveyance efficiency: 75%
  - Field application efficiency: 65%
  - Overall efficiency: 49%
- Silt rate: 0.75 acre-feet/Sq.mile of C.A

  . (3.57 ha-m/100 sq.km/year)
- Silt Storage:
  - Up to Sill level of H.R.: 452 Mm^3
  - Up to M.D.D.L. : 738 Mm^3

5.3 Actual Water Utilisation:

The year wise actual water utililisation since 1974 – 75 is given in Table 5.1. The analysis of data given in this table indicates following facts:

a) Water use for Non-Irrigation purposes is increasing year by year from 3.8 Mm^3 in 1975-76 to 154 Mm^3 in the year 2004-05. It is to be noted that as per project planning the provision for non-irrigation use is Nil.

b) In Jayakwadi project water planning like Bhima Project, (a similar major project in Bhima valley), there is no provision for utilisation of water for Lift irrigation from Reservoir. However, at present total sanction for 46735 ha area belonging to individual farmers, Co-Operative schemes and Government schemes is granted, there by allowing 233 Mm3 of water to be used for lift irrigation which is not considered during original project planning. Purpose of sanctioning water quota for lift irrigation to farmers residing adjacent to reservoir and who have sacrificed their land for project may be similar to providing water for irrigation to command area. Such allocation of water will definitely have certain implications in future when potential utilisation will be close to project planning. The maximum water use for Lift Irrigation on reservoir noticed so far is 179.24 Mm3. The details of schemes sanctioned are given below

Type of Scheme	**Details of Sanctions for lifts**		**Details of working schemes**		**Maximum Area Irrigated in 2006-07**	**Maximum Water Use (Mm^3)**
	Nos.	**Area (Ha)**	**Nos.**	**Area (Ha)**	**Area (Ha)**	
Co-operative	27	19982	2	447	38236	179.24
Government	3	20331	1	3205		
Individual	3929	3376	3929	3376		
Individual (Sprinkler)	2826	3046	2826	3046		
Total	6785	46735	6758	10074		

c) In project planning, no provision for silt accumulation in live storage is made. Actual silt depositions in live storage have resulted in less availability of water for irrigation thereby affecting actual water planning.

d) Out of 33 years, for 16 years i.e. almost 50% years, live storage from 13 Mm3 to 830 Mm3 remained unutilized at the end of irrigation year. Out of these 16 years for 10 years, unutilised storage was more than designed Carry over.

The abstract of the same is given below.

Abstract of Unutilised Water

Year	Live Storage Mm^3	% of Live Storage	Total Water use Mm^3	Balance at the end of Irrigation Year Mm^3 (%)
1976 - 77	1162	53	798	364 (31)
1977 - 78	939	43	742	197 (21)
1979 - 80	1468	68	993	473 (32)
1981 - 82	1600	74	1376	224 (14)
1983 - 84	2038	94	1463	575 (28)
1984 - 85	1751	81	1523	228 (13)
1988 - 89	2042	94	1620	422 (20)
1990 - 91	2171	100	1775	396 (18)
1992 - 93	690	32	677	13 (2)
1998 - 99	2127	98	1297	830 (39)
1999 - 2000	2167	100	1555	612 (28)
2000 - 2001	1282	59	1247	35 (3)
2004 - 2005	2129	98	1370	759 (36)
2005 - 2006	2171	100	1712	459 (21)
2006 - 2007	2171	100	1641	530 (25)
2007 - 2008	2171	100	1796	375 (17)

5.4 Conclusion:

From above data it is seen that, up to Irrigation year 2000-2001 unutilised storage including Designed carry over when reservoir was 100 % full or was close to it varies between 17% to 39%. On the backdrop of such unutilised storage and supply of water for Non Irrigation purposes along with reduction of live storage capacity due silt accumulation, since last 8 to 10 years, the project authorities have adopted policy of not making any provision for Design Carry Over in the Preliminary Irrigation Program. However, unutilised storage after 2000-2001 is still between 17 to 35%. The reasons for such unutilisation excluding inflow in June and late showers in Rabbi season needs to be explored.

On this background, at present the impact of diversion of water for non-irrigation purposes on utilization of irrigation potential is less significant than that of water remaining un-utilised at the end of irrigation year. The water remaining un-utilized in the year 2004-05 is 759 Mm^3 (about 39 % of live storage) which amounts to about 1,13,850 ha. of irrigation.

Table 5.1
Utilisation of Water (Mm3)
Jayakwadi Project (Paithan)

Year	Total Storage	Live Storage	%	water let through Canal				Non Irrigation use	Evaporation	Irrigation (LIS)	Total 9+10+11	Grand Total (8+12)
				Kharif	Rabi	H.W.	Total Irrigation					
1975-76	873	135	6.23	18.31	112.69	32.17	163.17	3.77	302.37	4.10	310.23	473.40
1976 - 77	1900	1162	53.54	69.75	143.93	25.18	238.86	3.49	545.44	10.25	559.19	798.05
1977 - 78	1677	939	43.26	51.31	95.13	37.96	184.39	3.49	543.53	11.47	558.49	742.88
1978 - 79	1434	696	32.05	71.83	208.41	136.45	416.68	5.00	377.93	7.81	390.73	807.41
1979 - 80	2206	1468	67.63	125.47	209.43	194.58	529.48	5.30	452.04	6.53	463.88	993.35
1980 - 81	1340	602	27.73	148.91	272.79	291.36	713.05	6.56	309.26	5.19	321.01	1034.06
1981 - 82	2338	1600	73.70	209.12	356.95	336.84	902.91	9.96	455.73	7.57	473.25	1376.17
1982 - 83	1949	1211	55.76	277.07	450.33	375.82	1103.21	13.61	435.72	7.22	456.56	1559.77
1983 - 84	2776	2038	93.87	64.14	409.36	454.80	928.30	13.38	511.49	10.07	534.94	1463.24
1984 - 85	2489	1751	80.67	240.02	439.00	419.46	1098.48	16.41	398.16	9.83	424.39	1522.88
1985 - 86	1401	663	3.55	242.77	268.47	161.81	673.05	20.54	258.06	17.23	295.83	968.88
1986 - 87	1043	305	14.03	139.39	25.37	19.38	184.13	22.57	272.83	25.16	320.55	504.68
1987 - 88	1213	475	21.89	18.26	36.21	110.38	164.84	19.33	255.62	41.19	316.14	480.98
1988 - 89	2780	2042	94.04	5.63	484.74	669.41	1159.77	21.38	379.50	59.26	460.14	1619.91
1988 - 90	2714	1976	91.02	75.71	682.73	552.74	1311.19	19.93	394.46	53.42	467.82	1779.00
1990 - 91	2909	2171	100.00	115.57	442.98	686.59	1245.14	30.82	453.68	45.18	529.68	1774.82
1991 - 92	2417	1679	77.32	400.68	771.96	397.74	1570.37	38.09	428.54	46.31	512.94	2083.31
1992 - 93	1428	690	31.80	17.80	270.18	0.38	288.35	58.96	276.37	53.72	389.05	677.40
1993 - 94	1501	763	35.15	0.24	191.10	483.05	674.40	48.23	288.65	57.80	394.67	1069.07
1994 - 95	2652	1914	88.16	260.16	578.58	711.70	1550.44	52.23	411.12	101.18	564.53	2114.97
1995 - 96	1044	306	14.10	0	158.94	0	158.94	73.33	141.54	21.81	236.68	395.62
1996 - 97	1509	770	35.49	0	199.21	238.30	437.51	54.85	330.46	22.29	407.60	845.11
1997 - 98	1807	1069	49.23	75.24	202.43	373.06	650.73	72.57	344.22	52.10	468.89	1119.62
1998 - 99	2865	2127	97.96	0	274.52	512.56	787.08	69.96	383.43	56.94	510.34	1297.42
1999 - 2000	2905	2167	99.83	77.10	426.29	506.38	1009.77	68.48	414.46	62.19	545.13	1554.90
2000 - 2001	2020	1282	59.04	100.90	477.39	272.11	850.40	72.01	295.42	29.48	396.91	1247.31
2001 - 2002	1232	494	22.76	22.62	201.53	33.85	258.00	79.58	200.05	11.82	291.45	549.45
2002 - 2003	1142	404	18.63	0	66.13	0	66.13	102.74	204.42	71.54	378.71	444.84
2003 - 2004	1131	393	18.09	0	0	0	0	154.09	206.94	137.21	498.25	498.25
2004 - 2005	2867	2129	98.07	7.91	419.20	331.18	758.29	150.29	296.50	165.20	611.99	1370.27
2005 - 2006	2909	2171	100.00	73.29	408.82	570.92	1053.03	142.67	337.21	179.24	659.12	1712.15
2006 - 2007	2909	2171	100.00	100.21	488.38	475.28	1063.86	114.10	346.76	116.64	577.50	1641.36
2007 - 2008	2909	2171	100.00	89.94	652.56	485.49	1227.99	129.35	312.78	125.64	567.77	1795.76

6 Impact on Agriculture System:

6.1 Introduction:

The objective of this chapter is to study the impact of variations in water availability on agriculture system. The data collected from CADA, Aurangabad and from other related organizations is used to study the impact with respect to actual crop pattern, crop yield, adequacy of water, irrigation scheduling etc.

6.2 Indicators for performance evaluation of agriculture system:

The actual yield received in Jayakwadi storage with respect to planned utilization during last 36 years (1975 to 2010) is as given below (chapter 4, Para 4.2.2)

% of actual yield with respect to planned utilization	No. of successful years (out of 36)
75% and above	**23**
50% to 74%	**3**
30% to 49%	**5**
Less than 30%	**5**

There are 10 years during which actual yield received is less than 50% and there are 10 years in which yield received is above 90%. Impact of this variable availability on agricultural system is evaluated using following indicators.

6.2.1 Actual Crop Pattern:

(a) Actual crop pattern in normal years:

The crop wise area irrigated in normal years (i.e. yield almost 100%) and its comparison with respect to designed crop pattern is given in Table 6.1

Table 6.1

Jayakwadi Project

Actual Crop Pattern in Normal years (Yield less than 100%)

Sr.No.	Crop	As per Design		Actual Area Irrigated in Normal Years									Average	% w.r.t. ICA
		%	Area (ha)	1983-84	1988-89	1989-90	1990-91	1998-99	1999-2000	2004-05	2005-06	2006-07		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Rice	10	18332	357	0	0	4	0	0	0	0	0	40	0.02
2	K.Jawar	12	21999	3935	0	2205	328	87	1726	0	253	7901	1826	1
3	Wheat	25	45830	9423	10779	13230	10925	6347	8347	1174	13595	22461	10698	5.84
4	R.Jawar	15	27498	5267	11739	12006	4151	4385	6147	174	4459	9179	6390	3.49
5	Gram	5	9166	2261	4446	6565	9394	372	1451	21	7561	3218	3921	2.14
6	Cotton	25	45830	845	0	1107	47	9267	13513	0	4320	6729	3981	2.17
7	Chillie & other	3	5500	193	0	781	30	305	1258	216	283	3943	779	0.42
8	Ground nut (HW)	3	5500	4542	21422	13919	17884	12235	10398	386	23846	0	11626	6.34
9	Shugarcane	3	5500	5912	8273	12183	11381	10329	14266	1869	26945	38452	14401	7.86
10	Other Perennials	1.5	2750	311	0	187	226	0	83	249	2431	1406	544	0.3
	Total		**187905**	**33046**	**56659**	**62183**	**54370**	**43327**	**57189**	**4089**	**83693**	**93289**		

Table 6.2

Jayakwadi Project

Actual Crop Pattern in Deficit Years (Yield nearly 50%)

Sr.No.	Crop	As per Design		Actual Area Irrigated in Normal Years									Average	% w.r.t. ICA
		%	Area (ha)	1985-86	1986-87	1987-88	1992-93	1995-96	2000-01	2001-02	2002-03	2003-04		
1	Rice	10	18332	225	52	0	0	0	0	0	0	0	31	0.02
2	K.jawar	12	21999	3801	4368	2007	49	29	1458	278	0	577	1396	0.76
3	Wheat	25	45830	4022	1016	948	2589	1136	10302	5171	5023	3281	3721	2.03
4	R.Jawar	15	27498	9885	4534	3135	10781	1875	6672	3329	2732	1937	4987	2.72
5	Gram	5	9166	5087	1244	592	5773	817	1045	587	439	369	1773	0.97
6	Cotton	25	45830	3882	488	512	492	1329	7488	3460	349	349	2039	1.11
7	Chillie & Other	3	5500	773	407	236	168	0	938	249	117	129	335	0.18
8	Groundnut (H.W.)	3	5500	1042	295	3751	134	0	2587	120	50	250	914	0.5
9	Sugarcane	3	5500	4901	1383	2976	2634	1698	20319	6611	2157	3755	5159	2.81
10	Other Perennials	1.5	2750	488	234	152	137	531	341	184	54	303	269	0.15
	TOTAL :		**187905**	**34106**	**14021**	**14309**	**22757**	**7415**	**51150**	**19989**	**10921**	**10950**		

(b) Actual crop pattern in deficit years:

The crop wise area irrigated in deficit years (yield less than 50%) and its comparison with respect to designed crop pattern is given in Table 6.2.

The comparison of crop pattern in normal and deficit years is given below in Table 6.3

Table 6.3

Comparison of crop pattern

Crop	% as per design	Actual %	
		Normal Years	Deficit Years
• Rice	10	0.02	0.02
• K.Jowar	12	1	0.75
• Wheat	25	5.84	2.03
• R.Jowar	15	3.5	2.72
• Gram	5	2.14	0.97
• Cotton	25	2.17	1.11
• Chillies & other	3	0.42	0.18
• Groundnut (H.W.)	3	6.34	0.5
• Sugarcane	3	7.83	2.81
• Other perennials	1.5	0.3	0.15

The above comparison indicates following results.

(i) Actual crop pattern in normal years is very much different than designed crop pattern e.g. Rice is almost nil, cash crops like sugarcane, and H.W. Ground nut are more (almost double the design cropping pattern), cotton is almost negligible, cereals are also minimum. This indicates that farmers prefer remunerative cash crops in normal years.

(ii) Sugarcane is tolerant to water stress and hence grown in larger proportion.

(iii) In deficit years, wheat and cash crop like hot weather groundnut is reduced to greater extent because they are sensitive to water stress.

6.2.2 Adequacy of Water Supply:

The year wise, crop wise area irrigated is given in Table 6.4. The water requirement based on Penman method is considered to work out the volume of water required at canal head assuming designed overall efficiency of 49%. This requirement is converted into root zone requirement. The actual Water Supplied at Canal head is converted to water received at root zone. (Actual overall efficiency of 21% is considered to workout adequacy of water at root zone). The analysis shows that average adequacy of water supply at root zone is 64% for 24 years. This indicates that crops received 36% less water than their requirement in most of the years although water supply at canal head is more than adequate.

6.2.3 Utilization of Crop Yield Potential:

The comparison of actual crop yield in the sub-basin with potential yield (front line demonstration) for major crops is given below in table 6.5

Table 6.5

Comparison of crop yield

Serial No.	Crop	Average Yield (kg/ha)	Potential Yield (kg/ha)	% of Average yield
1	Kh Sorghum	1166	2157	54
2	Wheat	1359	2110	64
3	Rabi Sorghum	945	1649	57
4	Gram	682	1105	61
5	H.W. Groundnut	1511	1800	84
6	Cotton (lint)	440	960	46
7	Sugarcane	68.5 (T/ha)	103 (T/ha)	67

The comparison of actual yield and potential yield show that actual yield is 16 to 50% less than the potential yield. This is because of following reasons.

(i) Inadequate water supply at root zone (about 36% less) due to poor overall irrigation efficiency.

(ii) Inputs other than water e.g. Seeds, cultivation practice etc. might also be affecting the yield.

6.3 Conclusion:

The performance of agriculture system is not satisfactory due to following reasons.

(i) Reduced supply of water at root zone, although water supply at canal head is more than adequate.

(ii) Ad-hoc irrigation management

(iii) Poor overall irrigation efficiency.

(iv) The adverse impact on agriculture system is mainly due to poor management rather than due to changing water allocation.

Table 6.4
Jayakwadi Project - Crop wise Area Irrigated (ha)

Season	Crop	NIR (mm) at root zone	75-76		76-77		77-78		78-79		79-80		80-81		81-82	
			Area (ha)	WR at Canal head Mm^3	Area (ha)	WR at Canal head Mm^3	Area (ha)	WR at Canal head Mm^3	Area (ha)	WR at Canal head Mm^3	Area (ha)	WR at Canal head Mm^3	Area (ha)	WR at Canal head Mm^3	Area (ha)	WR at Canal head Mm^3
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Kharif	Rice	392	225	1.80	8061	64.49	1303	10.42	641	5.13	324	2.59	175	1.40	1316	10.53
	Hy Jawar	40	1860	1.52	9383	7.66	5208	4.25	2118	1.73	800	0.65	398	0.32	3439	2.81
	Bajri	40	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
	Telbiya (Oil Seed)	0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
	Groundnut	150	0	0.00	22	0.07	326	1.00	537	1.64	310	0.95	202	0.62	1530	4.68
	Other	40	2150	1.76	1473	1.20	2110	1.72	1079	0.88	1047	0.85	513	0.42	3382	2.76
Total			4235	5.07	18939	73.42	8947	17.40	4375	9.38	2481	5.05	1288	2.76	9667	20.78
Rabi	Wheat	403	6500	53.46	10567	86.91	8103	66.64	5619	46.21	4008	32.96	4212	34.64	5843	48.06
	R.Jawar	268	5300	28.99	13193	72.16	5106	27.93	5823	31.85	4496	24.59	7759	42.44	2485	13.59
	Gram	195	1000	3.98	861	3.43	930	3.70	703	2.80	612	2.44	922	3.67	1138	4.53
	Sunflower	200	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
	Groundnut	120	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
	Other	195	500	1.99	269	1.07	338	1.35	431	1.72	368	1.46	963	3.83	349	1.39
Total			13300	88.42	24890	163.56	14477	99.62	12576	82.57	9484	61.45	13856	84.58	9815	67.56
T.S	Cotton	214	1500	6.55	93	0.41	1828	7.98	2067	9.03	4196	18.33	1338	5.84	2146	9.37
	Tur	200	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
	Other	200	0	0.00	12	0.05	57	0.23	100	0.41	94	0.38	0	0.00	88	0.36
Total			1500	6.55	105	0.46	1885	8.22	2167	9.44	4290	18.71	1338	5.84	2234	9.73
HW	Groundnut	500	90	0.92	185	1.89	284	2.90	1049	10.70	3416	34.86	8767	89.46	3560	36.33
	Sunflower	400	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
	Other	400	1710	13.96	94	0.77	13	0.11	24	0.20	31	0.25	131	1.07	33	0.27
Total			1800	14.88	279	2.66	297	3.00	1073	10.90	3447	35.11	8898	90.53	3593	36.60
Perinnials	Shugarcane	1300	0	0.00	134	3.56	555	14.72	821	21.78	1330	35.29	2710	71.90	5766	152.98
	Banana	1200	0	0.00	11	0.27	16	0.39	60	1.47	161	3.94	0	0.00	328	8.03
	Other	1200	0	0.00	90	2.20	54	1.32	126	3.09	222	5.44	0	0.00	135	3.31
Total			0	0	235	6.03	625	16.44	1007	26.34	1713	44.67	2710	71.90	6229	164.31
Grand Total ..			20835	114.92	44448	246.12	26231	144.67	21198	138.63	21415	164.99	28090	255.61	31538	298.99
Water Used:				167.261		252.601		199.34		424.486		536.009		718.245		910.478
Adequacy of water supply at canal head				1.46		1.03		1.38		3.06		3.25		2.81		3.05
Adequacy at root zone				0.62		0.44		0.59		1.31		1.39		1.20		1.31
Area Irrigated per unit of Water at Canal Head (Duty, Ha/Mm^3)				125		176		132		50		40		39		35

