

**MODERNIZATION OF AN EXISTING IRRIGATION PROJECT BY PERFORMANCE
EVALUATION USING PERFORMANCE INDICATORS****1. Smt Y Raghava Rani**

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ABSTRACT

Any Irrigation system invariably contributes to enhanced crop production and increased farm incomes to the rural households and it provides cyclical development in different sectors of the economy as a whole. However, some of the factors impede the agricultural output despite substantial contribution by the irrigation systems and they include (i) economic factors like adequate farm returns; (ii) performance factors namely water use efficiencies; (iii) social factors like failure to achieve equitable distribution of water and environmental factors related to soil salinity, water logging, public health, etc. In such a situation it is imperative to evaluate the performance of the irrigation systems against its desired objectives based on the FAO & IWMI, New delhi guidelines and such evaluation of the irrigation systems provide a crucial feed back to improve the water management to make the systems more accountable besides providing vital inputs to the planners, policy makers, implementing agencies and the beneficiaries to initiate feasible corrective measures. To improve the performance of the existing age old irrigation systems & its efficiency, the baseline survey, has been carried out in the selected irrigation schemes comprising major, medium and minor irrigation schemes by considering the year 1998-99 as the base year for conducting such a study to arrive identified performance indicators to serve as bench marks for future comparison on completion of the ongoing project. The Rajolibanda Diversion Scheme, Mahaboob Nagar dist, A.P is one of the selected major irrigation scheme commands and the baseline survey is carried out in RDS Main Canal and its distributaries, etc. and an attempt is made to evaluate the performance of the RDS project using performance indicators like engineering indicators, operational indicators, agricultural indicators, environmental and socio economic indicators as per the guide lines of IWMI, New delhi & FAO on the equity, timeliness, adequacy, locational, uniformity and irrigation efficiency criteria, Socio, economical environmental aspects and the results are discussed in the present paper.

1. INTRODUCTION

India is predominantly an agricultural country where more than 70% of population depends on agriculture. Massive efforts were made in the 5 year plan taken up to increase the irrigated area at a very fast rate to meet the rising demands of food and fiber of the country. As the consequence, by 1990 the area under the irrigation could be increased to 90 million hectares. Unfortunately the irrigation projects and network of canals could not be maintained properly to sustain the planned supplies to deliver the planned benefits. This has resulted into deteriorated canal system, unable to carry the required quantity of the water to the planned areas and as a consequence large gap resulted between the planned areas and the actual irrigated areas. This situation is still prevalent which dampens the production activity of the country. To arrest this decline, it is imperative to take appropriate steps immediately so that the potential developed is fully realized. Action has already been initiated in several projects to arrest this decline. But still a large number of projects are awaiting for attention, to improve the irrigation status.

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International eJournal of Mathematics and Engineering 141 (2011) 1273 - 1292

In the present research study, it is aimed to thoroughly analyze one of such schemes namely RDS to come out with remedial measures to bring its performance level to the originally planned level, meant for improving the performance of age old irrigation systems comprising major, medium and minor irrigation schemes by undertaking minimum rehabilitation of existing systems for improving their operation and maintenance performance. It has also contemplated massive awareness and training programmes for the water user associations and distributary committee office bearers besides institutional reforms in irrigation sector. The project expected to derive benefits through recovery of water charges, full financing for operation and maintenance of irrigation systems, improved performance of irrigation schemes and increased irrigated crop production. As it is mandatory to arrive the key indicators of socio-economic development prior to implementation to serve as bench marks for future monitoring and evaluation, an attempt is made to conduct the baseline survey in the present study area namely RDS, one of the major irrigation schemes in Mahabubnagar district of AP. Dozens of irrigation performance indicators have been proposed over the years. But they still receive relatively little use, and that use is mostly by researchers and agencies rather than managers. The irrigation community needs to select a core group of key indicators, that are applied often enough to establish an appropriate range of values for interpretation. Molden et al (1998) developed a list of key comparative indicators, which were also used in the present study and the results were discussed about the performance of RDS and the necessary suggestions.

2. DESIGN OF THE STUDY

The basic objective of the Baseline Survey is primarily meant for (i) to provide necessary data and information; (ii) to assess the current situation at field level and (iii) establish development performance indicators to monitor and evaluate the project success. The study comprises the components related to irrigation performance presented in the form of (a) Engineering Indicators; (b) agricultural performance in terms of Agricultural Production Indicators; (c) Socio-Economic Indicators; (d) Farmers' Turnover; (e) Water Delivery System Status; (f) Environmental Indicators. The approach and methodology for the above components and accordingly the present study report is designed. The year 1998-99 is considered as the base year for the purpose of the study & 1996-2001 is taken as study period.

3. STUDY AREA

1. **The Rajolibanda Diversion Scheme** main canal traversing from km 42.60 to km 142.95 through its 47 distributaries is serving the command spread over the districts of Mahaboobnagar and Kurnool. The canal serves a total command area of 37,789 ha and is spread over 6 mandals and 78 villages out of which one mandal is in Kurnool district. The whole conveyance system comprising of left bank canal of 143 km length completed in the year 1960. Under Krishna Water Dispute Tribunal Award 1976, the Rajolibanda Diversion Scheme left bank canal was allocating 484.2 Mm³ of water comprising 198.2 Mm³ from TB reservoir and the balance from river inflows.
2. **Location:** Rajolibanda Diversion Scheme (RDS) is an interstate project comprising of diversion of water from Tungabhadra river on which an anicut was constructed across it. The site of the anicut is located in Karnataka state, near Rajolibanda village in Raichur district. The diversion canal taken on the left bank from the anicut is in Karnataka state limits up to 42.60 km. From km 42.60 to km 142.95 the main canal with its distributary system contemplated to irrigate command area of 37,789 ha lie in Andhra Pradesh limits which was completed in 1960. The geo-coordinates of the project area are 78°13'36" to 16°03'00" N and 78°13'12" to 15°49'12" E. **Topography:** The command area is gently rolling with moderate slopes seldom exceeding 0.2 per cent to 0.30 per cent. The district is relatively elevated in the north and west and the latitude gradually declines from north-west to south-west. There are hill ranges extending from north to south consisting of flat topped hills. **Soils and their Suitability to Crops:** Soils in the command area fall into two main predominant categories, i) Sandy loams and ii) Black clay loams. The red soils and the shallow black soils are suited to ID crops while the black soils are generally suitable for paddy crop and deep rooted ID crops. Paddy is the predominant crop in the area. **Surface Drainage:** The

3. the district is 604mm. The command area is Influenced by “Gadwal” rain gauge station. **Cropping Pattern:** Localization of irrigation command was done for mixed cropping pattern with exception of small distributaries. In principle, the areas localized for wet crops are to receive water only in kharif and the areas localized for ID crops are to be given water only in rabi. Areas localized for perennial crops like sugarcane are supplied water in both the seasons. population of 3.51 million, with a density of 190 per sq.km. About 16 per cent of the population are cultivators. Farmers holding less than 1 hectare are 42 per cent of the total land holders. Farmers having holdings up to 2 ha are 51 per cent and above 2 ha are 49 per cent. Thus the RDS project benefits large majority of the marginal and small farmers in the district.

4. ENGINEERING INDICATORS

1. Performance evaluation for any irrigation system is essential to assess how far the goals and objectives set forth at the time of project formulation of the system have been achieved. This is a useful tool to provide necessary feedback for improving the systems management by initiating remedial measures.
2. A Baseline survey is the Bench Mark to indicate the status of irrigation system (Rajolibanda Diversion Scheme) to serve in future monitoring process. Engineering indicators are one set of indicators among others proposed to be studied. All the engineering indicators given in the terms of reference are studied for a period of 5 years i.e.; 2 years prior and 2 years after base year.

Engineering Performance comprises two sub-components namely (A) Operation Performance; (B) Maintenance Performance. Under each of these two sub-components the identified indicators involved are discussed in this paper for the purpose of the study.

A. OPERATION PERFORMANCE

The Engineering Indicators proposed to be studied under the operation performance of the existing Rajolibanda diversion, Irrigation systems in the study area from km 42.60 to 142.95 of the left bank canal are:

Operational Performance Indicators (OP)

- i. Actual dates of operation of canals versus planned dates of operation;
- ii. Ratio of actual flow at main canal head and distributory heads as a ratio of their planned flows;
- iii. Variation in flows at canal / distributory heads by MPMM;
- iv. Ratios of actual flow in tail clusters of main canal distributaries to planned flows;
- v. Ratios of volumes of water supplied to the irrigated areas in the jurisdiction of WUAs to the required volume of water.
- vi. Equity in irrigation between head and tail reaches;
- vii. Equity in water distribution between head and tail reaches;
- viii. Ratio of volume of water received at the off-take heads to the volume of water released at the major distributory head.

The analytical findings of the above performance indicators namely operation performance and maintenance performance in the Rajolibanda Diversion scheme area are discussed.

A. Operation Performance:

i) Actual Dates of Irrigation Versus Planned Dates of Irrigation:

The actual dates of opening of canal against the planned dates of opening and the actual dates of closing of canal against planned dates of closing are studied for Left Bank Canal and other canals for both the seasons during 1996-1997 to 2000-2001. The actual dates of canal openings are in conformity with the planned dates of opening.