Season	Crop	NIR at root zone (mm)	82-83		83-84		84-85		85-86		86-87		87-88	
			Area (ha)	WR at Canal head Mm3	Area (ha)	WR at Canal head Mm3	Area (ha)	WR at Canal head Mm3	Area (ha)	WR at Canal head Mm3	Area (ha)	WR at Canal head Mm3	Area (ha)	WR at Canal head Mm3
1	2	3	18	19	20	21	22	23	24	25	26	27	28	29
Kharif	Rice	392	1381	11.05	357	2.86	406	3.25	225	1.8	52	0.42	1	0.01
	Hy Jawar	40	5163	4.21	834	0.68	2580	2.11	1301	1.06	492	0.4	243	0.2
	Bajri	40	0	0	0	0	0	0	0	0	0	0	0	0
	Telbiya (Oil Seed)	0	0	0	0	0	0	0	0	0	0	0	0	0
	Groundnut	150	604	1.85	61	0.19	186	0.57	271	0.83	258	0.79	17	0.05
	Other	40	8920	7.28	3040	2.48	3880	3.17	2229	1.82	3571	2.92	1746	1.43
Total			16068	24.39	4292	6.21	7052	9.09	4026	5.51	4373	4.52	2007	1.68
Rabi	Wheat	403	6427	52.86	9423	77.5	8662	71.24	4022	33.08	1016	8.36	948	7.8
	R.Jawar	268	5372	29.38	5267	28.81	6180	33.8	9885	54.06	4534	24.8	3135	17.15
	Gram	195	1209	4.81	1659	6.6	1407	5.6	3623	14.42	986	3.92	295	1.17
	Sunflower	200	0	0	0	0	0	0	0	0	0	0	0	0
	Groundnut	120	0	0	0	0	0	0	0	0	0	0	0	0
	Other	195	344	1.37	602	2.4	675	2.69	1464	5.83	258	1.03	297	1.18
Total			13352	88.42	16951	115.3	16924	113.33	18994	107.39	6794	38.1	4675	27.3
T.S	Cotton	214	2212	9.66	845	3.69	1390	6.07	3882	16.95	488	2.13	512	2.24
	Tur	200	0	0	0	0	0	0	0	0	0	0	0	0
	Other	200	0	0	193	0.79	551	2.25	773	3.16	407	1.66	236	0.96
Total			2212	9.66	1038	4.48	1941	8.32	4655	20.11	895	3.79	748	3.2
HW	Groundnut	500	4004	40.86	4444	45.35	5654	57.69	531	5.42	27	0.28	1841	18.79
	Sunflower	400	0	0	0	0	0	0	0	0	0	0	0	0
	Other	400	0	0	98	0.8	352	2.87	511	4.17	268	2.19	1910	15.59
Total			4004	40.86	4542	46.15	6006	60.57	1042	9.59	295	2.46	3751	34.38
Perinnials	Shugarcane	1300	6911	183.35	5912	156.85	4045	107.32	4901	130.03	1383	36.69	2976	78.96
	Banana	1200	0	0	34	0.83	311	7.62	237	5.8	97	2.38	26	0.64
	Other	1200	276	6.76	277	6.78	153	3.75	251	6.15	137	3.36	126	3.09
Total			7187	190.1122	6223	164.47	4509	118.68	5389	141.98	1617	42.42	3128	82.68
Grand Total ..			42823	353.44	33046	336.6	36432	309.98	34106	284.58	13974	91.31	14309	149.24
Water Used:				1110.372		938.365		1108.313		690.279		209.281		206.032
Adequacy of water supply at canal head				3.14		2.79		3.58		2.43		2.29		1.38
Adequacy at root zone				1.35		1.19		1.53		1.04		0.98		0.59
Area Irrigated per unit of Water at Canal Head (Duty, Ha/Mm^3)				39		35		33		49		67		69

Season	Crop	NIR (mm) at root zone	88-89		89-90		90-91		91-92		92-93		93-94		94-95	
			Area (ha)	WR at Canal head Mm3	Area (ha)	WR at Canal head Mm3	Area (ha)	WR at Canal head Mm3	Area (ha)	WR at Canal head Mm3	Area (ha)	WR at Canal head Mm3	Area (ha)	WR at Canal head Mm3	Area (ha)	WR at Canal head Mm3
1	2	3	30	31	32	33	34	35	36	37	38	39	40	41	42	43
Kharif	Rice	392	0	0	0	0	4	0.03	232	1.86	0	0	0	0	0	0
	Hy Jawar	40	0	0	2091	1.71	20	0.02	1607	1.31	4	0	6	0	360	0.29
	Bajri	40	0	0	0	0	0	0		0		0	0	0	996	0.81
	Telbiya (Oil Seed)	0	0	0	0	0	0	0		0		0	0	0	449	0
	Groundnut	150	0	0	83	0.25	27	0.08	0	0	0	0	0	0	149	0.46
	Other	40	0	0	31	0.03	281	0.23	1310	1.07	45	0.04	6	0	338	0.28
Total			0	0	2205	1.99	332	0.36	3149	4.24	49	0.04	12	0.01	2292	1.84
Rabi	Wheat	403	10779	88.65	13230	108.81	10925	89.85	12060	99.19	2589	21.29	5165	42.48	14326	117.82
	R.Jawar	268	11739	64.21	12006	65.67	4151	22.7	16972	92.83	10781	58.97	932	5.1	3547	19.4
	Gram	195	1784	7.1	2000	7.96	1459	5.81	2074	8.25	3325	13.23	1013	4.03	2821	11.23
	Sunflower	200	0	0	1148	4.69	7659	31.26	1945	7.94	270	1.1	235	0.96	447	1.82
	Groundnut	120	0	0	0	0		0		0		0		0		0
	Other	195	2662	10.59	3417	13.6	276	1.1	10742	42.75	2178	8.67	2465	9.81	1555	6.19
Total			26964	170.55	31801	200.72	24470	150.72	43793	250.96	19143	103.26	9810	62.38	22696	156.46
T.S	Cotton	214	0	0	1107	4.83	47	0.21	7729	33.76	492	2.15	44	0.19	8503	37.14
	Tur	200	0	0	0	0	0	0	172	0.7	104	0.42	0	0	354	1.44
	Other	200	0	0	781	3.19	30	0.12	628	2.56	64	0.26	0	0	88	0.36
Total			0	0	1888	8.02	77	0.33	8529	37.02	660	2.83	44	0.19	8945	38.94
HW	Groundnut	500	17743	181.05	10724	109.43	15563	158.81	5064	51.67	53	0.54	13047	133.13	16953	172.99
	Sunflower	400	0	0	2472	20.18	1695	13.84	1101	8.99	0	0	284	2.32	2792	22.79
	Other	400	3679	30.03	723	5.9	626	5.11	6088	49.7	81	0.66	2846	23.23	867	7.08
Total			21422	211.08	13919	135.51	17884	177.75	12253	110.36	134	1.2	16177	158.68	20612	202.86
Perinnials	Shugarcane	1300	8273	219.49	12183	323.22	11381	301.94	7163	190.04	2634	69.88	5475	145.26	19202	509.44
	Banana	1200	0	0	15	0.37	57	1.4	102	2.5	58	1.42	26	0.64	71	1.74
	Other	1200	0	0	172	4.21	169	4.14	129	3.16	79	1.93	144	3.53	352	8.62
Total			8273	219.4878	12370	327.8	11607	307.48	7394	195.7	2771	73.24	5645	149.42	19625	519.8
Grand Total ..			56659	601.12	62183	674.04	54370	636.64	75118	598.27	22757	180.57	31688	370.68	74170	919.9
Water Used:				1219.024		1364.608		1290.322		1616.682		342.07		732.295		1632.05
Adequacy of water supply at canal head				2.03		2.02		2.03		2.7		1.89		1.98		1.77
Adequacy at root zone				0.87		0.87		0.87		1.16		0.81		0.85		0.76
Area Irrigated per unit of Water at Canal Head (Duty, Ha/Mm^3)				46		46		42		46		67		43		45

Season	Crop	NIR (mm) at root zone	95-96		96-97		97-98		98-99		99-00		2000-01		2001-02	
			Area (ha)	WR at Canal head Mm3	Area (ha)	WR at Canal head Mm3	Area (ha)	WR at Canal head Mm3	Area (ha)	WR at Canal head Mm3	Area (ha)	WR at Canal head Mm3	Area (ha)	WR at Canal head Mm3	Area (ha)	WR at Canal head Mm3
1	2	3	44	45	46	47	48	49	50	51	52	53	54	55	56	57
Kharif	Rice	392	0	0	0	0	4	0.03		0	0	0	0	0		0
	Hy Jawar	40	0	0	0	0	542	0.44	0	0	0	0	0	0	0	0
	Bajri	40		0	0	0		0		0		0		0		0
	Telbiya (Oil Seed)	0		0	0	0		0		0		0		0		0
	Groundnut	150	0	0	0	0	0	0	80	0.24	1726	5.28	1437	4.4	148	0.45
	Other	40	29	0.02	0	0	241	0.2	7	0.01	30	0.02	21	0.02	13	0.01
Total			29	0.02	0	0	787	0.67	87	0.25	1756	5.31	1458	4.42	161	0.46
Rabi	Wheat	403	1136	9.34	4918	40.45	4278	35.18	6347	52.2	8347	68.65	10302	84.73	5171	42.53
	R.Jawar	268	1875	10.26	2374	12.98	225	1.23	4385	23.98	6147	33.62	6672	36.49	3329	18.21
	Gram	195	707	2.81	1298	5.17	134	0.53	372	1.48	1451	5.77	1045	4.16	587	2.34
	Sunflower	200	0	0	191	0.78	149	0.61	96	0.39	1039	4.24	938	3.83	249	1.02
	Groundnut	120		0		0		0	0	0	0	0	0	0	0	0
	Other	195	110	0.44	252	1	115	0.46	0	0	0	0	0	0	0	0
Total			3828	22.85	9033	60.38	4901	38.01	11200	78.06	16984	112.29	18957	129.21	9336	64.09
T.S	Cotton	214	1329	5.8	2594	11.33	10194	44.52	9267	40.47	13513	59.02	7488	32.7	3460	15.11
	Tur	200	0	0	39	0.16	252	1.03	0	0	0	0	0	0	0	0
	Other	200	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total			1329	5.8	2633	11.49	10446	45.55	9267)	40.47	13513	59.02	7488	32.7	3460	15.11
HW	Groundnut	500	0	0	6639	67.74	7164	73.1	12235	124.85	10398	106.1	2587	26.4	120	1.22
	Sunflower	400	0	0	819	6.69	672	5.49	0	0	189	1.54	161	1.31	89	0.73
	Other	400	0	0	1042	8.51	2042	16.67	209	1.71	0	0	0	0	39	0.32
Total			0	0	8500	82.94	9878	95.26	12444	126.55	10587	107.64	2748	27.71	248	2.27
Perinnials	Shugarcane	1300	16986	450.65	1153	30.59	1913	50.75	10237	271.59	14266	378.49	20319	539.08	6611	175.39
	Banana	1200	0	0	11	0.27	0	0	0	0	83	2.03	180	4.41	56	1.37
	Other	1200	531	13	85	2.08	75	1.84	92	2.25	0	0	0	0	0	0
Total			17517	463.6531	1249	32.94	1988	52.59	10329	273.85	14349	380.52	19599	543.48	6667	176.77
Grand Total ..			22703	492.33	21415	187.75	28000	232.08	43327	519.18	57189	664.77	50250	737.52	19872	258.7
Water Used:				180.75		379.805		702.832		844.024		1071.96		879.951		269.82
Adequacy of water supply at canal head				0.37		2.02		3.03		1.63		1.61		1.19		1.04
Adequacy at root zone				0.16		0.87		1.3		0.7		0.69		0.51		0.45
Area Irrigated per unit of Water at Canal Head (Duty, Ha/Mm^3)				126		56		40		51		53		57		74

Season	Crop	NIR (mm) at root zone	2002-03		2003-04		2004-05		2005-06		2006-07		2007-08		2008-09	
			Area (ha)	WR at Canal head Mm3	Area (ha)	WR at Canal head Mm3	Area (ha)	WR at Canal head Mm3	Area (ha)	WR at Canal head Mm3	Area (ha)	WR at Canal head Mm3	Area (ha)	WR at Canal head Mm3	Area (ha)	WR at Canal head Mm3
1	2	3	58	59	60	61	62	63	64	65	66	67	68	69	70	71
Kharif	Rice	392	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hy Jawar	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Bajri	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Telbiya (Oil Seed)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Groundnut	150	0	0	577	1.77	0	0	17766	54.39	7901	24.19	10404	31.85	11337	34.71
	Other	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total			0	0	577	1.77	0	0	17766	54.39	7901	24.19	10404	31.85	11337	34.71
Rabi	Wheat	403	5023	41.31	3281	26.98	1174	9.66	13594	111.8	22461	184.73	34390	282.84	4475	36.8
	R.Jawar	268	2732	14.94	1937	10.59	174	0.95	3859	21.11	9179	50.2	9431	51.58	16445	89.94
	Gram	195	439	1.75	369	1.47	21	0.08	1555	6.19	3218	12.81	4385	17.45	8868	35.29
	Sunflower	200	117	0.48	129	0.53	168	0.69	0	0	0	0	2971	12.13	0	0
	Groundnut	120	0	0	0	0	0	0	1530	3.75	3943	9.66	0	0	288	6.09
	Other	195	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total			8311	58.48	5713	39.57	1537	11.38	20538	142.85	38801	257.4	51177	364	32276	168.13
T.S	Cotton	214	349	1.52	349	1.52	0	0	4508	19.69	6729	29.39	18785	82.04	51287	223.99
	Tur	200	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Other	200	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total			349	1.52	349	1.52	0	0	4508	19.69	6729	29.39	18785	82.04	51287	223.99
HW	Groundnut	500	50	0.51	250	2.55	386	3.94	0	0	0	0	0	0	0	0
	Sunflower	400	17	0.14	0	0	48	0.39	0	0	0	0	0	0	0	0
	Other	400	0	0	120	0.98	0	0	0	0	0	0	0	0	0	0
Total			67	0.65	370	3.53	434	4.33	0	0	0	0	0	0	0	0
Perennial	Shugarcane	1300	2157	57.23	3755	99.62	1869	49.59	26954	715.11	38452	1020.16	21145	560.99	20630	547.33
	Banana	1200	37	0.91	0	0	0	0	0	0	0	0	0	0	0	0
	Other	1200	0	0	183	4.48	249	6.1	0	0	1406	34.43	3083	75.5	5574	136.51
Total			2294	58.13	3938	104.1	2118	55.68	26954	715.11	39858	1054.59	24228	636.49	26204	683.83
Grand Total ..			11917	118.78	10950	150.5	4089	71.39	69766	932.03	93289	1365.56	108930	1114.38	123388	1110.66
Water Used:				269.809		137.674		137.213		923.518		1232.268		1148.98		1350.044
Adequacy of water supply at canal head				2.27		0.91		1.92		0.99		0.9		1.03		1.22
Adequacy at root zone				0.97		0.39		0.82		0.42		0.39		0.44		0.52
Area Irrigated per unit of Water at Canal Head (Duty, Ha/Mm^3)				44		80		30		76		76		95		91

7 Impact on Irrigation System Performance

7.1 Introduction:

The objective of this chapter is to evaluate the impact of changing water allocation on irrigation system performance with respect to overall irrigation efficiency, area performance, area irrigated per unit of water, equity of water distribution, actual reservoir losses etc. The data for evaluation purpose is collected from CADA, Aurangabad and Water Resources Development Centre, Aurangabad. The analysis of data with respect to proposed indications of performance is presented in this chapter.

7.2 Irrigation System Performance Indicators:

7.2.1 Overall Irrigation Efficiency:

The Project is designed with overall efficiency as given below.

- Conveyance Efficiency: 75%
- Field Application Efficiency: 65%
- Overall Efficiency: 49%

(Source: Revised Project Report, 1985, p 161)

The data on actual efficiency was collected and is given below.

a) Conveyance efficiency of main canal (%)

Year	Rabi		H.W.	
	PLBC	PRBC	PLBC	PRBC
2008-09	91	61	78	59
2009-10	86	43	65	-

(Source: Water Audit Report, 2008-09 and 2009-10)

Considering I.C.A. of respective Canals, the weighted conveyance efficiency of Main Canal is worked out. Based on this, average conveyance efficiency of main canal works out as 70 %.

b) Conveyance efficiency of Distributary = 70%

(Based on the observations by WALMI on Dy.No.1 of PRBC, 1980-81)

c) Conveyance efficiency of Minor & field channels = 70%

(Based on the observations by WALMI on Dy.No.1 of PRMC, 1980-81)

d) Field application efficiency = 60%

(Based on the WALMI's observations on M3 – PLBC, M4- PLBC, Dy.1 of PLBC M1 of Dy.5-PRBC.

Considering the observation as stated above, the overall irrigation efficiency works as below.

Over all Irrigation Efficiency = (a) x (b) x (c) x (d)

= 0.7 x 0.7 x 0.7 x 0.6

= 0.21

i.e. 21% (against 49% assumed in Project Design)

7.2.2 Evaporation Loss through Reservoir:

The total evaporation losses through reservoir assumed in Project design are 665 Mm^3 when storage is full. The observed evaporation losses for the years when storage is more than 90% full are given in Table 7.1

Table 7.1

Actual Evaporation Losses (Mm^3)

(Under nearly full storage condition)

Year	% Live Storage	Evaporation losses (Mm^3)			
		Kharif	Rabi	H.W.	Total
1983-84	94	63	129	319	511
1988-89	94	35	138	206	379
1989-90	91	90	124	180	394
1990-91	100	85	130	238	453
1998-99	98	58	96	229	383
1999-2000	100	99	109	206	414
2005-06	100	-	-	-	337
2006-07	100	-	-	-	343
2007-08	100	-	-	-	313
				Average	**392**

It shows that actual evaporation losses are about 60% of assumed losses in Project Design.

The break-up of evaporation losses for irrigation and non-irrigation purposes for a typical year 2007-08 is given below.

- Year: 2007-08 (Storage full)
- Irrigation Water Use = 1354 Mm^3 (91%)
- Non-Irrigation Use = 130 Mm^3 (9%)

  Total Use **1484 Mm^3**

- Break-up of Evaporation Losses

Irrigation:	392 x 0.91	=	357 Mm^3
Non Irrigation:	392 x 0.09		35 Mm3
	Total		**392 Mm^3**

7.2.3 Area Performance:

It is defined as a ratio of actual area irrigated in normal year to the irrigation potential contemplated in design. However actual crop pattern every year does not remain constant, but varies depending upon so many factors. When proportion of high water consuming crops like Sugarcane, H.W. Groundnut increases, which is very much true in case of Jayakwadi Project, it is necessary to bring all crops at Par for comparison purpose. The W.R.D., G.O.M. has therefore defined “Rabi Equivalent Area” to bring all crops at par by considering “Rabi Jawar” as a Standard Crop with Rabi Equivalent Factor as 1 and all other Crops are expressed in terms of Rabi Equivalent area. The Rabi Equivalent factors for all the Crops are standardized by Govt. vide circular No. BKS/1089/778/IM/ date 12/10/1989. According to the factors given in this circular, the Rabi Equivalent area for all the years since 1975-76 is given in Table 7.2. The equivalent area irrigated in Normal Years (Storage > 90%) and Area Performance during those years is given below in Table 7.3.

Table 7.2

Jayakwadi Project - Equivalent Crop wise Area Irrigated (ha)

Season	Crop	Rabbi equivalent Factor	75-76		76-77		77-78		78-79		79-80		80-81	
			Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Kharif	Rice	3	225	675	8061	24183	1303	3909	641	1923	324	972	175	525
	Hy Jawar	1	1860	1860	9383	9383	5208	5208	2118	2118	800	800	398	398
	Bajri	1	0	0	0	0	0	0	0	0	0	0	0	0
	Telbiya (Oil Seed)	1.5	0	0	0	0	0	0	0	0	0	0	0	0
	Groundnut	2	0	0	22	44	326	652	537	1074	310	620	202	404
	Other	1	2150	2150	1473	1473	2110	2110	1079	1079	1047	1047	513	513
Total			4235	4685	18939	35083	8947	11879	4375	6194	2481	3439	1288	1840
Rabi	Wheat	2	6500	13000	10567	21134	8103	16206	5619	11238	4008	8016	4212	8424
	R.Jawar	1	5300	5300	13193	13193	5106	5106	5823	5823	4496	4496	7759	7759
	Gram	1	1000	1000	861	861	930	930	703	703	612	612	922	922
	Sunflower	1.33	0	0	0	0	0	0	0	0	0	0	0	0
	Groundnut	1.33	0	0	0	0	0	0	0	0	0	0	0	0
	Other	1.33	500	665	269	358	338	450	431	573	368	489	963	1281
Total			13300	19965	24890	35546	14477	22692	12576	18337	9484	13613	13856	18386
T.S	Cotton	3	1500	4500	93	279	1828	5484	2067	6201	4196	12588	1338	4014
	Tur	3	0	0	0	0	0	0	0	0	0	0	0	0
	Other	3	0	0	12	36	57	171	100	300	94	282	0	0
Total			1500	4500	105	315	1885	5655	2167	6501	4290	12870	1338	4014
HW	Groundnut	3	90	270	185	555	284	852	1049	3147	3416	10248	8767	26301
	Sunflower	2	0	0	0	0	0	0	0	0	0	0	0	0
	Other	3	1710	5130	94	282	13	39	24	72	31	93	131	393
Total			1800	5400	279	837	297	891	1073	3219	3447	10341	8898	26694
Perinnials	Shugarcane	8.25	0	0	134	1106	555	4579	821	6773	1330	10973	2710	22358
	Banana	8.25	0	0	11	91	16	132	60	495	161	1328	0	0
	Other	6	0	0	90	540	54	324	126	756	222	1332	0	0
Total			0	0	235	1736	625	5035	1007	8024	1713	13633	2710	22358
Grand Total ..			20835	34550	44448	73517	26231	46151	21198	42275	21415	53896	28090	73291