The planned dates of closures are not adhered to during rabi season, because of the crop status. There is a variation of 20 to 27 days during base year and two subsequent years, except during 97-98 Rabi where it is 45 days.

ii) Variation in canal flows at the main canal head and distributory heads as a ratio to planned flow (Field efficiency & Conveyance efficiency)

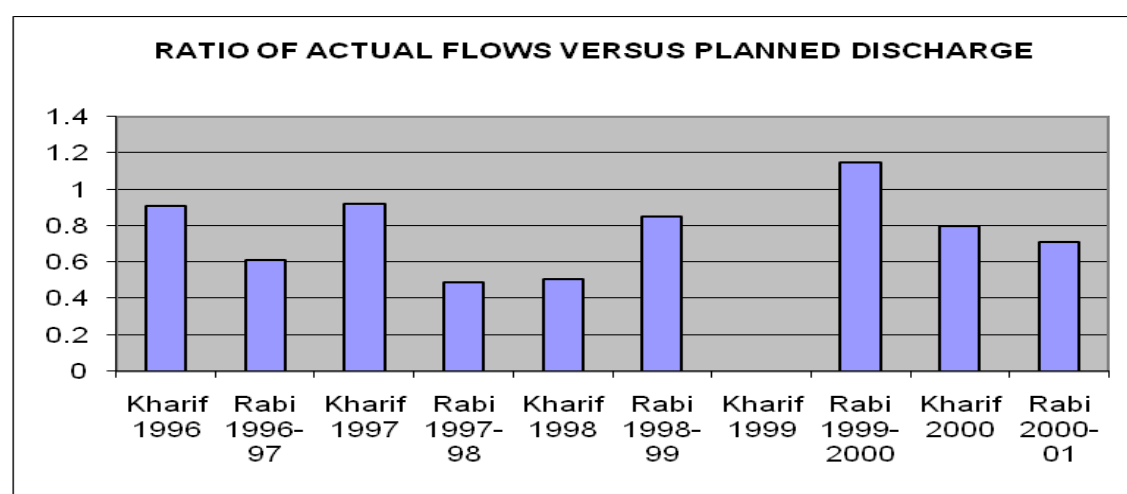
Main Canal : The aim of this indicator is to ascertain the actual flows (discharges and volumes) at the main canal head and distributary heads during the study period. The main canal enters in the Andhra Pradesh area at km 42.60 where the variations of flows are studied. The study reveals that, during kharif, the ratio of actual flows (discharges) during base year 1998-99 and two succeeding years are 0.79, 0.84 and 2.36 where as the ratio of actual volumes to planned volumes are 0.61, 0.65 and 1.83 respectively. On average of five study years, the ratio of discharges is 1.16 in kharif and 0.79 in rabi. Average ratio of volumes of water supplied for entire crop period is 0.90 in kharif and 0.53 in rabi. The short fall in the indicator values in rabi is because of the limitations of water availability in Tungabhadra river. The planned flows are worked out based on the duty adopted for the project (715 ha per 1 Cumec) and a base period of 120 days assuming paddy of medium duration and for ID crops like groundnut etc.

Distributaries: The performance of the distributary system is studied dividing the main canal ayacut into head reach (25%), middle reach (50%) and tail reach (25%). The study reveals that, in the base year kharif, excess flows were released in head reach in 1 distributary (1.44) and less ratios in 10 distributaries; ratios ranging from 0.47 to 0.91. In the middle reach no excess flows were released and less flows in 6 distributaries vary from 0.24 to 0.70. No data are available for tail reach. The observations made are i) that the planned areas relating to distributaries are not in proportion to localized areas. ii) water is not released rationally to the distributaries either in the ratios of their planned areas or in the ratio of localized areas or in proportion to their designed capacities.

Delivery performance ratios of actual flows to planned flows were not maintained in the all three reaches. The analysis shows that there is no equitable distribution of water among the distributaries of Rajolibanda Diversion Scheme main canal during "Base year kharif season". In head reach, 6% of total Distributaries received excess flows, in the middle reach 63% and in the tail reach no drawals were there. The tail reach is having only 3 Distributaries but nowater was available

Table-1. Rajolibanda diversion scheme ratio of actual flows versus planned discharge.

Sl.No	Crop season	Ratio of actual flow and planned discharges
1	Kharif 1996	0.91
2	Rabi 1996-97	0.61
3	Kharif 1997	0.92
4	Rabi 1997-98	0.49
5	Kharif 1998	0.51
6	Rabi 1998-99	0.85
7	Kharif 1999	-
8	Rabi 1999-2000	1.15
9	Kharif 2000	0.80
10	Rabi 2000-01	0.71



Inferences

As observed that planned areas to the distributaries were not allotted to the ratios of their localized areas of Rajolibanda Diversion Scheme main canal. The indicator showed that water is not released rationally to the distributaries.

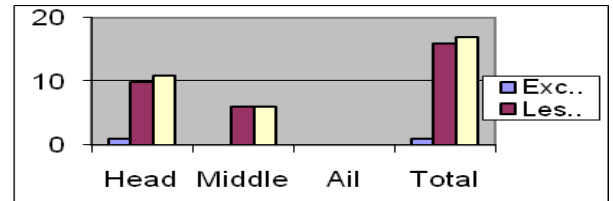
Either in the ratios of their planned areas, or

In ratios of their localized area or ratios of their designed capacities.