Season	Crop	Rabbi equivalent Factor	81-82		82-83		83-84		84-85		85-86		86-87	
			Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.
1	2	3	16	17	18	19	20	21	22	23	24	25	26	27
Kharif	Rice	3	1316	3948	1381	4143	357	1071	406	1218	225	675	52	156
	Hy Jawar	1	3439	3439	5163	5163	834	834	2580	2580	1301	1301	492	492
	Bajri	1	0	0	0	0	0	0	0	0	0	0	0	0
	Telbiya (Oil Seed)	1.5	0	0	0	0	0	0	0	0	0	0	0	0
	Groundnut	2	1530	3060	604	1208	61	122	186	372	271	542	258	516
	Other	1	3382	3382	8920	8920	3040	3040	3880	3880	2229	2229	3571	3571
Total			9667	13829	16068	19434	4292	5067	7052	8050	4026	4747	4373	4735
Rabi	Wheat	2	5843	11686	6427	12854	9423	18846	8662	17324	4022	8044	1016	2032
	R.Jawar	1	2485	2485	5372	5372	5267	5267	6180	6180	9885	9885	4534	4534
	Gram	1	1138	1138	1209	1209	1659	1659	1407	1407	3623	3623	986	986
	Sunflower	1.33	0	0	0	0	0	0	0	0	0	0	0	0
	Groundnut	1.33	0	0	0	0	0	0	0	0	0	0	0	0
	Other	1.33	349	464	344	458	602	801	675	898	1464	1947	258	343
Total			9815	15773	13352	19893	16951	26573	16924	25809	18994	23499	6794	7895
T.S	Cotton	3	2146	6438	2212	6636	845	2535	1390	4170	3882	11646	488	1464
	Tur	3	0	0	0	0	0	0	0	0	0	0	0	0
	Other	3	88	264	0	0	193	579	551	1653	773	2319	407	1221
Total			2234	6702	2212	6636	1038	3114	1941	5823	4655	13965	895	2685
HW	Groundnut	3	3560	10680	4004	12012	4444	13332	5654	16962	531	1593	27	81
	Sunflower	2	0	0	0	0	0	0	0	0	0	0	0	0
	Other	3	33	99	0	0	98	294	352	1056	511	1533	268	804
Total			3593	10779	4004	12012	4542	13626	6006	18018	1042	3126	295	885
Perinnials	Shugarcane	8.25	5766	47570	6911	57016	5912	48774	4045	33371	4901	40433	1383	11410
	Banana	8.25	328	2706	0	0	34	281	311	2566	237	1955	97	800
	Other	6	135	810	276	1656	277	1662	153	918	251	1506	137	822
Total			6229	51086	7187	58672	6223	50717	4509	36855	5389	43895	1617	13032
Grand Total ..			31538	98169	42823	116646	33046	99096	36432	94555	34106	89232	13974	29232

Season	Crop	Rabbi equivalent Factor	87-88		88-89		89-90		90-91		91-92		92-93	
			Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.
1	2	3	28	29	30	31	32	33	34	35	36	37	38	39
Kharif	Rice	3	1	3	0	0	0	0	4	12	232	696	0	0
	Hy Jawar	1	243	243	0	0	2091	2091	20	20	1607	1607	4	4
	Bajri	1	0	0	0	0	0	0	0	0		0		0
	Telbiya (Oil Seed)	1.5	0	0	0	0	0	0	0	0		0		0
	Groundnut	2	17	34	0	0	83	166	27	54	0	0	0	0
	Other	1	1746	1746	0	0	31	31	281	281	1310	1310	45	45
Total			2007	2026	0	0	2205	2288	332	367	3149	3613	49	49
Rabi	Wheat	2	948	1896	10779	21558	13230	26460	10925	21850	12060	24120	2589	5178
	R.Jawar	1	3135	3135	11739	11739	12006	12006	4151	4151	16972	16972	10781	10781
	Gram	1	295	295	1784	1784	2000	2000	1459	1459	2074	2074	3325	3325
	Sunflower	1.33	0	0	0	0	1148	1527	7659	10186	1945	2587	270	359
	Groundnut	1.33	0	0	0	0	0	0		0		0		0
	Other	1.33	297	395	2662	3540	3417	4545	276	367	10742	14287	2178	2897
Total			4675	5721	26964	38621	31801	46537	24470	38014	43793	60040	19143	22540
T.S	Cotton	3	512	1536	0	0	1107	3321	47	141	7729	23187	492	1476
	Tur	3	0	0	0	0	0	0	0	0	172	516	104	312
	Other	3	236	708	0	0	781	2343	30	90	628	1884	64	192
Total			748	2244	0		1888	5664	77	231	8529	25587	660	1980
HW	Groundnut	3	1841	5523	17743	53229	10724	32172	15563	46689	5064	15192	53	159
	Sunflower	2	0	0	0	0	2472	4944	1695	3390	1101	2202	0	0
	Other	3	1910	5730	3679	11037	723	2169	626	1878	6088	18264	81	243
Total			3751	11253	21422	64266	13919	39285	17884	51957	12253	35658	134	402
Perinnials	Shugarcane	8.25	2976	24552	8273	68252	12183	100510	11381	93893	7163	59095	2634	21731
	Banana	8.25	26	215	0	0	15	124	57	470	102	842	58	479
	Other	6	126	756	0	0	172	1032	169	1014	129	774	79	474
Total			3128	25523	8273	68252	12370	101666	11607	95378	7394	60710	2771	22683
Grand Total ..			14309	46767	56659	171140	62183	195440	54370	185946	75118	185608	22757	47654

Season	Crop	Rabbi equivalent Factor	93-94		94-95		95-96		96-97		97-98		98-99	
			Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.
1	2	3	40	41	42	43	44	45	46	47	48	49	50	51
Kharif	Rice	3	0	0	0	0	0	0	0	0	4	12		0
	Hy Jawar	1	6	6	360	360	0	0	0	0	542	542	0	0
	Bajri	1	0	0	996	996		0	0	0		0		0
	Telbiya (Oil Seed)	1.5	0	0	449	674		0	0	0		0		0
	Groundnut	2	0	0	149	298	0	0	0	0	0	0	80	160
	Other	1	6	6	338	338	29	29	0	0	241	241	7	7
Total			12	12	2292	2666	29	29	0	0	787	795	87	167
Rabi	Wheat	2	5165	10330	14326	28652	1136	2272	4918	9836	4278	8556	6347	12694
	R.Jawar	1	932	932	3547	3547	1875	1875	2374	2374	225	225	4385	4385
	Gram	1	1013	1013	2821	2821	707	707	1298	1298	134	134	372	372
	Sunflower	1.33	235	313	447	595	0	0	191	254	149	198	96	128
	Groundnut	1.33		0		0		0		0		0	0	0
	Other	1.33	2465	3278	1555	2068	110	146	252	335	115	153	0	0
Total			9810	15866	22696	37683	3828	5000	9033	14097	4901	9266	11200	17579
T.S	Cotton	3	44	132	8503	25509	1329	3987	2594	7782	10194	30582	9267	27801
	Tur	3	0	0	354	1062	0	0	39	117	252	756	0	0
	Other	3	0	0	88	264	0	0	0	0	0	0	0	0
Total			44	132	8945	26835	1329	3987	2633	7899	10446	31338	9267	27801
HW	Groundnut	3	13047	39141	16953	50859	0	0	6639	19917	7164	21492	12235	36705
	Sunflower	2	284	568	2792	5584	0	0	819	1638	672	1344	0	0
	Other	3	2846	8538	867	2601	0	0	1042	3126	2042	6126	209	627
Total			16177	48247	20612	59044	0	0	8500	24681	9878	28962	12444	37332
Perinnials	Shugarcane	8.25	5475	45169	19202	158417	16986	140135	1153	9512	1913	15782	10237	84455
	Banana	8.25	26	215	71	586	0	0	11	91	0	0	0	0
	Other	6	144	864	352	2112	531	3186	85	510	75	450	92	552
Total			5645	46247	19625	161114	17517	143321	1249	10113	1988	16232	10329	85007
Grand Total ..			31688	110504	74170	287341	22703	152337	21415	56790	28000	86593	43327	167886

Season	Crop	Rabbi equivalent Factor	99-2000		2000-01		2001-02		2002-03		2003-04		2004-05	
			Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.
1	2	3	52	53	54	55	56	57	58	59	60	61	62	63
Kharif	Rice	3	0	0	0	0		0	0	0	0	0	0	0
	Hy Jawar	1	0	0	0	0	0	0	0	0	0	0	0	0
	Bajri	1		0		0		0	0	0	0	0	0	0
	Telbiya (Oil Seed)	1.5		0		0		0	0	0	0	0	0	0
	Groundnut	2	1726	3452	1437	2874	148	296	0	0	577	1154	0	0
	Other	1	30	30	21	21	13	13	0	0	0	0	0	0
Total			1756	3482	1458	2895	161	309	0	0	577	1154	0	0
Rabi	Wheat	2	8347	16694	10302	20604	5171	10342	5023	10046	3281	6562	1174	2348
	R.Jawar	1	6147	6147	6672	6672	3329	3329	2732	2732	1937	1937	174	174
	Gram	1	1451	1451	1045	1045	587	587	439	439	369	369	21	21
	Sunflower	1.33	1039	1382	938	1248	249	331	117	156	129	172	168	223
	Groundnut	1.33	0	0	0	0	0	0	0	0	0	0	0	0
	Other	1.33	0	0	0	0	0	0	0	0	0	0	0	0
Total			16984	25674	18957	29569	9336	14589	8311	13373	5716	9040	1537	2766
T.S	Cotton	3	13513	40539	7488	22464	3460	10380	349	1047	349	1047	0	0
	Tur	3	0	0	0	0	0	0	0	0	0	0	0	0
	Other	3	0	0	0	0	0	0	0	0	0	0	0	0
Total			13513	40539	7488	22464	3460	10380	349	1047	349	1047	0	0
HW	Groundnut	3	10398	31194	2587	7761	120	360	50	150	250	750	386	1158
	Sunflower	2	189	378	161	322	89	178	17	34	0	0	48	96
	Other	3	0	0	0	0	39	117	0	0	120	360	0	0
Total			10587	31572	2748	8083	248	655	67	184	370	1110	434	1254
Perennials	Shugarcane	8.25	14266	117695	20319	167632	6611	54541	2157	17795	3755	30979	1869	15419
	Banana	8.25	83	685	180	1485	56	462	37	305	0	0	0	0
	Other	6	0	0	0	0	0	0	0	0	183	1098	249	1494
Total			14349	118379	20499	169117	6667	55003	2194	18101	3938	32077	2118	16913
Grand Total ..			57189	219646	51150	232127	19872	80936	10921	32704	10950	44427	4089	20934

Season	Crop	Rabbi equivalent Factor	2005-06		2006-07		2007-08		2008-09	
			Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.	Area (ha)	Equivalent area in Ha.
1	2	3	64	65	66	67	68	69	70	71
Kharif	Rice	3	0	0	0	0	0	0	0	0
	Hy Jawar	1	0	0	0	0	0	0	0	0
	Bajri	1	0	0	0	0	0	0	0	0
	Telbiya (Oil Seed)	1.5	0	0	0	0	0	0	0	0
	Groundnut	2	17766	35532	7901	15802	10404	20808	11337	22674
	Other	1	0	0	0	0	0	0	0	0
Total			17766	35532	7901	15802	10404	20808	11337	22674
Rabi	Wheat	2	13594	27188	22461	44922	34390	68780	4475	8950
	R.Jawar	1	3859	3859	9179	9179	9431	9431	16445	16445
	Gram	1	1555	1555	3218	3218	4385	4385	8868	8868
	Sunflower	1.33	0	0	0	0	2971	3951	0	0
	Groundnut	1.33	1530	2035	3943	5244	0	0	2488	3309
	Other	1.33	0	0	0	0	0	0	0	0
Total			20538	34637	38801	62563	51177	86547	32276	37572
T.S	Cotton	3	4508	13524	6729	20187	18785	56355	51287	153861
	Tur	3	0	0	0	0	0	0	0	0
	Other	3	0	0	0	0	0	0	0	0
Total			4508	13524	6729	20187	18785	56355	51287	153861
HW	Groundnut	3	0	0	0	0	0	0	0	0
	Sunflower	2	0	0	0	0	0	0	0	0
	Other	3	0	0	0	0	0	0	0	0
Total			0.00	0	0.00	0	0.00	0	0	0
Perennials	Shugarcane	8.25	26954	222371	38452	317229	21145	174446	20630	170198
	Banana	8.25	0	0	0	0	0	0	0	0
	Other	6	0	0	1406	8436	3083	18498	5574	33444
Total			26954	222371	39858	325665	24228	192944	26204	203642
Grand Total ..			69766	306063	93289	424217	104594	356655	121104	417749

Table 7.3

Area Performance in Normal Years

Year	**Designed Equivalent Area (ha)**	**Actual Equivalent Area Irrigated (ha)**	**Area Performance Ratio (3/2)**
1	2	3	4
1983-84	4,37,684	99096	0.23
1988-89	4,37,684	171140	0.39
1989-90	4,37,684	195440	0.45
1990-91	4,37,684	185946	0.43
1998-99	4,37,684	167885	0.38
1999-2000	4,37,684	219646	0.50
2005-06	4,37,684	306063	0.70
2006-07	4,37,684	424247	0.97
2007-08	4,37,684	356654	0.81

It shows that, the average Area Performance is about 40% in normal years. Up to 1999-2000, which is low, may be due to low irrigation efficiency (21% against 49% assumed during design). It is increasing afterwards due to accounting of area irrigated on wells. The diversion of water for Non-Irrigation purposes (more about 150 Mm^3) does reduced Irrigation Potential to about 10,000 ha. (Equivalent area 20,000 hectors). Even if this diversion is considered, the average area performance is not more than 45%.

7.2.4 Area Irrigated per Unit of Water:

It is the ratio of actual area irrigated to the water used at Canal head expressed in ha/ Mm^3.

The Year wise Area Irrigated per unit of water is presented in Table 6.4 (chapter 6 Impact on Agriculture System).

The average Area Irrigated per unit of water for 23 years is 63 ha/ Mm^3. at Canal head. The designed Area Irrigated per unit of water is 134 ha/ Mm^3. at Canal head. This indicates that actual area irrigated/unit of water is about 47% of designed one. This is mainly because of low overall efficiency and increase in area under water intensive crops.

7.2.5 Equity of Water Distribution:

According to Bench Marking report of 2009-10, the equity performance of Jayakwadi Project is as given below.

Head Reach: 56%

Middle Reach: 10%

Tail Reach: 12%

This indicates that the water distribution is not equitable in the command area.

7.3 Conclusion:

The Irrigation System performance with respect to all indicators is low due to poor water control and management, low irrigation efficiency, along with other reasons like deteriorated canal system, increase in area under groundnut and perennial crops, high land holding, uncertainty in reservoir filling etc.

8 Impact of Changing Water Allocation on Environmental System

8.1 The impact of reduced inflow in the reservoir and reduced water allocation in the command area with respect to sedimentation of reservoir, ground water status in the command, changes in river flow regime, quality of water in the river is studied and reported in this chapter.

8.2 Sedimentation of Reservoir:

The water in the Jayakwadi Project Reservoir called Nathsagar is first impounded in the year 1975. The siltation survey of the reservoir was done during 1994-97 i.e. after 20 years of first impoundment The result of siltation survey is given below (source: Water Audit Report 2009-10, WRD, GOM, March 2011).

- Catchment Area: 21750 Sq.km
- Gross Storage: 2909 Mm^3
- Live Storage: 2171 Mm^3
- Dead Storage: 738 Mm^3
- Year of first impounding: 1975
- Year of Siltation Survey: 1994-97
- Siltation Period: 20 Years
- Live Storage lost due to siltation: 127 Mm^3 (7%)
- Annual % lost due to siltation: 0.35
- Design rate of siltation: 3.57 ha-m/100 Sq.km/year
- Estimated rate of siltation: 4.4 ha-m/100 Sq.km/year

According to this survey, the actual rate of siltation is about 23% more than the designed rate of siltation. The higher rate of siltation may be due to following reasons.

(i) The silt carried by river water mostly gets deposited in the reservoir for most of the years in which there are no or very less releases of flood water through spillway. It is observed that out of 34 year (1975 to 2008), considerable discharge through spillway was released during 11 years only.

(ii) Non Ghat area of catchment consists of vertisole type of soil i.e. swelling and shrinkage type of soils. The soils are erosion prone when they are wet.

The main reason for increased rate of siltation may be on account of reduced inflow from upper side causing silt deposition in the reservoir and not carried out on the downstream side.

8.3 Changes in River flow pattern and regime:

The impact of reduction in the river flow after construction of major dam is more serious in case of Jayakwadi Project, because most of the monsoon and post monsoon flow is arrested by the reservoir. The inflow series shows that for about 70% years, there is no or very less outflow from the reservoir. During the years of appreciable outflow also, the outflow lasted for few days only. The senior citizens in the area commented that before Jayakwadi Project, there was a considerable flow in the Godavari River even in the month of May and now it goes dry after December. This has definitely affected the regime of river. The actual regime study has not been carried out by any agency. However, the visual observations show that lot of siltation and silt mounts are seen along the course of the river. The photographs enclosed as fig 8.1 and 8.2 shows clearly the change in the river course and silt mounts due to reduced flow over time.

Fig.8.1

Photographs showing deposition in Godavari River near Manjrath village.

Fig. 8.2

Photographs showing deposition in Godavari River near Manjrath village.

8.4 Quality of water in the River:

The water quality monitoring is being carried out under Hydrology Project Maharashtra (SW) which takes care of surface water quality monitoring through 7 stations excluding dam below Jayakwadi Project. The sampling stations are shown in fig.8.3

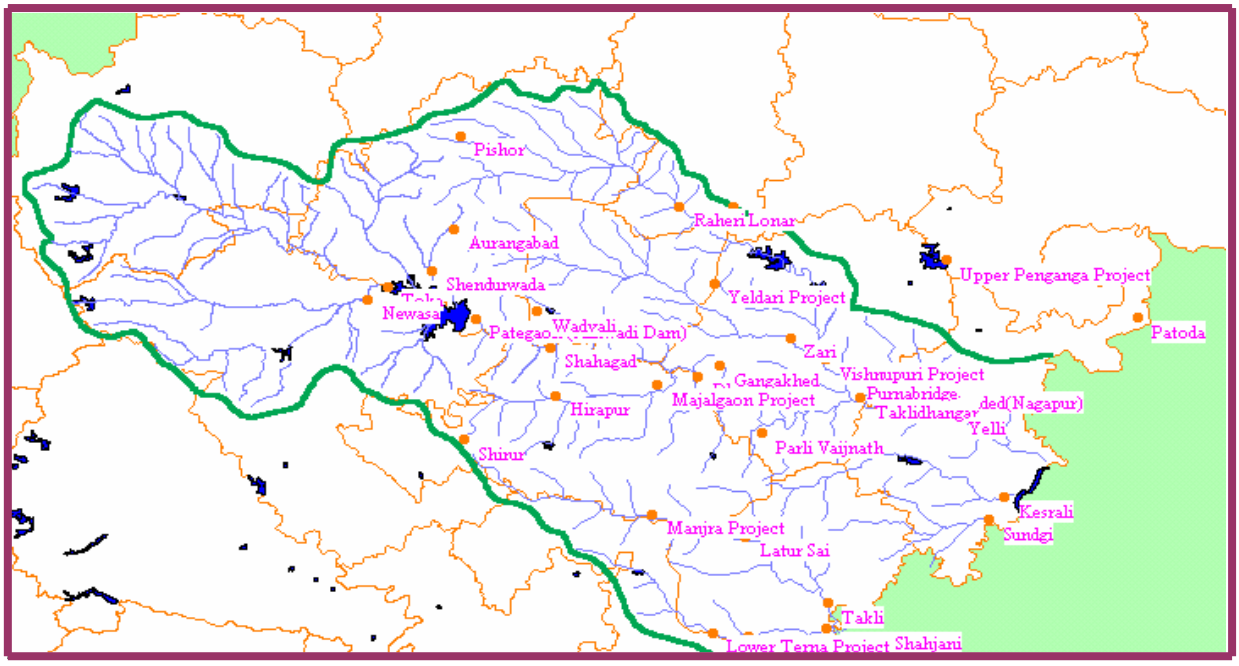


Fig 8.3

Sampling Stations below Jayakwadi Project

The data on following water quality parameters from June 2004 to May 2010 was analysed to determine the trend of water quality of Godavari River below Jayakwadi Reservoir (source: Water Quality Trend of Godavari River below Jayakwadi Dam up to State Border of Maharashtra by M.K. Pokale et. el. Article presented in National conference on Water for Future, Nanded (Maharashtra , Jan 7-8 , 2011)

1. pH
2. Biochemical Oxygen Demand (BOD),
3. Chemical Oxygen Demand (COD)
4. Coli forms Bacteria
5. Total Dissolved Solids (TDS)
6. Electrical Conductivity
7. Dissolved Oxygen (DO)

The average parameter wise results are shown in Table 8.1. From the analysis following conclusions are drawn.

- pH does not vary throughout the year and it is within range.
- Continuous flow of sewage wastes, dumping of animal dead bodies etc. and in stream uses of water like bathing, cattle wading etc. contribute significant load of pathogens in the river water making it unsuitable for drinking and bathing purposes.
- The DO level has been found to be normal.
- The TDS values observed are within limits except at Wadvali in summer.

The reduction and/or stoppage of river flow has resulted in making water unsuitable for domestic use and it is causing health hazard.

Table 8.1

Summary Report for the period between 01/06/2004 and 31/05/2010

Site Code	BOD3-27	COD	DO	EC_GEN	pH_GEN	Tcol_MPN	TDS
DHALEGAON							
N (No.of Observations)	23	27	27	27	27	27	27
Average	2.5	14.6	6.4	382.1	8.1	105.3	276.8
GANGAKHED							
N (No.of Observations)	32	32	32	32	32	32	32
Average	2.3	17.8	5.9	494.5	8.1	31.1	340.1
NANDED Nagapur							
N (No.of Observations)	22	25	26	26	26	24	26
Average	2.3	14.9	6.4	419.4	8.1	24.8	305.7
SHAHAGAD							
N (No.of Observations)	24	27	27	27	27	27	27
Average	2.1	11.1	6.3	453.0	8.1	71.9	325.9
TAKLI DHANGAR							
N (No.of Observations)	18	21	21	21	21	21	21
Average	2.0	10.1	6.6	371.5	8.1	65.2	269.5
WADVALI							
N (No.of Observations)	26	29	29	29	29	29	29
Average	2.8	13.1	6.5	546.3	8.1	23.6	368.7
YELLI							
N (No.of Observations)	22	25	25	25	25	25	25
Average	2.0	12.4	6.4	374.0	8.1	13.8	277.6

8.5 **Ground Water Status:**

Farmers shift from rain fed agriculture to irrigated agriculture, once the irrigation project comes into operation. Irrigated agriculture requires high inputs as compared to rain fed agriculture. Water remains critical input in irrigated agriculture. Farmers try to maintain the status of irrigated farming by making available the water from all the sources. In the command area of Irrigation Project, water available through irrigation system is the main source. However if water supply from irrigation system is variable, uncertain, and unreliable, farmers try to supplement the irrigation needs through use of ground water. They try to exploit ground water more and more when irrigation supply is unreliable.

The information on use of groundwater over time in Jayakwadi command area is collected and presented below in Table.8.2.

Table 8.2

USE OF GROUND WATER

YEAR	G.W. Draft (Mm^3) ♣
1988	89.70
1998	111.48
2004	118.37

(♣ Proportionate Ground Water draft in the command area as estimated by GSDA District wise.)

It is seen from the above table that Groundwater use is increasing overtime. Digging of well in very deep black cotton soils in this area is very difficult and expensive. Still farmers have developed 12792 wells in the command area. There were almost very few wells for irrigation purpose before the commencement of the project. This indirectly indicates that for sustainable irrigation, peoples are relying more on well irrigation.

8.6 **Conclusion:** Reduced water flow to and from irrigation project has resulted into sedimentation of reservoir with increased rate, affected the regime of the river below dam, quality of river water is not maintained due to stoppage of river flow.

Chapter No. 9

Impact of changing water allocation on socio-economic system

Water is an important and vital input in agriculture sector. It not only increases the agriculture production and cropping intensity but also has several indirect, tertiary, tangible and intangible effects. Socio Economic and cultural impact is one such important indirect effect of creation of irrigation potential. An attempt is made to assess the socio-economic impact of changing water allocation of Jayakwadi irrigation project by utilizing secondary sources of data and information as well as by collecting and analyzing primary data and information specifically for this study.

9.1 Analysis and study of Secondary data

Secondary data regarding technical aspects are generally maintained by the concerned Government Departments, in this case by Command Area Development Authority (CADA), Aurangabad. However, data regarding socio-economic aspects is comparatively not abundantly available. The following reports / articles are available, synoptic review of which is presented below:

9.1.1 Socio-Economic Surveys by MAU:

Department of Agricultural Economics & Statistics, Marathwada Agriculture University (MAU), Parbhani has carried out the bench mark socio-economic survey of Jayakwadi project and Purna project command areas in the year 1981 and the report is available in two volumes. Subsequently the Department of Agricultural Economics, MAU, Parbhani has carried out socio-economic follow-up survey of Jayakwadi Irrigation Project (Purna Project was not included in this survey) in 1996. Thus, a sort of benchmark and post project survey data is available (in the form of 'before project' and 'after project' study). Important findings from these two reports are briefly reproduced below:

- The increasing use of water utilization over 13 years brought a miraculous change in the life style of the farmers and in the cropping pattern of the region. The change in cropping pattern paved the new ways of avenues for agriculture in Jayakwadi command area. The study pointed out the gap in actual and recommended utilization of inputs and thereby showing the rich potentiality of production, which can be tapped by providing other infrastructure facilities to the farmers. The change in economic status of farmers has also infiltrated up to the weaker sections

of the society such as Scheduled Caste & Scheduled Tribe (SC/ST) farmers and landless laborers.

- The change in cropping pattern was significant. The food grain area declined to 66 percent from 77 percent. The area under cash crops, horticultural crops was increased by more than 5 percent and 2 percent respectively. The emergence of summer groundnut and sunflower (as new crops) was prominent. The (hybrid) kharif jowar was more or less completely replaced by bajra. The fruit crops like banana, guava, and sweet lemon emerged with promising strains. The cropping intensity was increased from 146.21 to 176.62 percent. Thus, the increase was by 30.41 percent. The utilization of irrigation was increased to 46.62 percent from 18.84 percent i.e. by 27.78 percent.

- There was 100 percent adoption of high yielding varieties in the case of cotton, wheat, sugarcane and summer groundnut. Rabi jowar and bajra exhibited 88 and 97 percent adoption under high yielding strains.

- There was significant increase in yields of all the crops over previous period except wheat. In sugarcane, there was marginal decline in percent hectare yield over the state average yield as there was no sugarcane observed in previous bench mark survey. In case of local cotton, there was substantial increase in yield over the earlier period. There is high scope to increase the yield as there is low utilization of N, P and K, manures and insecticides.

- The main source of credit in villages was primary co-operative credit society and finance distributed by nationalized bank and friends and relatives was around 10 percent.

- The overall employment was increased by 19 and 17 percent over the previous period for male and female due to increase in cropping intensity.

- Positive impact of irrigation was observed on the economy of farmers belonging to SC and ST category. The cropping pattern of the weaker section (ST/ST) farmers was substantially changed due to irrigation.

- A few patches of soils of Balegaon and Indegaon villages were observed to be saline due to excess utilization of irrigation for sugarcane crop.

In short slow but desirable impact of Jayakwadi Project was seen in the initial 15-20 years of irrigation.

9.1.2 Article by Shri. M. R. Dighe

Shri. M.R. Dighe, the then Chief Engineer and Chief Administrator, CADA, Aurangabad in his article entitled "Jayakwadi Project - A Blessing for Marathwada Region" (Irrigation and Power Journal, Maharashtra Special Issue, April-June 1995) has highlighted among other things the following indirect/tertiary benefits:

1. Jayakwadi birds sanctuary: In the Nathsagar Lake, the migratory birds have started visiting since 1979. The number of migratory species is increasing since then and the census in the year 1986 has revealed that about 150 species are visiting the lake. The most predominant water birds are Brahmney Ducks coming from Ladhak, Pintails from Europe, infled Pochards, common Pochards, Coots, common teals, etc. from Siberia. The main attraction of Jayakwadi birds sanctuary is flamingoes.

2. Paithan Hydel Scheme: The Paithan Hydel Scheme is a pumped storage development having installation of a 12 MW reversible pump turbine unit at the foot of the Paithan Dam. Since the utilization of water from the dam is primarily for irrigation, reversible pump turbine units have been installed so that it will continue to generate power even after full irrigation is developed and no water to be allowed to be wasted into the river, purely for power generation.

3. Sant Dnyaneshwar Udyan : In the memory of great Sant Dnyaneshwar, a garden (Udyan) is constructed as a part of Jayakwadi Project. The garden extends over 124 hectares of land on left flank and is constructed on the lines of famous gardens at "VRINDAVAN" in Karnataka State,"PINJORE" in Hariyana State and "SHALIMAR" in Jammu & Kashmir State. Due to development of this garden the entire downstream area of Paithan reservoir has become a landmark tourist place and estimated 2000-3000 tourists visit the garden daily.

4. Fish Seed Farm:

This is a large fish seed farm located on right flank on downstream of Paithan dam. The fish farm is proposed to yield each year over 400 M. tonnes of fish from Nathsagar formed due to Paithan dam, apart from supplying about 1.5 crores fish seed to different storages. About 40 lakhs of finger lings of cultivable varieties of fish seeds, viz. Cutla, Roha, Mrigal and Cyprinus are to be produced annually. The actual fish produce per year is now worth Rs. 130.00 lakhs. The production of fish is of the order of 650 M. Tonnes per year.

5. Aurangabad city water supply:

Water supply system for the city was executed in the year 1954 with the source of water supply as Harsool Reservoir. The capacity of this water works is approximately 10 MLD. With the increase in the demand the additional water supply scheme was executed in the year 1975 with the source of water supply as Jayakwadi Reservoir. The capacity of this water works was 28 MLD. Further the boosting scheme was executed in the year 1984, by way of which the capacity of the existing scheme, with Jayakwadi reservoir as source, was increased to 48 MLD. The present water supply to the city from various sources is 50 MLD. i.e. Kham-2 MLD, Harsool -9 MLD and Jayakwadi - 39 MLD. The present population of the city is around 5 Lacs. The present supply provides the rate of daily water supply per capita on average 100 lpd approximately.

One new scheme for augmentation to the water supply from Jayakwadi has been completed. The scheme is in parallel lines of existing water supply scheme. This scheme has the capacity as 100 MLD for phase-I requirements (year 2001) with a possibility of expansion to 200 MLD for phase-II requirement (year 2016) for catering the needs of prospective population of 10 Lacs in the phase-I and 16 Lacs in the phase-II and also the industries and other demands.

6. Water supply for Industrial Use:

Jayakwadi project is supplying water to Aurangabad and Paithan industrial area also. Water supply forms a basic need of industrial development. It is observed that 1331 industries with a total annual production of Rs.1400 crores have developed during 1980 to 1990. These industries are entirely dependent on Jayakwadi water supply and would not have come up without the assured and reliable water supply. The project has a reservation of 117 Mm^3.

7. Indirect Benefits:

i) Flood Protection: One of the important indirect benefits of the project is the flood protection it has given to Paithan town. The reservoir has reduced flood discharged into the river to a considerable extent.

ii) Support to Sugar Industries: With the advent of irrigation, increased sugarcane production has given birth to many sugar factories. In Jayakwadi command area four sugar factories are developed in the command while four more sugar factories, which are on the fringe of reservoir, are also dependent partially on sugarcane being grown on Jayakwadi water.

iii) Employment Generation: Jayakwadi project has directly or indirectly contributed to the employment generation in various fields such as:

i) Incremental labor in irrigated agriculture.

ii) Sugar factories

iii) Fisheries

iv) Industries

It is estimated that 400 lakhs man days/year have been created due to Project.

iv) Tourism Development: An attractive tourist spot is developed because of Dnyaneshwar Udyan & water sports activities and it is attracting approximately an average 3000 number of tourists per day.

8. Direct Economic Benefits :

Agriculture Benefits: A study has revealed that due to commissioning of the project, production of crops has steadily increased as seen in the following table.

Agriculture Benefits

Sr. No.	Year	Area Irrigated in ha.	Agricultural Produce				Net Benefit in Rs.Crores
			Before Irrigation		After Irrigation		
			Produced in (Lakh) Tonne	Amount in Rs. Crore	Produce in (lakh) Tonne	Amount in Rs. Crore	
1	1990-91	39311	0.2	6.8	7.921	44.13	37.33
2	1991-92	67595	0.34	16.1	6.13	74.15	58.05
3	1992-93	26119	0.13	5.15	21.43	42.19	37.04
4	1993-94	29180	0.15	5.2	4.421	64.86	59.66
	Total	**1,62,205**		**33.25**			**192.08**

Note: The values are worked out by considering the yield of the crops based on crop cutting experiments and prevailing market rates of the respective years.

In short, the author concludes that Jayakwadi project has contributed substantially in agricultural production, protection from flood damages, water supply to Aurangabad city which is the fastest developing city in the country and given boost to the industrial activities in Aurangabad district.

9.1.3 Article by Shri. S.C. Chakurkar:

An Article written in Marathi language by Shri. S.C. Chakurkar, the then Superintending Engineer and Administrator CADA, Aurangabad and his colleague Shri. Jaisingh Hire (in Sinchan Sadhana - a book compiled by Dr. D. M. More in 2010) has further highlighted the benefits of Jayakwadi project by giving data up to 2001-2002. The authors have also highlighted similar indirect and tertiary benefits which were highlighted by Shri. M. R. Dighe in his article. One of the important findings is presented by them in the following table.

Agricultural Production

Sr. No.	Year	Availability of water in the Reservoir (% mcum)	Area irrigated (ha.) due to canal and reservoir	Agricultural income under command area (lakh Rs.)	Agricultural Income under command area on well (lakh Rs.)	Agricultural Income under project but non command area (lakh Rs.)	Total Agricultural income (lakh Rs.)
1	1997-98	49.28%	47279	4104.83	416.61	1241.09	5762.53
		1068.79					
2	1998-99	97.96%	41546	6074.14	1430.75	1460.09	8964.98
		2126.76					
3	1999-00	99.83%	50234	5908.31	511.21	947.45	7366.97
		216.35					
4	2000-01	59.31%	39804	5819.45	945.65	1050.65	7815.75
		1281.73					
5	2001-02	22.76%	14285	2088.51	1095.85	1256.8	4441.16
		494.17					
Total agril. Income (lakh Rs.)		23995.24	4400.07	5956.08	34351.39		
Av. yearly		---		4799.05	880.01	1191.21	6870.27

It is observed from the above table that the average yearly agricultural income under command area is Rs.4799.05 lacs which are more than 4 times the average yearly agricultural income from the uncommand area. While the average yearly agricultural income on wells located in the command area is comparatively very low i.e. Rs. 880.01 lacs.

9.1.4 Article by Shri. A. A. Javalekar:

An Article entitled 'Jayakwadi Project Present Status as on November 2009' written by Shri. A. A. Javalekar, Retd. Executive Director, WRD presents the status and critical review of Jayakwadi project. A few findings pertaining to the present study from this article are as below-

- The area of sugarcane has increased in the command of Jayakwadi because of many sugar factories and encouraging Govt. policy. Therefore, the farmers have grown sugarcane in the year 2005 to 2008 and storages available in the Jayakwadi and Majalgaon Dams were also 100%. Many sugar factories in Parbhani district were not running. Even some sugar factories were ready to take sugarcane of farmers but because of poor road condition and non availability of good communication facilities, sugar factories could not lift the sugarcane for crushing. The sugarcane grown could not be transported by sugar factories.

- It was observed from 2005 to 2008 that the net per ha. Income of farmers from sugarcane per year on an average was Rs. 30,000 per year. The expenditure on agriculture inputs and labor has gone up to 50%. On the other hand income from combined crop of cotton and tur per ha. on an average is Rs.40,000/- per year. Thus there is a tendency of farmers to grow more cotton and tur rather than sugarcane, as the income is more and cotton and tur are two seasonal crops only whereas sugarcane is perennial. At the same time cotton and tur do not require intense canal irrigation as compared to sugarcane resulting less utilization of water from the storages. (These findings are based on three case studies conducted by the author of progressive farmers from Parbhani district).

- Land holdings in the command of Jayakwadi project especially in Parbhani district are on higher side i.e 75% of the farmers are having lands more than 2 ha.

9.1.5 Study of middle Godavari sub-basin:

Recently (2010-2011) a study of middle Godavari sub-basin (where Jayakwadi project command lies) has been done for the Government of Maharashtra as a part of a comprehensive study of entire Godavari basin. One of the objectives of the study is to assess the socio-economic impact due to development of irrigation potential in the sub-basin. For this comprehensive study a sample of farmers was selected from the command area as well as from the nearby uncommand area. A specially developed schedule was canvassed among sampled farmers and the data was analysed separately for command and uncommand area farmers.

A Table from this draft (unpublished) report relevant to the present study is as below:

Socio economic impact indicators at a glance for Jayakwadi Project

Sr. No	Items	Command area	Uncommand area	Comparison between Command & Uncommand area
1	Main Occupation	Agriculture	Agriculture	Favorable situation
2	Subsidiary occupation	5%	Nil	-
3	Family size	7.12	5.84	High in command area
4	Avg. Land holding (Irrigated) Ha.	5.38	Nil	Comparatively higher land (ha) holdings in both commands.
5	Avg. Land holding (rain fed) (Ha) and uncommand area	3.25	3.98	Higher in command area
6	Avg. Total Land holding (Ha)	5.1	3.98	Higher in command area
7	Agricultural Equipment	20%	8%	High in command area
8	House (Kachha/Pakka)	K = 57%, P = 43%	K = 77%, P = 23%	Increase in no. of Pakka (P) houses.
9	Livestock	73%	66%	High in command area
10	Consumer durables	79%	60%	High in command area
11	Main Crops (Kharif)	Cotton, Soyabean & Tur	Cotton, Bajara & Tur	Inclusion of cash crop
12	Main Crops (Rabi)	Jawar & Wheat	Jawar & Wheat	No change

Sr. No	Items	Command area	Uncommand area	Comparison between Command & Uncommand area
13	Main Crops (HW)	Groundnut	Nil	Inclusion of cash crop
14	Main Crops (Perennial)	Sugarcane & Fruit	Nil	Significant change in crops cropping pattern
15	Benefits of Irrigation	82%	Not Applicable	Significant achievement
16	Improved Standard of Living	78%	10%	Significant improvement in command area.
17	No. of Wells/farmer	1.08	0.57	Significant increase
18	Increase in Water Level	32%	Not Applicable	Significant increase
19	Real Benefits due to canal water	Y =32%, Some Extent = 68%	Not Applicable	Significant achievement
20	Increase in productivity	82%	Not Applicable	Significant increase
21	Change in cropping pattern	66%	Not Applicable	Significant change
22	Land degradation due to fertilizers	Y =4%, N =96%	Not Applicable	Negligible land degradation
23	Water logging	Y =21%, N = 79%	Not Applicable	Indicates alarming situation
24	Diseases due to irrigation	0%	Not Applicable	Significant achievement
25	Increase in subsidiary	15%	8%	Increasing trend in Subsidiary occupation
26	Increase in employment	63%	26%	significant increase
27	Migration	100% (stopped or decrease)	46% (increase)	Important significant achievement.
28	Increase in Agro industries	74%	13%	significant increase
29	Infrastructure Development	72%	63%	Infrastructure development,
30	Accessibility to Market	Y =5%, N = 95%	69%	etc. are independent of
31	Other facilities available	Y = 62%, N =38%	Y =75%, N=25%	irrigation facility.

In general it can be stated that significant impact on the socio economic condition of the farmers in the command area compared with the impact in uncommand area is observed due to Jayakwadi Project. Except water logging other undesirable factors (at Sr. No. 22, 24 & 27) are also almost nonexistent.

9.1.6 Human Development Index :

Maharashtra Human Development Mission is functioning since 29th June 2006 at Aurangabad. Human Development Index (HDIs) for all the districts in Maharashtra are available. The index is calculated by considering literacy ratio, infantile mortality rate and per capita district domestic product in rupees. The relevant data for districts in which Jayakwadi command area is spread and the sample is selected is presented in the following table.

Comparison of Per Capita income and HDI.

Sr. No.	District	Human Development Index	Rank In Maharashtra	Per Capita District Domestic Product (Rs.)	Rank In Maharashtra
1	Ahmednagar	0.57	11	15251	22
2	Aurangabad	0.57	12	19365	11
3	Jalna	0.27	33	12047	33
4	Parbhani	0.43	24	13827	26
5	Beed	0.47	18	15303	21
6	Maharashtra	0.58		22763	

Compared to the state HDI of 0.58, it is seen that barring Ahemadnagar & Aurangabad all other districts in the study area are far below state average. The ranking is still worse when per capita district domestic products are considered. As far as per capita domestic products is concerned, Aurangabad district is top most followed by Ahemadnagar district with Jalna at the bottom. Recently GoM has issued directives to pay special attention to the talukas having cooperatively very less HDI.

In general the study of secondary sources of information and data discussed above reveals following observations.

1) The MAU studies clearly bring out significant contribution of Jayakwadi project with change in cropping pattern, introduction of cash crops and increase in cropping intensity, etc. Standard of living of SC/ST and other socially under previllaged sections of society has also increased

2) Study of Mr. Dighe highlights the tertiary / intangible benefits of Jayakwadi project observed up to 1995.

3) These benefits are further substantiated with data up to 2001-2002 in the article by Mr. Chakurkar.

4) Article by Shri. A. K. Javalekar stresses the need and importance of roads, regulated markets, agro processing industries etc. The need for giving remunerative prices to agriculture produced is also underlined by the author.

5) HDI is a comprehensive indicator which shows that providing water is one thing but quality of life indicated by higher value of HDI is the ultimate goal.

In short, all the above mentioned studies show a positive impact on the socio-economic condition of farmers in the command area of Jayakwadi irrigation project.

9.2 Analysis and study of Primary data

In order to assess the socio-economic aspects of the beneficiary farmers due to the changing water allocation in the command area of Jayakwadi project, it was felt necessary that a sample survey of farmers be conducted. For the collection of this primary data, a schedule in Marathi was designed and the same was decided to be canvassed among representative sampled farmers belonging to the command area of Jayakwadi Project (Paithan Right Bank Canal (PRBC) and Paithan Left Bank Canal (PLBC) as well as beneficiary farmers lifting water from the back water.

9.2.1 Strategy for data collection:

The schedule was such that the trained investigators will ask the questions to the farmers and write their responses in the form of tick marks or codes already written against the questions in the schedule. Instead of giving questionnaire to the farmers for filling up the same this method of schedule was preferred in view of the illiteracy of the farmers, difficulties in understanding the questions correctly and likely mistakes. Initially, general information and simple questions are included in the schedule and then technical questions are asked. This schedule was prepared in consultation with the concerned Water Resources Department officials, experts and some field staff also. The schedule was also discussed in the training program specially organized for this purpose. The schedule was also pre-tested on about 15 farmers each from PLBC, PRBC and farmers lifting water. A few modifications were made in the schedule considering the response in the pre-testing.