1. Delivery performance ratios of actual flows to planned flows were not maintained in all the three reaches i.e Head reach, middle reach, and tail reach of Rajolibanda Diversion Scheme main canal. During base year 1998 kharif the number of distributaries with excess or less flows are as follows:

Table-2

Sl.No	Reach	Excess flows	Less flows	Total
1	Head	1	10	11
2	Middle	-	6	6
3	Ail	-	-	-
	Total	1	16	17



This shows that planned area of 3718.74 ha not received its legitimate share of water during the base year 1998 kharif.

Water deliveries were not made adhering to the water delivery schedule planned periodically responding to the overall crop demands by taking into consideration of the constraints of physical system the tail reach not received its share of water as per schedule.

Suggestions

Water releases are to be made as per the water delivery schedule prepared responding to the overall crop demands and planned area, by considering the constraint in the physical system related to, soil status, stage of crop, and climatic conditions and with flexibility in performance of irrigation system in view of prevailing climatic conditions such as severity in temperature and heavy precipitation of rainfall, standing depth and water balance in the field.

1. Excessive utilisation of water for irrigation is to be curbed and such excess water maybe diverted to the tail reaches.
2. The O and M organisation is expected to regulate the flows and ensure water is supplied to tail end planned ayacut. To achieve equitable and reliable distribution of water, the operational plan may be developed in three tier system. The first for main canal, determining the water flow along its length and discharges into each distributary the second tier at distributary level and the third for the minor level linking it with outlets. In preparation of operational plan for each season, the WUAs or the farmers organisation have to be involved and their views are to be considered.

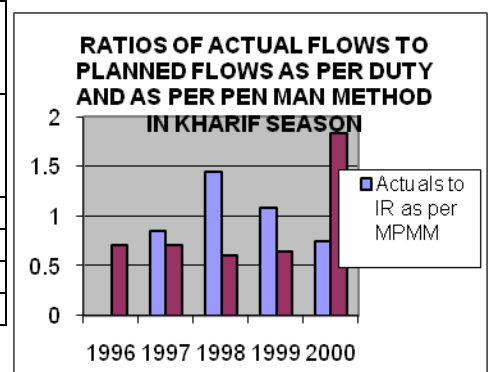
iii) Variation of flows as per crop water requirements by modified penman method as a ratio of actual water utilisation including rainfall contribution to net irrigation requirements

Crop water requirements by Penman Method are worked out by considering 50 per cent effective rainfall supplementation, 90 per cent field efficiency and 85 per cent conveyance efficiency.

Net irrigation requirements for the area actually irrigated is worked out. Total of canal water delivered and rainfall contribution arrived at and compared to the irrigation requirements to arrive at the indicator value. (ratio).

Indicator value more than unity infers over irrigation, surplus drained off where as less than unity indicates under irrigation leading to reduction in yield. The study relating to this indicator reveals that during base year kharif, the ratio of utilisation is 1.44 and it is 1.09 and 0.75 in the succeeding years. The indicator values in rabi during base year and succeeding years are 1.33 only, since there was no rainfall.

Sl.No.	Year	Actual to planned flows (volume) as per duty	Actuals to IR as per MPMM
1	1996	0.71	N.A.
2	1997	0.71	0.85
3	1998	0.61	1.44
4	1999	0.65	1.09



5	2000	1.83	0.75
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The Table - 3 infers lot of variation in the ratios worked out as per the duty and as per irrigation requirements as per penman method. IT suggests the revising duty based on the irrigation requirements as per MPMM. The details as per IR and RF for the study years 1997 kharif to 2000 kharif.

As seen from Table - 4, the data for kharif paddy on average worked out to 800 hectares per cumec (56 ac per cusec). The duty for kharif ID crops predominantly groundnut worked out to 4890 ha per cumec. (340 ac per cusec). It is most economical in the sense of water utilisation to raise late kharif ID crops of suitable varieties in as much as most of the water requirement are met from the rainfall contribution.

Table - 4 : WORKED OUT DUTIES IN KHARIF PADDY AND ID BASED ON IRRIGATION REQUIREMENTS AS PER MPMM (INCLUDING RF CONTRIBUTION)								
Sl.No.	Year	Water Requirements per hectare ('000 cum)		Base period (days)	Discharge requirement in cumecs		Worked on duty in ha per cumec	
		As per IR including rainfall contribution			Wet	ID	Paddy	ID
		Paddy	ID					
1	1997	14.15	-	120	0.00136	-	735	-
2	1998	11.54	1.67	120	0.00111	0.00016	901	6250
3	1999	13.25	2.93	120	0.00128	0.000283	781	3534
4	2000	12.96	-	120	0.00125	-	800	-
Average							804	4892
							or 56.22	Or 342

Table - 5 indicates the ratios of areas actually irrigated in the kharif from 1996 to 2000.