A sample of about 1500 farmers was selected considering their location i.e. head, middle and tail reach in respect of the water distribution system consisting of two main canals, distributaries and minors. Another aspect considered was that there should be representation in the sample to the farmers from all the districts benefited by Jayakwadi project. Care was

taken to see that farmers having large, medium and small & marginal landholdings are represented in the sample. The aim was to see that the sample becomes representative of the entire population of beneficiary farmers benefited by Jayakwadi project. In view of significant number of farmers lifting water from back water it was decided to have their representation also in the sample. Considering the importance of the socio-economic aspects in the entire study, availability of time, money, etc. a total sample size of 1500 to 1600 was decided. Actually, 1578 farmers from 90 villages were included in the sample.

A one day training program was organized in Aurangabad where the investigators and the concerned WRD staff was trained. They were told about the purpose and object of the socio-economic survey. All the questions included in the schedule and their possible answers, etc. were discussed with them. Wherever required, additional information and explanations were given to them. Then open discussion was arranged to get the feedback from the investigators and WRD staff. Some experience sharing was also done by some participants regarding their experiences in similar such data collection efforts. The subject matter experts, and WRD staff gave useful hints. Do's and Don'ts were also discussed. How to establish rapport with the contact farmers included in the sample, how to take help from local WRD staff and Sarpanch, if necessary, etc. were also discussed. A dry run was conducted with a couple of investigators and modifications were discussed. It was made clear that the technical staff of WRD will have the role of supervision on the data collection activities and that of a facilitator in establishing adequate rapport with the sampled farmers.

The WRD staff supervised the actual data collection and close monitoring was done ensuring quality of data and its reliability. Random checks by the higher officials and consultants were also done on the field. All these efforts were taken to ensure high quality, reliability and validation of the primary data.

9.2.2 Schedule of questions

The schedule contains about 50 questions asked in Marathi (local language) and the same were filled in by the investigators considering the response of the farmers. The entire data was computerized and analysed statistically, which gave the necessary assessment of the impact. The first few questions in the schedule were for getting general information of the respondents like their name, location, village, survey/gut number, minor number, etc. The subsequent questions were designed to get information on new irrigated crops taken by them, their perception about the present water allocations for different uses, starting of anciliary livelihood activities, on farm water application methods, use of drip and sprinkler,

development of infrastructure facility, improved income and standard of living, etc. These questions are divided in the following categories.

1) General information like name of the farmer, village, survey and gut number and location on the water distribution system, viz. canal/distributary/minor.
2) Questions related to agricultural aspects such as land holding, crops taken, cropping intensity, additional sources of water, subsidiary occupation, agricultural income, etc.
3) Questions related to irrigation, scheduling, water users association, irrigation behavior of farmers, etc.
4) Questions related to non irrigation uses of water, water allocation, uncertainty in getting canal water, etc.
5) Questions related to the overall indirect / intangible impact of Jayakwadi irrigation project.

The details of the farmers included in the sample are given in the following table :

Composition of sample

Sr.No.	Village	Taluka	District	No. of farmers
1	Pravara Snagam	Newasa	Ahmadnagar	15
2	Toka	Newasa	Ahmadnagar	15
3	Mungi	Sheogaon	Ahmadnagar	20
4	Dahigaon	Sheogaon	Ahmadnagar	15
5	Erandgaon	Sheogaon	Ahmadnagar	15
6	Jamgaon	Gangapur	Aurangabad	15
7	Kayegaon	Gangapur	Aurangabad	15
8	Amalner	Gangapur	Aurangabad	3
9	Waghadi	Paithan	Aurangabad	15
10	Vihamandva	Paithan	Aurangabad	15
11	Paithan	Paithan	Aurangabad	15
12	Apegaon	Paithan	Aurangabad	15
13	Hiradpuri	Paithan	Aurangabad	15
14	Pategaon	Paithan	Aurangabad	20
15	Changatpuri	Paithan	Aurangabad	20
16	Buttewadi (Aurangpur)	Paithan	Aurangabad	19
17	Amrapur waghude	Paithan	Aurangabad	1

Sr.No.	Village	Taluka	District	No. of farmers
18	Dhakephal	Paithan	Aurangabad	4
19	Jalgaon	Paithan	Aurangabad	6
20	Babultara	Georai	Beed	20
21	Talwada	Georai	Beed	20
22	Golegaon	Georai	Beed	20
23	Adgaon	Georai	Beed	20
24	Chavanwadi	Georai	Beed	20
25	Jategaon	Georai	Beed	20
26	Bagpimpalgaon	Georai	Beed	20
27	Malegaon	Georai	Beed	20
28	Dhondrai	Georai	Beed	20
29	Gulaj	Georai	Beed	20
30	Borgaon	Georai	Beed	20
31	Sultanpur	Majalgaon	Beed	20
32	Kesappuri	Majalgaon	Beed	20
33	Takarvan	Majalgaon	Beed	20
34	Mahakala	Ambad	Jalna	20
35	Wadigodri	Ambad	Jalna	20
36	Chumrapuri	Ambad	Jalna	20
37	Ekalhera	Ambad	Jalna	20
38	Gondi	Ambad	Jalna	20
39	Patharwala	Ambad	Jalna	20
40	Tirthpuri	Ghansavangi	Jalna	20
41	Murti	Ghansavangi	Jalna	20
42	Rajatakli	Ghansavangi	Jalna	4
43	Ganeshnagar	Ghansavangi	Jalna	15
44	Rajurkarkotha	Ghansavangi	Jalna	1
45	Limbi	Ghansavangi	Jalna	20
46	Ku. Pimpalgaon	Ghansavangi	Jalna	20
47	Shripad Dhamangaon	Ghansavangi	Jalna	20
48	Loni (B)	Partur	Jalna	10
49	Loni	Partur	Jalna	10
50	Savangi	Partur	Jalna	20

Sr.No.	Village	Taluka	District	No. of farmers
51	Pimpli Dhamangaon	Partur	Jalna	16
52	Banachiwadi	Partur	Jalna	2
53	Ko-Hadgaon	Partur	Jalna	2
54	Dharasur	Gangakhed	Parbhani	20
55	Kekarjawla	Manwat	Parbhani	20
56	Manglur	Manwat	Parbhani	20
57	Rampuri	Manwat	Parbhani	20
58	Ambetakli	Parbhani	Parbhani	20
59	Pokharni	Parbhani	Parbhani	20
60	Daithna	Parbhani	Parbhani	20
61	Amdapur	Parbhani	Parbhani	20
62	Lohgaon	Parbhani	Parbhani	20
63	Takalgavahan	Parbhani	Parbhani	20
64	Zhadgaon	Parbhani	Parbhani	20
65	Pingli	Parbhani	Parbhani	20
66	Varpud	Parbhani	Parbhani	20
67	Pimprideshmukh	Parbhani	Parbhani	20
68	Aaswala	Parbhani	Parbhani	20
69	Karegaon	Parbhani	Parbhani	20
70	Kasapuri	Pathri	Parbhani	20
71	Jawla	Pathri	Parbhani	20
72	Nathra	Pathri	Parbhani	20
73	Pathargawhan	Pathri	Parbhani	20
74	Pathargawhan [Kh]	Pathri	Parbhani	20
75	Mardasgaon	Pathri	Parbhani	20
76	Hadgaon [B]	Pathri	Parbhani	20
77	Warkhed	Pathri	Parbhani	20
78	Devegaon	Pathri	Parbhani	20
79	Simurgavahan	Pathri	Parbhani	20
80	Khedula	Pathri	Parbhani	20
81	Borgavahan	Pathri	Parbhani	20

Sr.No.	Village	Taluka	District	No. of farmers
82	Pathri	Pathri	Parbhani	20
83	Maliwada	Pathri	Parbhani	20
84	Bandarwada	Pathri	Parbhani	20
85	Kherda	Pathri	Parbhani	20
86	Gunj	Pathri	Parbhani	20
87	Tura	Pathri	Parbhani	20
88	Renapur	Pathri	Parbhani	20
89	Tadkadas	Purna	Parbhani	20
90	Makhni	Purna	Parbhani	20
			TOTAL:	**1578**

9.3 Findings :

Categoriwise important findings obtained after the analysis of primary data collected through sample survey of the beneficiary farmers are presented below:

9.3.1 Agricultural Aspects

Sr. No.	Aspects / Questions	Percentages (%)
1	How much land do you hold in your name?	
	(Av.Ha)	1.90
	(Std.Deviation Ha)	1.58
2	Which new crops you have taken since you started getting Canal Water from Jayakwadi Project during last 30 years?	
	Wheat	52.92
	Groundnut	25.92
	Cotton	83.59
	Jawar (Sorghum)	30.04
	Sugarcane	50.44
3	Do you take crops during Kharif, Rabbi and hot weather seasons?	
	1. Kharif,	7.10
	2. Kharif and Rabbi,	57.48
	3. Hot weather	2.15
	4. Perennial,	17.30
	5. Different crops in three seasons	7.79
4	Have you started taking crops requiring comparatively less water considering the vagaries of monsoon and uncertainty in getting water from Jayakwadi project? Yes / No	
	Yes : 90.49%	
	1. Sunflower,	7.10
	2. Bengal gram (Chana)	52.28
	3. Sorgam (Jawar),	57.22
	4. Linseed,	3.49
	5. Peas	1.58

5	Considering the overall situation of availability of water and element Of uncertainty do you select such varieties of crops which can Sustain longer stress of water? Yes : 61.34% No : 42.14%	
6	Considering the water availability which crops do you take in normal (good years) and scarcity (bad) years?	
	Good Year	
	1. Banana	9.57
	2. Groundnut	20.85
	3. Cotton	80.35
	4. Sugarcane	81.43
	5. Wheat	45.82
	Bad Year	
	1. Jawar (Sorghum)	57.48
	2. Bajara	22.94
	3. Chana	11.98
7	Is it possible to repay the loans taken for agriculture purposes Considering the income? Yes / No	
	Yes	59.57
	No	34.66
	No response	2.53
8	What measures do you suggest to bridge the gap between minimum support price announced by Government and actual market price?	
	1. Decide Govt. Price considering market price	57.54
	2. Establish system of taking quick review of support price	39.23
	3. Other	1.58

9	What are the prevailing daily wages in your village to the laborers?	
	Average daily wages for female workers	Rs.107
	Std.Deviation	20.84
	Average daily wages for male workers	Rs.186
	Std.Deviation.	32.03
10	What are the actual working hours per day?	
	Average daily hours per day for female workers	6.46 hrs
	Std.Deviation	0.91
	Average daily houses per day for Male workers	6.99 hrs.
	Std.Deviation.	1.18
11	Do women participate in the sales / marketing of agricultural produce?	
	Yes	37.20
	No	61.41

Comments: The table is self-explanatory. Average land holding is 1.90 ha. Significant change in cropping pattern is seen. Choice of crops and varieties in view of less availability of water is done by the farmers. Similarly, choice of crops in good and bad years is also done by them. They are able to repay loans. Farmers want deciding minimum support price mechanism to be a dynamic process. Daily wages of agriculture labors are increasing while their daily out turn is decreasing which is a cause of concern. Women participation in marketing activities is much less.

9.3.2 Irrigation related aspects

Sr. No.	Aspects / Questions	Percentages (%)
12	In order to make efficient and economical use of available water have you started using advanced irrigation methods like drip irrigation / sprinkler irrigation?	
	Yes	15.02
	No	84.73
13	If it is not possible to use advanced methods of irrigation due to Financial difficulties have you adopted any of the following water Saving measures?	
	1. Proper irrigation & cross slopes	12.29
	2. Land leveling	42.78
	3. Irrigation layouts like ridges & furrows etc.	41.51
	4. Other	2.92
14	Just as you measure fertilizers given to the crops, seed bags, no.of sprayings of insecticides/pesticides etc. do you measure quantity of water given to the crops?	
	Yes	4.25
	No	95.18
15	Do you obtain the important information regarding availability of water in the dam, no. of rotations, schedule of rotations and your turn of getting water?	
	Yes	46.58
	No	46.07

16 What is your opinion about the present practice of farmers lifting? Water from the reservoir and from canal for irrigating their crops in the uncommand area?

Right	49.18
Wrong	42.71
If Right, measures to regulate:	
1. Regulating actual water supplies to restrict unauthorized area	30.35
2. Restriction on crops	11.28
3. Actual use of advanced irrigation methods like drip	14.58

17 What defects / deficiencies have been developed in the distribution system (Canal / Distributary / Minor outlets / etc.) of this project because of inconsistency in the regular water Supply every year?

1. Disturbed lining	15.78
2. Reduction in carrying capacity	33.97
3. Vegetative growth etc.	65.65
4. Gates not maintained	42.78
5. Scouring of earth work	26.36
6. Siltation	64.70
7. Minors not in the proper shape	58.94
8. Distribution system is ok	8.75

18 Do you feel that training regarding water literacy, efficient use of water etc. to the farmers be still continued to be given by WALMI Aurangabad, CADA I Agriculture Department?

Yes	92.84
No	7.10

19	Government of Maharashtra is implementing the practice of giving water on volumetric basis to the group of farmers (Water users Association) on the pattern of Waghad Project in the command of Jayakwadi and other irrigation project in Maharashtra. Do you think that this measure will be good and beneficial?	
	1. Yes	41.51
	2. No	26.93
	3. Do not know	22.75
20	Do you think that it is necessary to test the quality of water (from well, bore well, canal, etc.)?	
	Yes	73.26
	No	29.53
	Can not say	5.26
21	In view of less availability of water do you think that it is necessary to irrigate during night? If yes are you ready to irrigate during night?	
	Yes	85.68
	No	13.31
	If yes	
	Yes	82.19
	No	3.36
22	Do you think that the present water distribution system of flow irrigation consisting of canal / distributary / minor is appropriate and useful? Yes/No	
	If No, should the canal water be provided through pipe from minor onwards	
	Yes	31.94
	No	44.99
	All who said yes have agreed for water supply through pipe	

23	Have you reclaimed your own water logged / saline / degraded land for doing irrigated agriculture?	
	Yes	26.93
	No	71.80
24	Do you think that the present practice of having chaksize of 15-20 ha. designed for irrigation planning is ok ?	
	Yes	54.18
	No	35.36
	The suggested chaksizes are :	
	10-15 ha.	29.40
	20-25 ha.	7.35
	25-30 ha.	0.32
25	What is your opinion about the water rates fixed for the hot weather season for the flow irrigation in command area and rates applicable to the lift irrigation from reservoir?	
	Appropriate	56.59
	Not Appropriate	41.32
	If not appropriate the changes suggested are :	
	The rates for the command area should be reduced	38.66
	The rates for lift irrigation be increased	1.65
26	On the background of 30% reservation to women in local self governance, has women's participation increased in the functioning of Water Users Associations ?	
	Yes	28.45
	No	69.20
	The reasons for less participation are :	
	Male dominance	27.82
	Availability of time is constraint	4.18
	Social norms and taboos	41.38

27	Is there regular availability of seeds of improved / high yielding varieties?	
	Yes	77.06
	No	21.36

Comments: Adaption of drip and sprinkler system is very slow. However, comparatively less costly measures like irrigation layouts etc. is done by farmers. Only 5% farmers measure water given to the crops which is a serious concern. Less than 50% farmers take information about irrigation scheduling etc. from the concerned department. Lifting of water from reservoir is accepted by farmers but they want strict regulation on its use. Water conveyance system is poor. Only 8.75% farmers say that the system is ok. About 42% farmers want WUAs. Awareness about quality of water is comparatively high. Night irrigation is now accepted by the farmers. Piped supply according to them is not required. Need about reclaiming their own affected land is not yet felt because it is perhaps a costly proposal. Present chaksize is ok. 41% farmers feel that lift water charges be revised. Participation of women in WUAs is very less. Seeds are regularly available.

9.3.3 Non Irrigation Uses & Uncertainty

Sr. No.	Aspects / Questions	Percentages (%)
28	Is Water from Jayakwadi project being used for purposes other than agricultural?	
	Yes	67.17
	No	12.42
	If Yes, the purposes identified:	
	1. Drinking purpose,	86.50
	2. Industrial purpose,	93.92
	3. Hydro power generation,	38.09
	4. Recreation,	4.06
	5. Cultural purpose	4.06
29	Drinking water is being supplied to Aurangabad city by Corporation. This quantity is going to increase in future. What is your opinion about this? Right/Wrong	
	Right	56.21
	Wrong	43.66
	If Right, What should be the frequency?	
	1. Frequency should be reduced	10.90
	2. Alternate day,	17.68
	3. Water supply should be stopped	1.52
	4. Alternate arrangement should be made by Corporation	---
30	Barring a few exceptions, you have been experiencing the shortage of water for agricultural use from Jayakwadi project during last 10-15 years. Expecting this trend infuture have you made any other arrangement to improve water availability?	
	Yes	64.13
	No	35.80
	If Yes	

	1. Bore well	22.05
	2. Open dug well	47.78
	3. Farm pond	0.32
	4. Soil conservation works	---
	5. Recharging of well	0.32
	6. Additional bore (Horizontal/Vertical)	5.58
	7. Other	0.76
31	Considering the overall uncertainty in irrigated agriculture have you started ancillary / supporting profession / activity?	
	Yes	24.14
	No	65.65
	If yes	
	Dairy	18.12
	Animal husbandry	12.61
	Renting agricultural equipment/ implements	5.13
	Agro processing	1.90
	Other	8.62
32	Considering the water uncertainty should the watershed development works be taken up in the command of this project ?	
	Yes	77.63
	No	22.12
	If yes	
	Farm pond	61.53
	Other Watershed development works	54.63
	Nala bunding etc.	35.49
	Other	4.63
33	Because of uncertainty in getting water from Jayakwadi Project has anybody from your family / village migrated to other place?	
	Yes	24.78
	No	75.03

34 Considering the less availability of water resulting into some command area which is deprived of canal water but still being declared as command area what issues / problems have cropped up?

1. No watershed development works because area is declared as command area.	84.73
2. Restriction on sale and purchase of land	57.98
3. Enforcement of Land Ceiling Act etc.	18.69
4. Other	2.85

35 Considering the less availability of water should some area be deleted from the present command area?

Yes	23.00
No	59.13
Can not say	17.24

36 Some reasons for getting inadequate and uncertain water for agricultural purposes from the Jayakwadi project are listed below. It is requested to put number 1, 2, 3 as per their importance (No.1 for most important reason):

1. Less water yield in the reservoir	87.14
2. Faulty / dilapidated distribution system	85.99
3. Negligence / lethargy of concerned department / authority	71.04
4. More drawl of water from reservoir and from the upper reach of distribution system	71.55
5. Absence of co-operation and sense of understanding among beneficiaries	64.51

37	Do you have suggestions for reducing the element of uncertainty in getting water from Jayakwadi project.	
	Yes	63.88
	No	28.39
	If yes	
	1. Filing of upstream reservoirs in equal proportion (basin wise)	28.58
	2. Experiments of group farming / corporate farming	19.07
	3. Imposing restriction on use of water for other than agricultural purpose	32.13
	4. Assure minimum stipulated no. of rotations in the year	20.98
	5. Do not give water during hot weather season but do give assurance of water for Kharif and Rabbi seasons.	18.95
	6. Other	4.94

Comments : Farmers knowledge and awareness about other uses of water is quite high. Majority of farmers have accepted the need for water supply to Aurangabad city. However, they want that in bad years the frequency of water supply be reduced. In view of less availability and uncertainty of water they have taken efforts to augment the existing water supply. Very few farmers have taken up other supporting activities for livelihood. A strong need is felt for taking up watershed development works in the command area. Migration is reported by 25% farmers which is an indication of urbanization. In view of water shortage and uncertainty farmers recommend that some command area be deleted / de-notified. The major reason identified by them for uncertainty and less availability of water is the less water yield in the reservoir. They have suggested measures for reducing the uncertainty. They want that upstream reservoirs be proportionately filled up i.e. they want basin wise water policy rather than individual project wise policy. Farmers also want that restrictions should be imposed on non-irrigation uses. They suggest that give less number of watering's but with maximum assurance.

9.3.4 Overall Impact

Sr. No.	Aspect	Percentages
38	Do you think that agro based processing industries have increased in your region because of Jayakwadi Project?	
	Yes	57.79
	No	42.08
39	Do you think that all weather roads, regulated markets, means of transport, etc. have increased in your region because of Jayakwadi Project?	
	Yes	70.79
	No	28.96
40	Inspite of many odds / difficulties still do you think that this project has definitely benefitted you?	
	Yes	80.29
	No	18.88
	If yes	
	1. Employment generation increased	10.01
	2. Financial situation improved	25.79
	3. Improvement in educational facilities	---
	4. Market facilities improved	---
	5. Medical / Public Health facilities improved	---
	6. Able to take cash crops	18.57
41	Has your overall standard of living improved because of this project?	
	Yes	74.84
	No	24.46
	If yes	
	1. Pakka House	63.43
	2. New Agricultural implements / equipments	17.36
	3. Vehicles	11.66
	4. Ability to spend more on education and health of family members	36.19
	5. Availability of funds for well / pump / etc.	13.43
	6. Other	1.58

42	What is your approximate per hectare income in Rupees in the last three.seasons? Rs. …….. per hectare	
	1. Less than Rs. 25,000	20.34
	2. Rs. 25,000 to 35,000	18.88
	3. Rs. 35,001 to 50,000	22.43
	4. Rs. 50,000 to 75,000	16.22
	5. More than Rs. 75,000	22.12
43	"One person from your family to take care of agriculture in the village and other family members to shift to nearby town / city for service" has this happened in your family?	
	Yes	26.30
	No	73.70
44	Have any changes from the environmental point of view taken place due to this project?	
	1. Drinking water facilities improved	77.19
	2. Increase in well water	75.98
	3. Bird sanctuary	10.58
	4. Vegetative growth (flora and fauna increased)	55.96
	5. Tourism development	3.04
	6. Water logged / saline soils	10.08
	7. No 'round the year water flows' in the rivers	3.87
	8. Other	3.30
45	Are foot bridges / bridges / crossings constructed on the KT Weirs, nallas, streams in the command area to facilitate transport / communication	
	Yes	15.91
	No	20.41
	Places have been identified	60.08

46	For agricultural development works such as digging well, drip irrigation, bore well, etc. are co-operative credit society or similar financial institutions available?	
	Yes	71.48
	No	25.79
	Were you required to take loan from private money lender?	
	Yes	38.53
	No	53.80

47	For efficient and effective use of canal water do you think it is necessary to construct en-rout storages and or storages at the end of distributary / minor?	
	Yes	15.84
	No	74.14

Comments: The agro processing activity has increased. Other infrastructure has also improved. As many as 80% farmers feel that they are benefitted by Jayakwadi project and their overall standard of living has improved. Per ha. income is not very satisfactory but can be improved. 26% migration is reported. Environmental changes are significant and except water logging they are all beneficial and favorable. Communication / transportation facilities need to be improved. They have reported that financial institutions are available but still they are taking loan from private sources. They do not see any need for enroute storages.

9.3.5 Summary of findings:

Despite changing water allocations and uncertainty, significant changes in socio-economic aspects have taken place. Farmers have adjusted to this situation of uncertainty and shortages. That they are benefited by the project is an establish fact. There is scope for improvement even with the uncertainty and shortage of water. It is seen that the element of uncertainty can be reduced through basin wise planning of filling reservoirs, water saving techniques, on farm development works, more and continued need based training etc. In short, there is significant potential to increase the benefits further.

10 Impact on Industrial Development

10.1 Introduction:

It is seen that Jayakwadi Project is boon for industrial development in this economically backward region. Although the provision for industrial and domestic water supply in the original project planning is nil, but slowly needs and demands has resulted in diverting water for industrial and domestic purposes. Up till now sanctioned water quota for drinking and industrial purpose is 185.75Mm3 & 53.733Mm3 respectively. Against total sanction quota of 239.483 Mm3 maximum water use for Non Irrigation was observed as 150.29 Mm3 in the Year 2004-05

10.2 Diversion of water for Non-Irrigation use:

Table 10.1 gives year wise breakup of irrigation and non-irrigation use. It is seen that out of 30 years, the total non-irrigation use is less than 10% of design live storage. Non irrigation use includes industrial as well as domestic water use. Domestic water use is more than industrial water use which is about 30% of total non-irrigation use. Therefore it can be said that industrial water use is not considerable as compared to irrigation use. The maximum total non-irrigation use at present is about 150 Mm^3, off which industrial use is about 50 $Mm^{3.}$ Thus industrial water use is about 3% of total irrigation use. Even if we can increase present conveyance efficiency from 35% to 38%, this industrial requirement can be met without affecting irrigation potential.

Therefore it can be concluded that at present, diversion of water for industrial purpose considered alone is not affecting the irrigation potential. On other hand, industrial development in this region due to Jayakwadi Project has contributed considerably for raising economy and employment generation in the area.

10.3 Industrial Development:

The details of industries developed around Jayakwadi Project through Maharashtra Industrial Development Corporation (MIDC) are given in Table 10.2. The abstract of industrial development including industries other than MIDC is as given below.

Category	No.of Industrial Area	Employment (Approx.)
MIDC	19 (6902 ha. area & 4405 plots)	45785
Sugar Factories	11	55000
Ginning & Pressing	12	1200
Other Industries	10	1500

The study conducted by Chief Engineer & Chief Administrator, CADA, Aurangabad (1995) shows that 1135 Industries including Sugar factories with a total annual turnover of 1400 crores have developed during 1980 to 1990 due to water supply from Jayakwadi Project. The employment generation is about 50,000.

10.4 Revenue Generation:

The breakup of revenue generation for Irrigation and non-irrigation use is given below

Particulars	Year			
	2006-07	2007-08	2008-09	2009-10
I. Irrigation Use				
a) Water use	1166.65	1148.98	1350.044	333.61
b) Gross revenue	645.31	1678.4	3411.76	1281.7
c) Revenue/unit of Water use (Rs lacs/Mm3)	0.55	1.46	2.52	3.85
II Non Irrigation Use				
a) Water use	97.357	201.456	208.786	125.404
b) Gross revenue	5089.2	8757.86	5010.87	6898.22
c) Revenue/unit of Water use (Rs lacs/Mm3)	52.46	43.47	24.08	55

It indicates that revenue per unit of water use for non- irrigation purpose is higher than that for Irrigation purpose.

10.5 Impact on Reservoir losses:

The Jayakwadi Reservoir is located in flat terrain. More surface area of impounded water is exposed to evaporation. The evaporation is maximum in summer season. Therefore, for fulfilling non-irrigation water requirement in summer season, more water is required to be reserved duly taking into account the evaporation losses. A study conducted by WALMI Aurangabad showed that, in the year 2001-02 actual water used for non-irrigation purposes from the reservoir is 18 Mm^3 , but the corresponding evaporation loss is 29 Mm^3 requiring total 47 Mm^3 of water to be kept reserved. This indicates that evaporation loss is more than the actual requirement. This can be minimized by storing water in secondary small storage, which has been discussed in detail in Chapter No.14 on “Mitigation Measures”.

10.5 Limitations of Industrial Development:

The discussion held with MIDC officials indicated that at present water availability is not a constraint for Industrial Development.

10.6 Conclusion:

The volume of water diverted for industrial use is very less as compared to water use for irrigation and domestic purposes and has not affected the irrigation potential of the project. Slight reduction in the conveyance losses from canal and distribution network will make available the water for industrial use. On the contrary the industrial development because of the project has contributed significantly in the economic & social uplift of the region. Purchase of 135 Mercedes Benz Cars by the group of Industrialist from Aurangabad city in a single stroke in the year 2011confirms the economic development in Industrial sector which is supported by the water supply from Jayakwadi project. Measures to reduce evaporation losses in summer season are necessary to save water particularly when there is less inflow compared to the inflow contemplated in project design.

Table 10.1
IRRIGATION & NON-IRRIGATION USE

Year	Actual Live Storage	Total withdrawal from reservoir Mm3	Irrigation use	% w.r.t. Live storage	Non-irrigation use (Industry + domestic)	N.I Use % compared to withdrawal from Storage	N.I Use % compared to Design Live Storage (2170.935 Mm3)
1975-76	135.250	171.03	167.261	97.8	3.769	2.2	0.17
1976-77	1162.350	252.601	249.108	98.6	3.493	1.4	0.16
1977-78	939.170	199.35	195.863	98.3	3.487	1.7	0.16
1979-80	695.800	541.311	536.009	99	5.302	1	0.24
1980-81	1468.250	724.801	718.245	99.1	6.556	0.9	0.30
1981-82	602.000	920.737	910.478	98.9	10.259	1.1	0.47
1982-83	1600.020	1123.986	1110.372	98.8	13.614	1.2	0.63
1983-84	1210.550	951.749	938.365	98.6	13.384	1.4	0.62
1984-85	2037.910	1124.718	1108.313	98.5	16.405	1.5	0.76
1985-86	1751.340	710.818	690.279	97.1	20.539	2.9	0.95
1986-87	663.240	231.852	209.281	90.3	22.571	9.7	1.04
1987-88	304.600	225.363	206.032	91.4	19.331	8.6	0.89
1988-89	475.230	1240.405	1219.024	98.3	21.381	1.7	0.98
1989-90	2041.610	1384.537	1364.608	98.6	19.929	1.4	0.92
1990-91	1976.040	1321.139	1290.322	97.7	30.817	2.3	1.42
1991-92	2171.000	1654.772	1616.62	97.7	38.152	2.3	1.76
1992-93	1678.620	401.028	342.07	85.3	58.958	14.7	2.72
1993-94	690.340	780.521	732.295	93.8	48.226	6.2	2.22
1994-95	763.100	1684.28	1632.05	96.9	52.23	3.1	2.41
1995-96	1913.950	254.077	180.75	71.1	73.327	28.9	3.38
1996-97	306.110	434.654	379.805	87.4	54.849	12.6	2.53
1997-98	770.453	775.397	702.832	90.6	72.565	9.4	3.34
1998-99	1068.789	914.28	844.024	92.3	70.256	7.7	3.24
1999-00	2126.758	1140.439	1071.96	94	68.479	6	3.15
2000-01	2167.353	951.963	879.951	92.4	72.012	7.6	3.32
2001-02	1281.731	349.387	269.809	77.2	79.578	22.8	3.67
2000-03	494.169	244.364	137.674	56.3	106.69	43.7	4.91
2003-04	404.373	291.307	137.213	47.1	154.094	52.9	7.10
2004-05	392.687	1101.042	923.518	83.9	177.524	16.1	8.18
2005-06	2129.141	1374.937	1232.268	89.6	142.669	10.4	6.57
2006-07	2170.935	1757	1166.65	66.36	97.357	5.5	4.48
2007-08	2170.935	1872.912	1148.98	61.37	201.456	10.73	9.28
2008-09	2170.935	2069.45	1350.044	65.24	208.786	10.08	9.62

Table 10.2

MAHARASHTRA INDUSTRIAL DEVELOPMENT CORPORATION (MIDC) AROUND JAYAKWADI PROJECT

Sr. No.	Industrial Unit	Total Area (ha)	Year of Establishment	Total Plots	Major Industries	Employment (Approx.)	Remarks
1	Aurangabad	35	1963	133	Silver light, Nirlep, Grand Master, Ajanta Tiles	900	
2	Additional Aurangabad (Gandheli)	2700	2010				Special Economy zone is proposed
3	Chikalthana	720	1965	954	Wochardt, German Tools, Hindustan Levers, Garware Plastics, Maharashtra Distillaries, Lupin'	12350	
4	Waluj	1563	1983	1540	Bajaj Auto, Colgate Palmolive, Johnson & Johnson, Siemens, Endress & Housers, Starlite	18800	
5	Shendra (5 Star)	860		316	Skoda, Aluminium related SEZ, Wochardt	1000	Now included in Industrial corridoor
6	Paithan	286		187	Pepsi, Ajanta Pharma, M/s Hindustan.	2315	
7	Old Jalna	50		80	MAHICO, BALAJI Oil Mill, PITI Oil Mill	750	
8	Additional Jalna	281		454	TIN Vishwa	4200	
9	Jaffrabad	14		31		210	
10	Bhokardan	11		51		165	

Sr. No.	Industrial Unit	Total Area (ha)	Year of Establishment	Total Plots	Major Industries	Employment (Approx.)	Remarks
11	Ambad	35		26		525	
12	Partur	51		51		765	
13	Beed	68	1971	224	Gajanan Maharaj Refinery, Dutta Plastics, Trimurti Plastics, Laxmi Ice, Jay Maladi foods, RCC Pipe, Oil Mills	400	
14	Ashti	15		29		225	
15	Dharur	12		53		180	
16	Parbhani Dist. (4 Units)	201	1976	276		3000	
		6902		**4405**		**45785**	

(Sources: 1) Information booklet of MIDC, Aurangabad. 2) MIDC- 47th Annual Report 2008-09)

11 Comparative Performance of Jayakwadi with Other Project

11.1 The objective of this chapter is to compare the performance of Jayakwadi Project with other Project of the same period. The Mula Irrigation Project is a Major Project u/s of Jayakwadi project in the same basin i.e. Godavari. Mula Project and Jayakwadi Project are almost completed and commissioned during the same period. i.e. 1976. It is therefore worthwhile to compare the performance of Jayakwadi with Mula. The information published in Benchmarking and Water Audit reports of GOM is used for comparing performance using key indicators related to water use. The basic difference between these two projects is that, though Mula is a eight monthly project perennial crops are grown in its command at an appreciable percentage which leads to increase water use per Ha area irrigated with increase in Agricultural output.

11.2 Comparative Performance

The comparative performance of Jayakwadi with Mula Project with respect to following indicators is given in Table 11.1

1. Annual Irrigation Water Supply per unit Irrigated area (m^3/ha)
2. Area Irrigated per unit of water at Canal head (ha/Mm^3)
3. Agricultural output per unit of Irrigated area (Rs./ha)
4. Agricultural output per unit of Irrigation Water Supply (Rs./m^3)
5. Equity performance i.e. percentage of area irrigated with respect to I.C.A in Head, Middle and Tail reaches of Canal.
6. Percentage evaporation losses with respect to actual live storage on 15^{th} October.

Table 11.1

Comparative Performance of Jayakwadi & Mula

Sr.No.	Performance Indicator	State Target	5 years average (2005-06 to 2008-09)		Remarks
			Jayakwadi	Mula	
1	Annual Irrigation Water Supply per unit of Irrigated area (m^3/ha)	7692 m3/ha	11895	12163	
2	Area Irrigated per unit of water at Canal head (ha/Mm^3)	130	84	82	
3	Agricultural output per unit of Irrigated area (Rs./ha)	25000	25230	30224	
4	Agricultural output per unit of Irrigation Water Supply (Rs./m^3)	3.15	2.97	5	
5	Equity performance i.e. percentage of area irrigated w.r.t. I.C.A in Head, Middle and Tail reaches of Canal.		H M T 56 10 12	H M T 60 62 58	
6	Actual evaporation losses with respect to actual live storage on 15th October (%)		19.25	10	

(Source: Bench marking & Water Audit report of 2009-10 published by Maharashtra Water Resources development Center, Aurangabad. M.S.)

11.3 Conclusion:

a) It is seen from the information presented in Table 11.1, the performance of Jayakwadi Project in respect of Irrigation efficiency is more or less close to Mula Project. But the performance of both the project compared to state target is below the line suggesting necessity in improvement in physical condition of canal system and present irrigation management practice.

b) Also, the configuration of area irrigated in Head, Middle and Tail reach of Mula project is better than Jayakwadi project. It underlines the fact that, middle and tail portion of canal system of Jayakwadi project is deprived from getting water for irrigation. This may be one of an important cause for low utilisation of potential developed on Jayakwadi project.

c) More Agricultural output on Mula project compared to Jayakwadi project may be on account of more area under cash crops.

d) Large spread of Jayakwadi reservoir along with considerable unutilised storage at the end of Irrigation year must be responsible for more evaporation losses than that are in Mula project It is to be noted that in case of Jayakwadi Project, the actual evaporation loss percentage (19.25%) compared to provision in project report(30%) is quite less.

12. Future Demands for Non Irrigation Purposes

12.1 Introduction:

The demand for domestic and industrial water use is increasing day by day. The state water policy has given highest priority for domestic water use. Although the industrial water use finds third priority in the recent govt. Policy, certain quantum of water needs to be reserved for industrial use so that industries are kept running. Therefore the future demands for non-irrigation use up to 2030 are estimated based on the quota sanctioned by project authority for lifting water from reservoir and projections made by Maharashtra Water & Irrigation commission, 1999 for water needs to be fulfilled from river portion on D/S of Paithan dam.

12.2 Future Demands for Non-Irrigation uses:

12.2.1 Future demands from reservoir Considering the priorities for domestic water supply and necessity of water supply for Industrial development which ultimately helps to boost the economical level of population in adjoining area of the project, quota to the tune of 185.75 Mm3 and 53.733 Mm3 is sanctioned from Jayakwadi reservoir for Domestic and Industrial Water supply respectively. At present though actual total Non-Irrigation Water use is around 150 Mm3 , considering industrial development activity at Aurangabad city, in near future actual utilisation is likely to grow up to the sanctioned quota or even more.

12.2.2 Future demands from River on D/S of dam

The Maharashtra Water and Irrigation Commission in its report of 1999, has estimated non-irrigation requirement up to 2030 for lower Godavari Sub-basin i.e. from Jayakwadi Reservoir to Nanded. The operational area of Jayakwadi Project lies in this Sub-basin. The details of the same are given below.

- Total geographical area of lower Godavari basin = 17616 Sq.kms.
- Non Irrigation use and requirements (Mm^3)

Particulars	**1996**	**2030**
Drinking Water	98.5	241.94
Cattle	43.5	58.1
(A) Total Domestic	142.0	300.04
Industries:		
Thermal	30.4	52.5
Other Industries	9.9	39.3
(B) Total Industries	40.3	91.8
Total Non-Irrigation (A) + (B)	**182.3**	**396.84**

Gross command area of Jayakwadi Project = 2638.58 Sq.Km

Proportionate Non-Irrigation requirement for 2030 in Jayakwadi area is

Domestic:		45 Mm^3
Industrial:	14 Mm^3 + Thermal 52 =	66 Mm^3
	Total :	111 Mm^3

This requirement is at the destination, considering the losses in the system from source to destination with efficiency of 50%, the non-irrigation requirement for 2030 at source would be 222 Mm^3 which fairly tallies with the present sanctioned quota.

In project planning there is no provision for letting out water on D/S of the project for meeting out the domestic need of population residing in villages along the banks of Godavari River. Still it can be mentioned that, above water requirement in Rabbi and Hot weather season can be partially met out from storages built up by constructing Barrages (see Table below) on Godavari River from Paithan dam to state boundary.

High Level Barrages across Godavari River, D/S of Jayakwadi Project

Sr.No.	Name of Barrage	Tq.	Dist.	Storage Mm^3
1	Appegaon	Paithan	Aurangabad	7
2	Hiradpuri	Paithan	Aurangabad	9.69
3	Jogla Devi	Ghansavangi	Jalna	10
4	Mangrule	Ghansavangi	Jalna	25
5	Raja Takli	Ghansavangi	Jalna	25
6	Loni savangi	Partur	Jalna	30
7	Digras	Palam	Parbhani	63.85
8	Dhalegaon	Pathri	Parbhani	14.87
9	Mudgal	Pathri	Parbhani	11.87
10	Muli	Gangakhed	Parbhani	11.35
11	Aamdura	Mudkhed	Nanded	23.71
	Total Storage			**232.34**

13 Mitigation Measures and Demand Management

13.1 Jayakwadi Project, like most of the projects located in water deficient region, faces shortage of water particularly during low rain fall year mainly because of following reasons:

(1) Reduction in the yield due to increased upstream interception

(2) Diversion of available water for non-irrigation purposes such as domestic and industrial use.

(3) Diversion of about 233 Mm3 of water for Reservoir Lift Irrigation which is not considered in original project planning

(4) Reduction of live storage by 195 Mm3 by silt accumulation

This situation is not likely to be improved in future, on the contrary will worsen day-by-day. Therefore time has come to resort to scientific mitigating and demand management measures to optimize the use of available water. Based on the outcome of study done in earlier chapters, following measures are suggested.

13.2 Mitigating & Demand Management measures:

13.2.1 Revising guidelines for water planning in the basin.

The Godavari basin in Maharashtra State from its origin at Trimbakeshwar till it enters the Andhra Pradesh in Nanded District can be divided in to 3 zones, based on the rainfall.

a) **Zone I:** High rainfall zone from Tembakeshwar to Nandur Madhameshwar weir on main river and Nilwande dam on Pravara river. This is called Ghat catchment. The rainfall in this zone is ranging from 3048 mm to 1016 mm.

b) **Zone II:** Low rainfall zone .i.e. from end of Ghat catchment to Aurangabad and Jalna District. The average rainfall in this zone is 610 mm. Jayakwadi Project is located in this zone.

c) **ZoneIII:** Medium rainfall zone, i.e. from end of zone II to state Border. The average rainfall in this zone is 890mm.

The water planning in the state is generally done on the following guidelines at present.

- Major Projects : 75% dependable yield
- Medium Projects: 60% dependable yield
- Minor Projects: 50% dependable yield
- Small Irrigation Schemes

  Including water conservation works: No restriction on their numbers and capacity (dependability is not taken into account)

The present norms irrespective of rainfall pattern in various zones of the basin are affecting the inflow in Jayakwadi Project situated in low rainfall zone. The medium, minor and small projects which are planned for lower dependability are reducing the inflow in Jayakwadi Project. Most of the times, the majority of yield from high rainfall zone is retained there itself. It is therefore suggested to adopt following norms for water planning in this basin for all types of projects.

Zone I	:	75% dependable yield for all types of projects.
Zone II	:	50% dependable yield for all types of projects.
Zone III	:	60% to 50% dependable yield to harness all balance Permissible yield in the basin by creating oversize storages.

All the existing, ongoing and future projects in Zone I may be revised based on 75% dependable yield and projects in Zone II for 50% dependable yield.

13.2.2 Reducing Evaporation from Reservoir.

(i) Evaporation losses as per project design are 665 Mm^3. Data about actual losses shows that, during normal year, they are to the tune of 450 Mm^3 which are less than what are assumed in project planning. Still owing to large spread of the reservoir, these losses (20% of design live storage) are more than other similar projects (Mula 10%) in the valley. These losses can be further reduced by increasing the utilisation in Rabi season to an extent that water required for H.W crops including perennials as per existing crop percentage and Non irrigation water requirement up to 15^{th} July is kept in reservoir at the end of Rabi season. In other words PIP of the year should be planned and implemented such that there is no unutilised storage in the reservoir at the end of July.

(ii) The Jayakwadi Reservoir is located in flat terrain. More surface area of impounded water is exposed to evaporation. The actual evaporation in normal years, season wise is given in chapter 7 (Table 7.1). The abstract of the same is given below.