Table - 5 : RATIOS OF AREAS IRRIGATED IN KHARIF		
Sl.No.	Year	Rajolibanda Main Canal
1	1996	0.91
2	1997	0.92
3	1998	0.54
4	1999	N.A.
5	2000	0.71

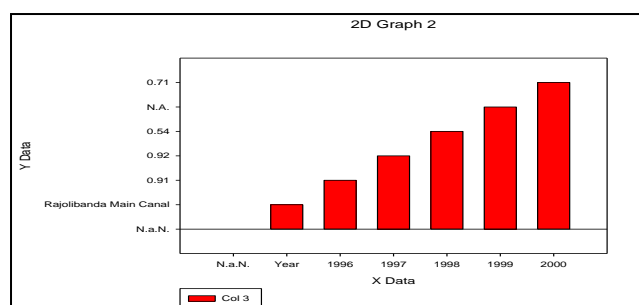
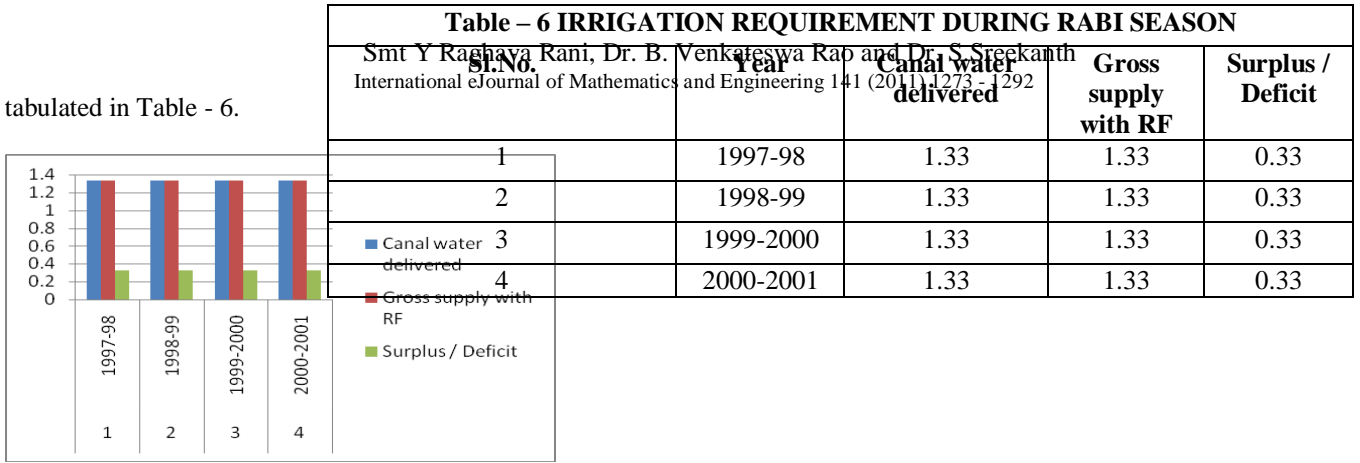


Table - 5 indicates that there is no correlation between the water utilisation as per MPMM and the area actually irrigated. In the base year, water utilised ratio as per MPMM is 1.44 where as the actual irrigated area ratio is 0.54 only. During last year i.e., 2000 kharif; the ratios are 1.09 and 0.71 respectively.

Thus it infers that, irrigation requirements as per MPMM was not at all taken into account and no rescheduling of water supplies made corresponding to the rainfall precipitation in the area. The actual area irrigated has utilised than the irrigation requirements in two years in 1998 kharif where as less utilisation made in 1997 and 2000 kharif. The rainfall during rabi is nil. The ratios of gross supplies utilised the irrigation requirements as per MPMM during rabi season are

tabulated in Table - 6.



Ratios of canal water delivered at distributary head gross supplies made (including rainfall contributing any) to the irrigation requirements. As seen from the Table - 6 in all the years during rabi 33% excess water was utilised for the actual area irrigated than the irrigation requirements. Duty as per MPMM worked out in rabi as 1990 ha per 1 cumec on 140 as per cusec of water . As per the actual utilisation, the worked out duty is 1500 ha per cumec. Quantum of water supplies may be limited as per duty worked out by MPMM method only.

Suggestions

1. Sophisticated measuring devices are to be introduced for measurement of correct releases of water into each and every offtake along main canal and water reading register to be maintained .
2. The water budget is to be prepared before the start of the crop season and suitably rescheduled taking into account of the rainfall in the command. The operation of gates to be monitored suitably with respect to rainfall stage of crops and crop water requirement at the stage. Water releases, may be limited as per duty based on crop water requirement by MPMM method working out to 1990 ha per cumec or 2000 ha per cumec (140 ac per cusec).
3. The excess utilisation indicates that there are abundant inflows in the river. Also the monsoon sets in during the month of June of every year and water releases continued upto March . This suggests proposing rabi crops also with preponement of the opening of canals by a month and raising crops of short duration. This arrangement will, not only curbs once irrigation but also gives access for increasing production With this, optimum utilisation of water can be achieved and water delivery performance can be improved.

iv) Ratio of volume of water supplied to the avacut under the jurisdictional areas of WUAs as a ratio to planned volumes

In Rajolibanda Diversion Scheme project duty of 50 acres / cusec is adopted for both main canal and major Distributaries and base period of 120 days is considered for medium duration paddy crop. Analysis of water volume performance in terms of actual irrigated area in the Jurisdictional area of 26WUAs in the base year 1998-99 as other four study years were presented in Annexure -IV.5 and details of season wise “Water volume performance ratios” and other relevant details are furnished in Table - 7.

Sl. No	WUAs	Distributaries supplying water	Ratio of volume of water supplied to the required volumes				
			1996 Kharif	1997 Kharif	1998 Kharif (Base year)	1999 Kharif	2000 Kharif
1	Sidhanoor	D12A, D13, D14	0.77	0.77	0.77	0.77	0.77
2	Pulikal	D15, D16, D16A	0.78	0.78	0.78	0.77	0.78
3	Pedadhanwada	D17	0.78	0.78	0.77	0.78	0.77
4	Mandoddi-I	D18	0.77	0.77	0.78	0.78	0.78
5	Uppal	D19, D19A, D20, D21, D22	0.78	0.77	0.78	0.77	0.77
6	Mandoddi-II	D23, D24	0.78	0.78	0.77	0.78	0.78
7	Rajole	D25	0.78	0.77	0.77	0.77	0.78

Head reach overall ratios			0.78	0.774	0.746	0.774	0.776
8	Konkal	D25A, D26A	0.78	0.78	0.78	0.78	0.78
9	Rajole II	D26	0.77	0.77	0.78	0.77	0.77
10	Paipada	D27	0.78	0.77	0.77	0.78	0.77
11	Paipada II	D27A, D28	0.77	0.78	0.77	0.78	0.77
12	Kurvipada	D29	0.78	0.77	0.78	0.77	0.78
13	Vallur	D29A,B,C,D,E,F	0.78	0.77	-	0.78	0.78
14	Cheenipadu	D30	0.77	-	-	-	-
15	Narayanapur	D31,A,B, C,D	-	-	-	-	-
16	Itikyalapadu	D32A,D33	-	-	-	-	-
17	Takkasila	D34,D35,D36	-	-	-	-	-
18	Pullur	D36A	-	-	-	-	-
19	Undavally	D37A, D37B, D37	-	-	-	-	-
Middle reach overall ratios			0.78	0.775	0.776	0.777	0.775
20	Kyatur	D38, D38A,D39	-	-	-	-	-
21	Alampur	D40	-	-	-	-	-
Tail reach overall ratios			-	-	-	-	-

The observations made in case of 7 WUAs at head reach are as in Table - 8.

Sl. No	Year	Excess flows		Less flows	
		No of WUAs	Range of ratios	No of WUAs	Range of ratios
1	1996	0	-	7	0.77 to 0.78
2	1997	0	-	7	0.77 to 0.78
3	1998	0	-	7	0.77 to 0.78
4	1999	0	-	7	0.77 to 0.78
5	2000	0	-	7	0.77 to 0.78

From **Table - 8** it is observed that in the head reach, there are no excess flows including the base year 1998. The range of flows is 0.77 to 0.78. In the middle reach there were 12 WUAs the volume of actual flows to the planned flows in the 5 study years shown in **Table - 9**.

Sl. No	Year	Excess flows		Less flows	
		No of WUAs	Range of ratios	No of WUAs	Range of ratios
1	1996	0	-	7/12 DNA for 7 WUAs)	0.77 to 0.78
2	1997	0	-	6/12 DNA for 6 WUAs)	0.77 to 0.78
3	1998	0	-	6/12 DNA for 6 WUAs)	0.77 to 0.78
4	1999	0	-	6/12 DNA for 6 WUAs)	0.77 to 0.78
5	2000	0	-	6/12 DNA for 6 WUAs)	0.77 to 0.78

It is observed that in middle reach there were no excess flows during all the 5 years. There are flows in 7 WUAs in 1996 and 6 WUAs in the period from 1997-2000. There are no flows in tail reach.

The indicator aims at actual volume of water supplied to the target volume in 2 water users associations under Rajolibanda Diversion Scheme, Left Main Canal. The ayacut distribution under different reaches through the WUAs are

Sl.No.	Reach	Percent of Ayacut	No. of WUAs
1	Head	25	7
2	Middle	50	12
3	Tail	25	2

The indicator values in the head reach 7 WUAs in the base year are 0.75 and in the middle reach 0.78. There are no flows in the tail reach.

No excess flows are observed in the head reach or middle reach.

Suggestions

For improving the “Water volume” performance for irrigation of WUAs wise area, the following suggestions are made. WUA wise periodical water budgeting has to be made according to the stage of crop growth in consultation with WUAs and water regulation is to be made as per the schedule - water budgeting may be flexible in view of the constraints like intensity, frequency of rainfall, severity of temperature etc.