Table 13.1

Average Season wise Evaporation losses in Normal Years (for 6 years)
(Based on data in table 7.1)

Season	Evaporation losses (Mm^3)
Kharif	72
Rabi	121
H.W.	230

The evaporation is maximum in H.W. season. This can be reduced by storing water for H.W. season in secondary storages for irrigation as well as non-irrigation purposes. The details of the same and estimation of reduction in H.W. evaporation losses are given below.

(a) Planned utilization in H.W.Season at canal head (without evaporation losses) — 251 Mm^3

(b) Non-irrigation requirement in H.W. season (Aurangabad city) [source : Note of M.I.Dn. Aurangabad 2002] — 35 Mm^3

(c) Net utilization for irrigation in H.W. Season (a-b) — 216 Mm^3

(d) Net utilization for irrigation in H.W. season at field head with conveyance efficiency of 75% assumed during project design (c x 0.75) — 162 Mm^3

(e) ICA of both the canals — 183322 ha.

(f) Allocation of water for irrigation purpose in H.W. season per ha. Of I.C.A. (d/e) — 884 m^3 / ha. Say 900 m^3/ ha.

(g) Size of storage tank for storing 900 m^3 of water:

Circular tank is proposed.

Let depth = 7.5 m

Surface area of circular tank = 900/7.5 = 120 m^2

. ‘ . Diameter of tank = 12.5 m

(h) Evaporation from storage tanks:

Cover the tanks to 90% area

Assuming per day evaporation rate = 10 mm

No.of days for H.W. season = 120

No. of tanks 1,83,322

Surface area of tanks = 120 m^2

Net Evaporation loss from these tanks

= 120 x 0.1 x 10/1000 x 120 x 183322

= 2.64 Mm^3 Say **3 Mm^3**

(i) Storage tank for Non-irrigation purpose for Aurangabad city

- Proposed site : Sindhan
- Storage capacity : 52.55 Mm^3
- Evaporation loss : 1.45 Mm^3 Say **2 Mm^3**

(source: Note prepared by M.I.D. Aurangabad, 2002)

(j) Total evaporation losses in secondary storages for irrigation as well as non-irrigation purposes in H.W. Season — 5 Mm^3

(k) Present evaporation in H.W. — 230 Mm^3

(l) Saving in evaporation in H.W. season, if water is stored in storage tanks (k-j) i.e. 230 – 5 = — 225 Mm^3

This shows that entire present as well as future non-irrigation requirement can be met out from the saving of evaporation losses in H.W. season if alternative operation policy as illustrated above is adopted. This saving can increase irrigated area by about 25000 ha. In addition to this, a further saving of water on the field can be achieved if pressurized irrigated methods are adopted on storage tanks. These tanks can also be used as life saving irrigation tanks in kharif season by storing rainwater in them. These tanks will act as a interface between gravity canal conveyance network and pressurized irrigation systems. It will increase the flexibility in on farm water management for the farmers; of course there are cost & power requirements. But in water crises situation such measures are essential. It is the need of the time.

13.2.3 Operation of Project with Induced water stress:

When water supply in the project is limited, it is necessary to operate the system in such a way to give benefit to large number of farmers. This can be achieved by supplying reduced quantity of water to individual crop and irrigating additional area with the water, thus saved.

All the crops in the command area may not respond equally to water stress. Therefore scientific approach will have to be followed to strike a balance between reduced water supply and maximizing the total production in the command as a whole. If the actual water supply (ETa) is reduced over the total growing period of the crop i.e. ETa < ETm (i.e. actual Evapotranspiration is less than maximum Evapotranspiration), actual crop yield (Ya) will be less than maximum crop yield (Ym). This reduced crop yield can be estimated using crop yield response functions given in FAO 95 Irrigation & Drainage paper No.33 "yield response to water". Such crop yield response functions for major crops grown in the command of Jayakwadi Project are given in Table 13.2

Table 13.2

Crop Yield Response functions (FAQ 33)

Sr.No.	Crop	Crop Yield Response Functions	Limitations
1	Sugarcane	RY = (1.209 RE) - 0.209	RE $\geq$ 0.70
2	Banana	RY = (1.294 RE) - 0.294	RE $\geq$ 0.80
3	L.S.Cotton	RY = (0.844 RE) + 0.156	RE $\geq$ 0.45
4	Sorghum	RY = (0.891 RE) + 0.109	RE $\geq$ 0. 47
5	Wheat	RY = (1.153 RE) - 0.153	RE $\geq$ 0.60
6	Gram (Bean)	RY = (0.856 RE) + 0.114	RE $\geq$ 0.53
7	H.W. Groundnut	RY = (0.692 RE) + 0.308	RE $\geq$ 0.70

(In the above functions RY is relative yield i.e. Ya/Ym for corresponding relative evapotranspiration RE, over the total growing period i.e. Eta/Etm. This relationship is linear up to certain limit of RE mentioned, beyond which it is assumed that ther is a drastic reduction in the yield and irrigation is not economically viable.)

Using these crop yield response functions for different levels of relative water supply ranging from 100% to 60%(i.e. stress 0 – 5 – 10 ……40%), yield and additional area irrigated total production from the command and total value of agricultural produce is estimated. Detailed calculations are given in the article on " Planning & Operation of Irrigation Projects with limited Water Supply" by J.T. Jangle, et.el. and presented in the National Seminar on Crop Yield Response to Water, Feb 9-11, 1988 at WALMI Aurangabad (This article is available in WALMI, Aurangabad's publication No. 25 , Feb 1988 P. 76 to 82.) The analysis shows that total production in the command area goes on increasing even if the water stress is increased up to certain limit. In the cas of Jayakwadi Project for 20% water stress, total production in the command as a whole goes on increasing beyond which it is drastically reduced. Therefore it can be concluded that irrigation water supply to different crops grown in the Jayakwadi Command can be reduced by 20% without sacrificing the total production. The results are presented in the Table 13.3 & fig. 13.1

Table 13.3

Production and cropping intensity for varing degree of water stress

Water stress %	Relative ET (Eta/Etm)	Cropping Intensity (%)	Total production (Rs.)
0	1	102.5	8,22,250
5	0.95	107.9	8,22,672
10	0.90	113.9	8,23,890
15	0.85	120.6	8,25,252
20	0.80	128.2	8,26,784
25	0.75	136.7	7,96,049
30	0.70	146.4	7,99,041
35	0.65	157.7	6,87,260
40	0.60	170.8	6,92,423

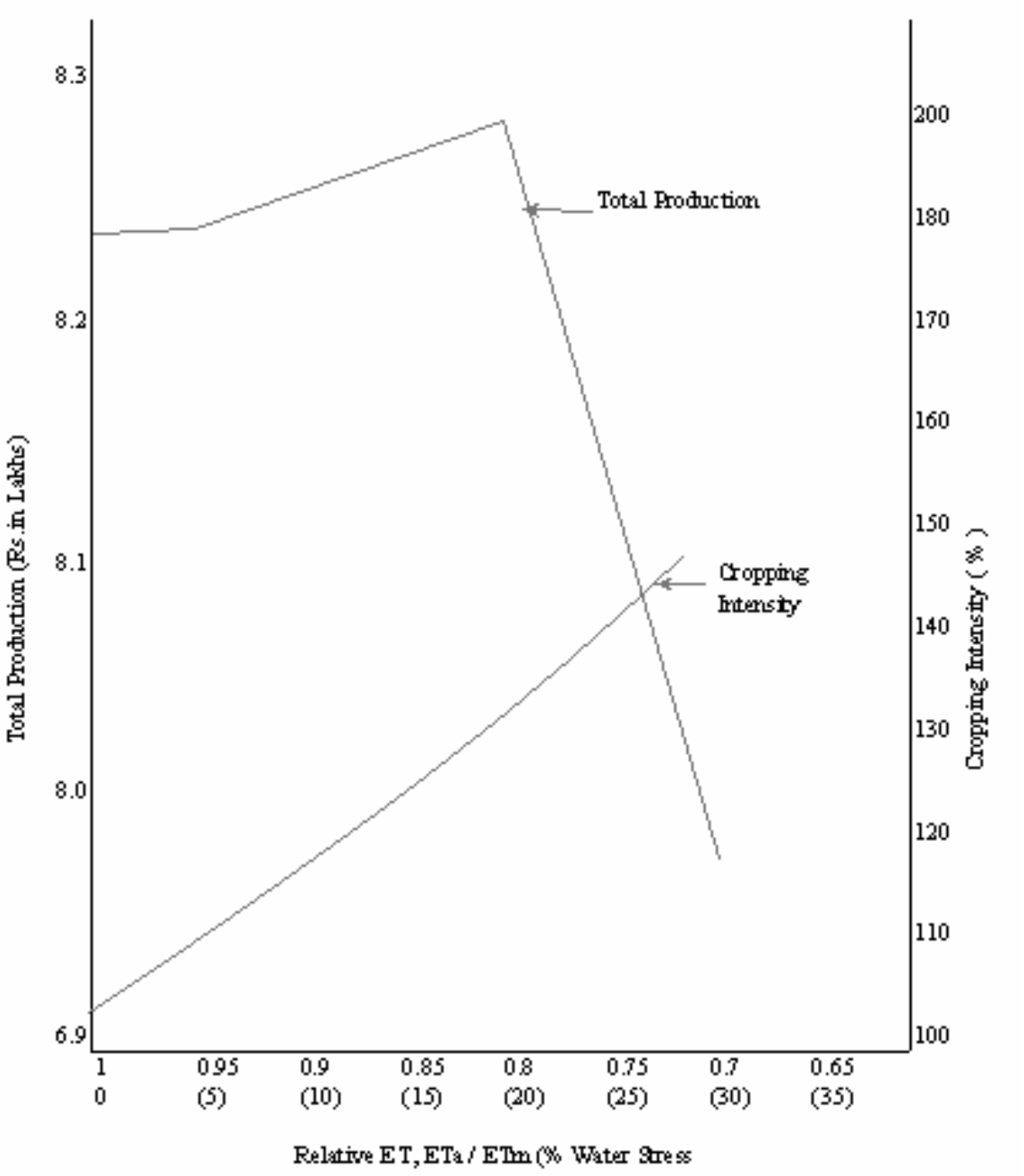


Fig. 13.1 STRESS VS TOTAL PRODUCTION & CROPPING INTENSITY

13.2.4 Reducing conveyance losses in Canal and distribution Network:

The present conveyance efficiency from Canal head to the field head is about 35% against 75% assumed during project design. It is because of the following reasons.

(i) Seepage through joints and cracks developed in concrete slab lining.

(ii) Damaged lining due to swelling and shrinkage property of vertisole (B.C. Soil)

(iii) Water control i.e. effectiveness of off-take head regulators, outlets, measuring devices is poor.

(iv) Irrigation scheduling on ad-hoc basis.

(v) Night irrigation is not practiced by most of the farmers.

(vi) Participation of farmers in IWM is lacking.

(vii) Canals not carrying designed discharge resulting into more wetted perimeter for the less discharge.

(viii) Capacity of outlet is fixed (30 lps) irrespective of area which it is serving (chak area), which necessitates rotational running of outlet, minors & distributaries resulting into frequent operation of network resulting into unsteady state condition almost all the time.

(ix) Long length of canals & distributaries resulting into more time of filling, dead ponds in the canal and hence more losses.

In order to minimize conveyance losses, it is proposed to adopt following measures.

(a) Use self-regulated outlets having capacity in proportion of area which it is serving. In this case all the outlets and minors and distributaries will run simultaneously, which will simplify the operation and equity of water distribution can be achieved effectively. Govt. of Maharashtra WRD vide circular No. BKS 2006/(443/06)IM(P) dated 26th July 2006 has issued instructions in this regard (copy of circular is enclosed as Annexure V)

The simultaneous running of off-takes will ease out the constrain of inadequate canal capacity for both the canals. This type of operation for 6 rotations in Rabi season (21 days rotation with 16 days on and 5 days off.), requires 100 cumec capacity for the command of both the canals. The present carrying capacity of PLBC i.e.60 cumec against 100 cumec and PRBC 40 cumec against 64 cumec will be sufficient to complete the irrigation in each rotation.

(b) The provisions of Maharashtra Management of Irrigation System by farmers Act, 2005 (MMISF Act, 2005) should be applied as early as possible to ensure Participatory Irrigation Management (PIM). Presently 171 number of Water User's Associations are functional in the command area against about 500 WUAs required.

(c) Conveyance losses be measured by standard method and standardized for effective monitoring and evaluation.

(d) Repairs to lining in the reaches where heavy seepage losses are observed.

If these measures are adopted, the conveyance efficiency will improve from 35% to at least 60%.

13.2.5 Reducing Field Application Losses

The present field application efficiency is about 60% i.e. 40% of water made available at field head is lost due to various reasons. If following measures are adopted by the farmers, the field application efficiency can be increased to 80%.

(a) Applying measured quantity of water to the crops as per their needs. In this respect farmers need to be trained through Agricultural extension service.

(b) Use of Scientific Gravity Irrigation methods such as Border, Basin or Furrow depending upon the type of crop. The design i.e. size , geometry, length, inlet stream size, cut-off time etc. for each method depending on soil type, land slope and net irrigation requirement can be designed to apply water efficiently and uniformly. In this case also agricultural extension services are important.

(c) Developing interface between canal water distribution network and pressures irrigation methods like Sprinkler, Drip, Sub surface irrigation methods. Form ponds or farm storage tanks can be developed to use these types of pressurized irrigation methods. If adopted for high water consuming crops like H.W. Groundnut, Sugarcane, Banana, Cotton etc. 40% field application losses can be saved.

(d) Introduction of Participatory Irrigation Management (PIM) by applying the provision of MMISF Act, 1975, where there is a freedom of crop pattern and flexibility in Irrigation Scheduling.

(e) Enabling farmers to use scientific irrigation management techniques through training and demonstrations. The role of Agriculture Department with the help of W.R.D. is very important in this respect.

(f) Improving other agriculture inputs and facilities such as seeds, fertilizers, credit, low cost farm machinery, transport-storage-marketing facilities etc. so that farmer get more net benefit, in turn he will try to maximize output per unit of water.

13.2.6 Review of Irrigation Potential of the Project:

The Project is located in low rainfall zone. The actual Utilisation on u/s side situated in high rainfall zone is more than the permissible. Similarly part of the command particularly lower 1/3 of command lies in assured rainfall zone. In view of facts it is proposed to review the water planning and irrigation potential of this project may be reviewed based on 50% dependable yield.

13.2.7 Recycle and reuse of Water:

The present non-irrigation use is about 150 Mm^3. The water supply to city like Aurangabad, and Industrial water generates sizable effluents. It is estimated that at least 50% water supplied can be recycled and reused (75 Mm^3).In the agreement the condition of recycling the supplied water is included. Its strict implementation is necessary.

13.3 Potential in Water Saving in Normal Year:

The potential in water saving by adopting various measures is estimated as given below.

(a) Reducing evaporation from reservoir: 225 Mm^3

(b) Operation of Project with induced water stress

- Total planned utilization at Canal head in Rabi + H.W.
  Excluding N.I. supply = (1741 – 100) = 1641 Mm^3
- Saving due to 20% water stress
  = 1530 x 0.2 = 318 Mm^3 Say 300 Mm^3

(c) Reducing conveyance losses:

- Present conveyance efficiency = 35%
- Achievable conveyance efficiency = 60 %

Saving in conveyance losses = 25%

- The net utilization in Rabi & H.W. is about 1640 Mm3

  Saving in conveyance losses = 1640 x 0.25 = 410 Mm^3

  (d) Reducing Application losses:

  Water reaching field head with 35% conveyance efficiency

  = 1640 x 0.35 = 574 Mm^3

- Present field application efficiency = 60%
- Achievable field application efficiency = 80%
- Saving = 20%

  Actual Saving = 574 x 0.2 = 115 Mm^3

  (e) Recycle & Reuse = 75

  Total potential saving = a + b + c + d + e

  = 1155 Mm^3

13.4 It is necessary to divert the water from Western flowing rivers in Godavari Basin by inter basin transfer to meet out the shortages on account of excessive interception of water on U/S of Jayakwadi project.

13.5 Diversion of Irrigation on Barrages:

Total 10 barrages with storage capacity of 208.22 Mm^3 are planned/constructed on Godavari River in the length of Jayakwadi Command Area. About 25000 hector of command area of Jayakwadi project placed in tail reaches o distribution network may get water from these barrages. Such shifting of command area to barrages will reduce the loads on canal flow irrigation, thereby bringing improvement in irrigation efficiency of Project to certain extent.

14 Guidelines for Future Planning and Water Allocation

14.1 Water Planning

14.1.1 Following guidelines are generally followed for planning of Water Resources Development projects, at present.

- Major Projects: 75% dependable yield
- Medium Projects: 60% dependable yield
- Minor Projects: 50% dependable yield
- Small schemes: Including water Conservation works — No restriction on numbers. Their cumulative impact on existing projects is not taken into account.

Every Basin and Sub-basin has head, middle and tail reach. The development in upper reach affects lower reach particularly when projects or schemes are planned in isolation. When small and minor projects are taken up on a large scale in upper reach, the Major and Medium Projects in lower reach get affected over the time. Consider the case of Jayakwadi Project located in the middle reach of Godavari River, the planned u/s reservation is 3271 Mm^3 (115.5 TMC), however present planned u/s utilization including on-going and small schemes is 4225 Mm^3 . The share of local sector and watershed development schemes in u/s diversions is about 774 Mm^3 which is about 30% of planned utilization of Jayakwadi Project. Therefore abstraction due to small schemes including watershed development works shall be considered while estimating the yield.

14.1.2 The present guidelines for water planning are based on different dependability for different categories of projects irrespective of rainfall pattern in the basin. The yield in the basin is mainly dependent on rainfall. Therefore rainfall distribution must be taken into consideration while planning project of any category (small or big).

It is proposed to categories total rainfall in the following groups.

High Rainfall: > 1000 mm

Medium Rainfall: 700 mm to 1000mm

Low Rainfall: < 700 mm

The basin is proposed to be divided in three zones i.e. Head, Middle and Tail, depending upon the total rainfall. The water planning of all types of projects located in a particular zone may be done on uniform dependability as given below in Table 14.1

Table 14.1

Proposed Dependability for All Types of Projects for Water Planning

Zone	Rainfall Pattern		
	High (> 1000 mm)	Medium (700 to 1000 mm)	Low (less than700 mm)
Head	75%	60%	50%
Middle	60%	60%	50%
Tail	≤ 50%	≤ 50%	≤ 50%

The existing as well as future projects of all categories including small schemes may be redesigned based on above dependability. The River Basin approach for development and management as envisaged in National Water Policy as well as State Water Policy should be followed in true spirit. The master plan of each basin, Sub basin needs to be prepared.

14.2 Regeneration Flow:

Generally 5 to 10% regeneration flow from u/s utilization is assumed while estimating the yield available at particular project site. The ground water extraction in all the parts of river basin is increasing day-by-day in most parts of the state. Considering the case of Jayakwadi Project, the ground water use in the catchment over the time is given below in Table 14.2.

Table 14.2

Ground water use in the catchment of Jayakwadi Project

YEAR	Ground water use (Mm^3)
1988	889
1995	921
2004	1062
2008	1975

It is seen from the above data that groundwater use in the catchment area of Jayakwadi is increasing overtime. At present it is about 1975 Mm^3. The regeneration flow assumed during planning is 10% i.e. about 200 Mm^3. However the use of ground water in the catchment is so high that, there is hardly any regeneration flow received in the reservoir. This situation exits almost throughout the state. Therefore it is proposed that regeneration flow may not be assumed during water planning.

14.3 Water Allocation:

Last 50 years experience shows that, there is demand of water from different water use sectors though the reservoir is constructed for irrigation purposes. It is now necessary to allocate water for sectors other than irrigation i.e. domestic, industry, environment, Cultural and other minor uses. The project planning should allocate water for these different sectors. The Maharashtra Water Resources Regulatory Authority (MWRRA) Act, 2005, under section 16 (A), empowers Govt. to allocate water for different sectors of water use. The state water policy, 2003, under section 2.1.1 provides for river basin/sub-basin as a unit for water resources management. In the light of these provisions and practical needs, it is proposed that the surface water availability in river sub-basin based on 75% dependability may be considered for sectoral allocation. The allocation for various sectors in terms of percentage of total availability may be as indicated in Table 14.3. The projects in the sub basin shall be considered as controlling unit for regulating the use of water by various sectors.

Table 14.3

Sectoral Allocation in Sub-Basin (%)

Sr. No	Class of Sub-basin as defined by MW & IC based on water availability/ha	Domestic	Irrigation	Agro-based Industry	Other Industry	Environ-ment	Other
1	Highly Deficit (up to 1500 m^3/ha)	15	75	4	3	2	1
2	Deficit (1501 to 3000 m^3/ha)	12	77	4	4	2	1
3	Normal (3001 to 8000 m3/ha)	10	78	4	5	2	1
4	Surplus (8001 to 12000 m3/ha)	10	74	4	9	2	1
5	Abundant (>12000 m3/ha)	10	74	4	9	2	1

15 Summary and Conclusion

15.1 Most of the projects, initially constructed for irrigation purpose are now being used as multi-purpose projects. In State Water Policy also top priority has been given to Domestic water use. Therefore it is necessary to allocate water for domestic, industrial, environmental and other purposes in addition to irrigation. This has necessitated diversion of some water meant for irrigation to Non Irrigation purposes. Jayakwadi project is a classic example of such diversion of water where the provision for Non Irrigation in project planning is nil. It is therefore necessary to study the impact of such diversions on original project planning and suggest mitigation measures to minimise the adverse impact. The study of Jayakwadi Project is taken up for this purpose.

In addition to study of the impact of diversion of water for purposes not considered in project planning, the scope of study is widened to evaluation and analysis of present inflow, silt encroachment in live storage, irrigation performance, current conveyance & evaporation losses, diversion of water for reservoir lifts, excessive utilisation on upstream of dam as these factors are also responsible for affecting original project planning.

15.2 To start with, review of similar studies, taken by different organisations was taken and is included in Chapter.3. Review of 8 studies was taken and outcome of the same in brief is as given below.

- Excessive interception of water on u/s of the project.
- Considerable reduction in irrigation potential.
- Inequitable distribution of water in the basin and command.
- Total cropping intensity, adoption of high yielding varities of crops, overall Input-Output in crop production, net agricultural income, employment to landless laborers in the command area has increased substantially.
- Benefits other than agriculture like domestic water supply, Industrial Development, fish production, flood protection, Tourism is substantial.

15.3 Review of Hydrology of the project at various points of time and by various agencies, from 1964 to 2001 is taken and included in Chapter 4. The review reveals following facts.

- Yield as per Original project planning (1964): 1974 Mm^3
- Yield as per 2001 Study: 759 Mm^3
- Actual yield (1975 to 2001): 802 Mm^3
- Year wise yield received is adequate to meet out 75% demands of planed irrigation utilization in Rabi and HW season for 70% years.
- Actual interception of water in the catchment of Jayakwadi Project is 4226 Mm^3 against 3271 Mm^3 assumed in project planning.
- Diversion of water on u/s side due to local sector and watershed development schemes is 774 Mm^3 (about 40% of planned utilization) which is not considered while estimating the yield.
- Ground water extraction in the catchment area is about 1975 Mm^3 which is far more than regeneration flow of 200 Mm^3assumed in water planning.

15.4 Review of water planning and actual utilization is taken and presented in Chapter 5. In project planning, water allocation for Non-Irrigation use, lift Irrigation on reservoir and provision for silt in live storage is Nil. However, diversion of water for actual Non-Irrigation use, Reservoir lifts is 150 Mm^3& 179 Mm^3 respectively. Moreover, reduction in live storage on account of silt accumulation in live storage is 127 Mm3. Thus, reduction in water availability for irrigation water on account of diversion of water for purposes other than project planning and silt accumulation in Live Storage is 456 Mm3 which is 21% of design Live Storage. Prime-facie, diversion of such appreciable amount of water may create an impression of devastating effect on project objectives.

However whatever may be the causes, in spite of less water availability in the storage for most of the years, at the end of irrigation year water remained un-utilized in 16 out of 33 years. This underlines the fact that, impact of diversion of water for non-irrigation is less significant due to under-utilization of available water for Irrigation purposes.

15.5 The impact on Agriculture System is presented in Chapter. 6. It is summarized below.

- Actual crop pattern developed in command is very much different than assumed in project planning. Proportion of water intensive crops like Sugarcane, HW Groundnut is higher in normal years.
- For 24 years out of 33 years, average adequacy of water at root zone is 64% only i.e. crops received 36% water less than their requirement although water supply at canal head is more than adequate.
- Actual crop yield is less than the potential yield (16% to 50% less) (see table 6.5).
- The adverse impact on agriculture system is mainly due to poor on and off farm water management rather than due to changing water allocation.

15.6 The impact on Irrigation System performance is presented in Chapter.7. It is summarized as below.

- Overall irrigation efficiency is 21% against 49% assumed in project design. This is mainly due to deterioration of the distribution system.
- Average area performance based on Rabi equivalent is 40% in normal years (see table 7.3) indicating that utilization is poor due to poor water management and not due to diversion of water for non-irrigation purposes. Unutilized storage at the end of irrigation year confirms that diversion of water for non-irrigation purposes is no way concern for low utilization of irrigation potential.
- Area irrigated per unit of water at canal head is 63 ha/ Mm^3 against 134 ha/ Mm^3 assumed in project design.
- The water distribution is not equitable in the command area (see Para 7.2.5)

15.7 The impact on changing water allocation on Environmental System is presented in Chapter. 8. Important findings are as summarized below.

- Actual rate of siltation is higher i.e. 14.4 ha-m/100 SqKm/year against 3.57 assumed in design. It is mainly due to very less opportunity for silt to get discharged out of reservoir as reservoir is receiving less water from u/s and spillway is required to be operated for very less years and that too for limited time.
- The regime of the river is affected due to stoppage of flow in the river on d/s side.
- The reduction and /or stoppage of river flow on D/S of dam have resulted in making water unsuitable for domestic use and is causing health hazard.
- On the background of higher rate of actual silt at reservoir compared to contemplate silt rate in project planning, it is suggested to revise the formula for estimating silt rate by considering the data of actual silt rate in a particular river basin.

15.8 The impact of changing water allocation on Socio-Economic System is analysed by, conducting a scientific socio- Economic survey in the command and findings are presented in Chapter. 9. Despite changing water allocations and uncertainty in irrigation water supply, significant changes in S\socio-economic aspects have taken place. Farmers have adjusted themselves to the situation of uncertainty and shortages of water. It is an established fact that they are benefited by the project. There is significant potential to increase the benefits further by improving management.

15.9 The impact on Industrial Development is presented in Chapter. 10. The volume of water diverted for industrial use is very less as compared to water use for irrigation purpose (3% of irrigation use) and it has not affected the irrigation potential. Slight reduction in conveyance losses from canal and distribution network will make available the water for industrial use. On the contrary, the industrial development due to water availability from Jayakwadi has contributed significantly in economic and social up lift of the region. (Establishment of 4500 industries, having turnover of more than 1400 crores have led to generation of employment of 100000).

15.10 It is estimated that total Non-Irrigation requirement by the year 2030 would be about 222 Mm^3 which can be met out partly from the Project and partly from the storages created in the Godavari River by High Level Barrages. (Chapter12).

15.11 On the background of change in water allocation along with changes in inflow, silt accumulation, increase in u/s interception, mitigation measures are suggested in Chapter.13. The summary of the same is given below.

- All the existing, on-going and future projects in catchment area of Jayakwadi Project be redesigned based on 75% dependable yield so that Jayakwadi project receives its planned yield.
- Evaporation losses from the reservoir can be reduced by utilizing maximum possible water in Rabi season so that water at onset of Hot Weather season is just sufficient to suffice the need of sanctioned Perennial crops and Non Irrigation requirement. Secondly, by storing water required for H.W. season in secondary storages will save water up to 225 Mm^3 (See Para 13.2.2)
- Operation of the Project based on induced scarcity i.e. supply 20% less water to crops but increasing total production and cropped area in the command. It will save 300 Mm^3 of water (Para 13.2.3)
- Reducing conveyance losses in canal and distribution network by adopting various measures illustrated in Para 13.2.4 including use of Self-Regulated outlets, adopting policy of simultaneous running of Channels, implementing provisions of MMISF Act (PIM)
- Reducing field application losses by adopting various measures illustrated in Para 13.2.5.
- Recycle & Reuse of water supplied to Non-Irrigation purposes.

  If these mitigation measures are adopted, there is a potential of saving 1115 Mm^3 of water (Para 13.3).

15.12 Guidelines for planning projects in future are suggested in Chapter 14. They are summarized as below.

- As per present practice, the obstruction of water due to small schemes having command area less than 250 hectors is not considered. However, considering its striking effect on Yield of D/s side project, it is necessary to consider the utilization of water by small schemes while estimating the yield.
- Variable dependability's for all types of projects depending on rainfall pattern in the basin or sub-basin may be adopted. Following matrix of dependability is proposed for water planning (Para 14.1.1)

Proposed Dependability for Water Planning.

Table 14.1

Proposed Dependability for All Types of Projects for Water Planning

Zone	Rainfall Pattern		
	High (> 1000 mm)	Medium (700 to 1000 mm)	Low (< 700 mm)
Head	75%	60%	50%
Middle	60%	60%	50%
Tail	≤ 50%	≤ 50%	≤ 50%

- Regeneration flow may not be considered as ground water extraction is considerable in almost in all parts of the State.
- Implementing provisions of MWRRA, Act, and MMISF Act for river basin planning and management.
- Allocation of water for different sectors of water use may be considered in water planning based on following percentages.

Table 14.3

Sectoral Allocation in Sub-Basin (%)

Sr. No	Class of Sub-basin as defined by MW & IC based on water availability/ha	Domestic	Irrigation	Agro-based Industry	Other Industry	Environ-ment	Other
1	Highly Deficit (up to 1500 m^3/ha)	15	75	4	3	2	1
2	Deficit (1501 to 3000 m^3/ha)	12	77	4	4	2	1
3	Normal (3001 to 8000 m3/ha)	10	78	4	5	2	1
4	Surplus (8001 to 12000 m3/ha)	10	74	4	9	2	1
5	Abundant (>12000 m3/ha)	10	74	4	9	2	1

15.13. Conclusions:

- Impact of interception of water for Non-Irrigation purposes is less significant than that due to non-utilization of available water fully and poor on and off farm irrigation management.
- Impact of reduced inflow in the reservoir as well as in the river d/s of the dam, on environmental system with respect to regime of the river, water quality reservoir siltation and ground water use is significant.
- Significant favorable impact on Socio-Economic aspects in spite of changes in water allocation and water supply uncertainty.
- Diversion of 3 % of design live storage for industrial development has brought a notable economic development.
- Mitigation measures as suggested, if adopted, will overcome the problem of reduced water availability which is likely to increase in future with increase in population and industrial growth.

Interaction with Jayakwadi Project Authorities:

The inferences drawn on various aspects of performance of Jayakwadi project and the assessment of impact of change in water allocation on project's performance in this study are solely based on data collected from project authorities along with different organisations related with projects water use. Therefore it was found necessary to have an interaction/opinion of the current project authorities, field officers on the content of this study.

Therefore, a copy of the draft report was sent to the Chief Engineer & Chief Administrator, (CAD) Aurangabad and the Superintending Engineer & Administrator (CADA) Aurangabad and Beed on 21/01/2012 with a request to share their views on different aspects covered by this study.

The project Authorities were personally contacted and gist of the study was briefed to them. Important issues, like change in water allocation on account of diversion of water for Non Irrigation water supply, Lift Irrigation on reservoir and excessive interception of water by constructing no. of local sector level schemes on U/S of the Jayakwadi project which were not considered while designing the project, accumulation of silt in Live Storage portion and rate of actual silt observed against assumed in project report, benefits derived in the form of boosting economy through Industrial development at Aurangabad and area surrounding reservoir by sacrificing just 3% of live storage for Non Irrigation purpose were discussed with them in detail. Reasons for low irrigation efficiency, low potential utilisation, unutilized storage at the end of irrigation years and mitigation suggested for achieving the project objectives were discussed as well.

During discussion Project authorities showed consensus over most of the inferences and output of the study. No major differences over the study were reported by the authorities. On the contrary they expressed satisfaction over the comprehensive study and usefulness of the measures suggested as mitigation.

Annexure I

JAYAKWADI PROJECT

Salient Features.

Sr.No.	**Specification**	**Paithan Dam**
1	Catchment Area	21,750 Sq,Kms (8,400 sq.miles)
2	Gross Storage	2,909m.cum (10272 m.cft.)
3	Max. Height of Dam above river bed.	37 meters (120 feet)
4	Length of Dam	10.20 Kms
5	Length of overflow section	417m (1367 feet)
6	Type of dam	Earthen
7	Area under submergence	35,000 Ha. (86,000 Acres)
8	Earth Work	12.85m.cum. (759m.cft.)
9	Masonry work	0.33m.cum (11.86mcft.)
10	Spillway gates a) Number b) Size c) Type d) Designed flood	27 12.50 x 7.90 m Radial 18,150 Cumec
11	Installed capacity for hydro power	12 M.V.
12	Level :	
	i)River Bed	431.21 m
	ii) Minimum Drawdown level	455.52 m
	iii) Spillway Crest	455.98 m
	iv) F.R.L.	463.90 m
	v) H.F.L.	465.59 m
	vi) Dam Top	468.94 m
	Deepest foundation for masonry dam	427.64 m
	vii) Deepest Cut of level of Earthen Dam	419.917 m

Annexure II

DETAILS OF JAYAKWADI RESERVOIR FILLING

Sr.No.	Year	Available Live Storage on 15th of October in Mm^3	% Storage
1	1975-76	135.25	6.23
2	1976-77	1162.35	53.54
3	1977-78	939.17	43.26
4	1978-79	695.8	32.05
5	1979.8	1458.25	67.63
6	190-81	602.02	27.23
7	1981-82	1600.02	73.7
8	1982-83	1210.55	55.76
9	1983-84	2037.91	93.87
10	1984-85	1751.34	80.67
11	1985-86	663.24	30.55
12	1986-87	304.6	14.08
13	1987-88	475.23	21.89
14	1988-89	2041.61	94.04
15	1989-90	1975.04	91.02
16	1990-91	2171	100
17	1991-92	1678.62	77.32
18	1992-93	690.34	31.8
19	1993.94	763.1	35.15
20	1994.95	1913.95	88.26
21	1995-96	306.11	14.09
22	1996-97	770.453	35.49
23	1997-98	1068-789	49.23
24	1998-99	2126.758	97.96
25	1999-2000	2167.353	99.83
26	2000-01	1281.731	39.31
27	2001-02	494.169	22.76
28	2002-03	404-373	18.62
29	2003-04	392.6987	18.09
30	2004-05	2129.141	98.07
31	2005-06	2171	100
32	2006-07	2171	100
33	2007-08	2171	100

(DISTRIBUTION OF LAST 33 YEARS)

Sr.No.	Available live storage %	No. of Years
1	0 to 25%	7
2	25 to 50 %	9
3	50 to 75 %	4
4	75 to 100 %	13

Annexure - III

Details of Outflow from
Jayakwadi project for the period 1975 to 2008

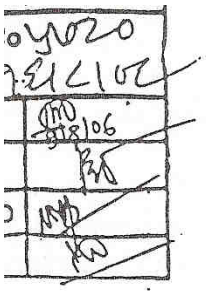
Sr.No.	Year	Outflow in Mm3
1	1975	3317.09
2	1976	5479.422
3	1977	1420.863
4	1978	529.892
5	1979	1943.152
6	1980	3077.777
7	1981	867.061
8	1982	0.311
9	1983	98.723
10	1984	0.0
11	1985	0.0
12	1986	0.0
13	1987	0.0
14	1988	187.348
15	1989	1.830
16	1990	1588.567
17	1991	1619.906
18	1992	0.939
19	1993	1.193
20	1994	1736.331
21	1995	0.000
22	1996	0.556
23	1997	2.525
24	1998	442.825
25	1999	242.400
26	2000	7.770
27	2001	319.448
28	2002	2.276
29	2003	0.144
30	2004	0.0
31	2005	2869.417
32	2006	5636.676
33	2007	781.000
34	2008	1182.000

Annexure-IV

List of Water Quality sampling stations Under Godavari Basin

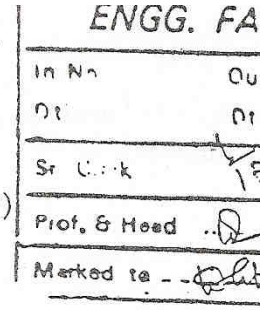
Water Quality sampling Stations Upstream of Jayakwadi Dam		
Sr.No.	**Name of Station**	**Name of River**
1	Takali GD site	Godawari
2	Kopargaon	Godawari
3	Newase	Pravara
4	Gangapur Dam	Godawari
5	Darna Dam'	Darna
6	Bhandardara Dam'	Pravara
7	Nandur Madhmeshwar Dam'	Godawari
8	Mula Dam'	Mula
9	Kadawa	Kadawa
10	Kushavarta (Trimbak)	Godawari
11	Someshwaar	Godawari
12	Ramkund (U/S)	Godawari
13	Ramkund (D/S)	Godawari
14	Tapovan	Kadawa
15	Nasardi River	Nasardi
16	D/S ofEklahare TPS	Godawari
17	Saikheda	Godawari
18	Toka Bridge	Godawari
Water Quality sampling stations Downstream of Jayakwadi Dam		
19	Kesrali	Godawari
20	Nanded Nagapur	Godawari
21	Raheri	Godawari
22	Shahagad	Godawari
23	Sundgi	Godawari
24	Takli	Godawari
25	Zari	Godawari
26	Hirapur	Godawari
27	Pishor	Anjana
28	Dhalegaon	Godawari
29	Purnabridge	Godawari
30	Taklidhangar	Godawari
31	Yelli	Godawari
32	Toka Bridge	Godawari
33	Patgaon	Godawari
34	Aurangabad city	Khan River
35	Shendurvada Tal Gangapur	WanRiver
36	Parali Vaijnath Tal-Parli, Dist-Beed	Abdgari River
37	Ajantha-Andhari Tal-Sillod Dist Aurangabad	Abdgaru River
38	Rahati	Purna River
39	Gangakhed Dist Parbhani	Godawari
40	Vishnupuri	Godawari
41	Yeldari	Purna River
42	Manjalgaon	Sindhphana

Annexure-V



Self Regulating Outlets on the Distribution System.

GOVERNMENT OF MAHARASHTRA.
Water Resources Department,
Govt. Circular NO.BKS 2006/(449/06)/IM(P)
Mantralaya, Mumbai -400 032
Dated : 26th July, 2006.



Government Circular :-

The MMISF Act 2005 aims at providing assured predetermined water quota to each beneficiary in the command . The quota is worked out in proportion of CCA. This aim can be achieved in its true sense if the outlets in the distribution network delivers discharges in proportionate to their culturable command area so that all outlets will run simultaneously and thus the objective of equitable distribution can also be achieved. It is very difficult to supply water equitably using present pipe outlet and rotational running. The simultaneous running of all outlets will also simplify the operation of distribution network by W.U.A. The existing capacity of water distribution network is adequate to use this operation policy. This is possible by using double baffle Self-Regulated Outlet (S.R. Outlet) recommended by MERI, Nasik.

- The S. R. outlet can be fabricated with desired width. Its accuracy can be rounded to one cm. If the desired discharge for the chak (which would be proportionate to the CCA in the chak) is 20 l.p.s. The width of outlet would be 20 cm.
- Height of crest above CBL is 7.5 cm.
- Minimum head over the crest to pass 30 lps is 13.9 cm.
- Maximum head over the crest for 10% variation in the discharge is 32 cm.
- Allowable fluctuation in the water level in the minor / subminor is 18.1cm. i.e. 21.4 to 39.5 cm.
- It is desirable to ensure free flow condition on the down stream side of the outlet in order to ensure correct discharge.
- The varying sizes of S. R. outlets will be installed on the distribution network which will deliver constant discharge in proportion to the cultural command area in the chak.
- The maximum capacity of S. R. outlet and F. C. should be 30 lit/sec.
- The monitoring of time and locking arrangement is not required.
- The water use entitlement of the tail end farmer will be assured.
- The access to take excess and to take water out of turn will be eliminated.
- The operation of distribution network will be easy and simple to follow.

If the water level fluctuations in the parent channel exceeds the modular limit of double baffle SR outlet i.e. 18 cm., the sill level of outlet will have to

RDTA/III/1307 (1,000 - 4-06) 1.

P.T.O.

be fixed accordingly and limit the fluctuations by providing weir type level regulators (Cross/ Diagonal/ Duckbill).

Use of s. R. outlets and weir type level regulators have been recommended in the MWSIP .Project. Hence this type of operation policy may be implemented on these projects, on priority.

By order and in the name of Governor of Maharashtra.

(V. D. HOSHING)
Deputy Secretary to the Government of Maharashtra,

Copy to :
Private Secretary Hon. Minister, Water Resources Department (excluding MKVDC)
Private Secretary Hon. Minister, Water Resources Department (MKVDC)
Private Secretary Hon. State Minister, Water Resources Department ,
The Chief Secretary , Mantralaya, Mumbai ,
All Principal Secretary / Secretary, Mantralaya, Mumbai.
All Divisional Commissioners,
All Executive Directors, Irrigation Development Corporation.
All Chief Engineers, Water Resources Department,
The Chief Engineer , Maharashtra Jivan Pradhikaran,
All Superintending Engineers, Water Resources Department,
All Executive Engineers, Water Resources Department,
Desk IM(P) for collection.

Annexure-VI

Statement showing proposed barages @ D/s of Jayakwadi Project on Godavari River.

Sr.No.	Name of village	Taluka	District	Dist.from Jayakwadi	Catchment Area Km^2	Gross Storage Mm^3	Irr. Potential Ha.
1	Apegaon	Paithan	Aurangabad	23	222	7	870
2	Hiradpuri	Paithan	Aurangabad	60	416.41	9.69	1118
3	Jogladevi	Ghansavangi	Jalna	76.50	1153	10	1083
4	Mangrud	Ghansavangi	Jalna	94	348.25	25	3067
5	Shivangaon	Ghansavangi	Jalna	109.60	452.20	25	3044
6	Loni Savangi	Partur	Jalna	132.60	605	30	3942
7	Dhalegaon	Pathri	Parbhani	155	778	14.87	2052
8	Mudgal	Pathri	Parbhani	195	1605	11.87	1831
9	Mudi	Gangakhed	Parbhani	242	1400	11.35	1637
10	Digras	Palam	Parbhani	289	1300	63.85	3483

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