1. Measuring gauges are to be installed at all off take sluices for maintaining the required water levels and gauge readings are to be recorded at each change of operation. This would facilitate the correct volume of water supply in the irrigation command.
2. The age old practice of over irrigation has to be discouraged and the ayacutdar have to be educated about the advantages of utilising water as per consumptive use.
3. Each WUA may organise a demonstration plot on modern irrigation and water management techniques at different stages of crop growth to achieve desired results. It would disseminate to all the ayacutdars in the area of each WUA, to implement good water management practices from the age old over irrigation practices

5. EQUITY IN IRRIGATION BETWEEN HEAD REACH AND TAIL REACH

This indicator provides equity in irrigation (actual areas irrigated) among the distributaries with special focus on Head and Tail reaches. The data on planned irrigated areas and the actual irrigated areas are the basis to arrive the equity factor relating to areas irrigated between tail reach areas and head reach areas on main canal and major distributaries. Data relating to actual areas irrigated and under ratios of water received at the head reach and tail reach distributaries on the main canal are essential for complete analysis and evaluation

1. Quantum of water allocated to different beneficiaries / quantum of water to be supplies as per planning of the project.
2. Share of water received by beneficiaries / share planned in the project.
3. Intensity of irrigation in a given area / over all intensity of irrigation in the project command.(Head reach, middle reach , tail reach)

Ensuring equity in water distribution is one of the prime objective of participatory irrigation management after the formation of WUAs. About 46.0 per cent of the selected farmers expressed that the water distribution is more equitable after the formation of WUAs with about 53.0 per cent in the head reach, 59.0 per cent in the middle reach and 25.0 per cent tail reach have expressed their satisfaction while the balance expressed inequity in water distribution after the formation of WUAs (Table - 10).

Sl.No.	Reach	Yes		No		Total	
		No	%	No	%	No	%
I	Head	16	53.33	14	46.67	30	100
II	Middle	17	58.62	12	41.38	29	100
III	Tail	7	25	21	75	28	100
Total		40	45.98	47	54.02	87	100

ix) Reliability of Water Supply

Reliability besides equity and timeliness is more crucial during the crop growth with irrigation command. Any adverse effects may affect the overall crop production. Among the selected farmers in the ayacut 27.59 per cent expressed that the reliability of water supply has improved after the formation of WUAS and vast majority constituting 72.41 per cent have disagreed. It is heartening to note that 43.33 per cent of farmers in head reach and 34.48 per cent farmers in middle reach have agreed that there is improvement of water supply with reliability (Table - 11).

Sl.No.	Reach	Yes		No		Total	
		No	%	No	%	No	%
I	Head	13	43.33	17	56.67	30	100
II	Middle	10	34.48	19	65.52	29	100
III	Tail	1	3.57	27	96.43	28	100
Total		24	27.59	63	72.41	87	100

This indicator accounts for the volume of water released at Rajolibanda Diversion Scheme main canal head and the volume of water received at the distributary heads located all along main canal represented by a ratio. This enables to assess the variation in volume of water received in all distributaries to the volume of water released in the main canal. There are 47 distributaries taking off from Rajolibanda Diversion Scheme main canal. During the crop season, flows are maintained in main canal on all the days and in distributaries flows are maintained depending upon the supply of water on rotational basis/Warabandhi system being adopted.

The data of daily water discharges in cusecs were collected for all flow days during the crop season, at head of Rajolibanda Diversion Scheme main canal and at all distributary heads taking off from the main canal. From the said daily water discharges, cumulative volume of flow days, and the volume of water released in the main canal and volume of water received in each distributary in each season are arrived. The ratios of volume of water received in the distributaries to the volume of water released in the main canal were worked out. The ratios computed for main canal releases and distributary drawals for kharif season from 1996-2001 and for 1996-97 to 2000-2001 rabi seasons presented below. The season wise ratios of volume of water received by all the distributaries to the volume of water released in the main canal are shown in **Table - 12**

Table - 12

Sl. No.	Year & Season	Period (No. of days)	Parent Canal	Heads of all distributaries and other channels taking off from the parent canal & tail end regulator			Ratio of volume of water received in all distributaries and other channels to volume of water released at parent canal head col.7/col.4	Remarks	
				Volume of water released in main canal in the season 1000cum	Distributary/Other channels				Total Volume of water received in all distributaries in the season 1000cum
					Name	Location on parent canal km			
1	2	3	4	5	6	7	8	9	
			RDS Main Canal					Distributorywise data not available. As directed by field staff the volume of all the Distributaries arrived based on duty of 50 ac/1	
1	1996-97 (K)		101274	All Distributaries		92268	0.91		
	1996-97(R)		77384	All Distributaries		28252	0.37		
2	1997-98 (K)		109722	All Distributaries		78174	0.71		
	1997-98(R)		111044	All Distributaries		28277	0.25		
3	1998-99 (K)		111013	All Distributaries		75813	0.68		

	1998-99(R)		105350	All Distributaries	44157	0.42	cusec for kharif wet for 93 days flow period and for ID 70 ac/ cusec with base period of 80 days.
4	1999-00 (K)		96966	All Distributaries	79339	0.82	
	1999-00 (R)		92986	All Distributaries	47254	0.51	
5	2000-01 (K)		113350	All Distributaries	74840	0.66	
	2000-01 (R)		82646	All Distributaries	30001	0.36	

As seen from Table - 12 the ratios of the releases in the main canal to the total volumes received in all distributaries worked out for 1998 kharif (Base year) was 1.07 and 1998-99 rabi (Base year) 1.0 and other four study years it varies from 0.748 to 1.07. Except 2000 kharif (0.748) the ratios are almost 1.0. The transmission loss reflected during the year 2000 kharif. The variation of ratio $1.00 - 0.748 = 0.252$ has to be accounted for which is due to transmission losses in the main canal. The rest of the ratios for balance 9 seasons are around 1.00 which appears to be not realistic. Which emphasises the need for maintaining precise gauge readings for all the offtakes? The realistic volumes may have to be assessed by observation of correct water readings at head of main canal and at all off take points, corrective measures have to be taken to avoid erroneous water readings, discharge calculations etc.

B. Maintenance Performance

ACTUAL CAPACITY OF THE MAIN CANAL AND DISTRIBUTARIES AS RATIO OF THEIR DESIGNED CAPACITIES

Closely related to the operation performance indicator- II, this indicator is focussed at the actual capacity against designed capacity of the main canal as well as distributaries. It is a well known fact that the carrying capacity of the canal depends on sectional area, wetted perimeter and its surface functions and bed form. The canal section is designed with balanced sections with required side slopes maintaining non-silting and non-scouring velocities. Over a period of time the canal sections gets distorted due to depositing suspended matter in water called silt and erosions due to velocities resulting in flows causing fall in full supply levels. With the result, water volume performance would provide deviations and as such contemplated areas could not be irrigated. There are two approaches involved in arriving at the ratios of actual discharge against the designed capacity for the main canal and the distributaries and they are:

- (i) Actual carrying capacity of canal versus designed capacity. This can be worked out only when the data related to the cross sections of the main canal and distributaries are available. This data is not available for most of the projects.
- (ii) Actual flow versus designed discharges. In the absence of the cross sections of the canals the actual capacities at peak flows are identified and for the peak depth, the designed discharges with designed parameters are worked out and the indicators arrived at. For arriving at the indicators, the data of water depths at peak flow conditions at specific locations as well as the hydraulic details at such locations are essentially required. And accordingly the ratio have been calculated

Carrying Capacity Ratio = Actual canal capacity for selected canal / Designed canal capacity for the selected canal

The ratio should be close to one. In the present case, it is found 70 % is closer to one

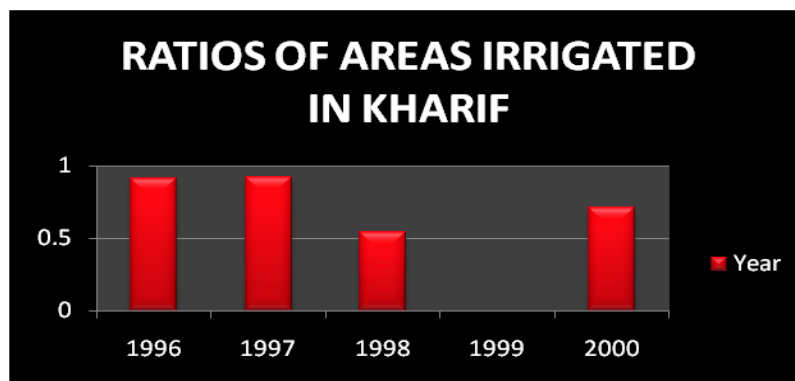
The flow ratios found to be varying from 0.45 to 1.25 canal flows higher than the designed capacity are also undesirable because of the risk of canal failure

Therefore, there is utmost need for periodic repairs and rehabilitation for upkeep of the canal sections to the designed standards

i) Actual area irrigated as a ratio of planned area (kharif & rabi separately)

This indicator facilitated to study the variation in area actually irrigated against the planned area in terms of ratio and provide valid reasons for such variation. The following are the ratios of actual areas irrigated against planned areas in kharif during base year and two subsequent years.

Sl.No.	Year	Rajolibanda Main Canal
1	1996	0.91
2	1997	0.92
3	1998	0.54
4	1999	N.A.
5	2000	0.71



There is decrease in the areas irrigated against planned in the prebase period and Improvement in the areas irrigated against planned in the post base year period.

ii) Ratios Of WUA wise areas actually irrigated To planned area Of irrigation

The jurisdictional areas of 7 WUAs in the head reach are irrigated by 17 distributaries. In the tail reach, the jurisdictional areas of 3 WUAs are irrigated by 3 distributaries. The reach wise performance ratio of actual area irrigated to the planned area in kharif is as below:

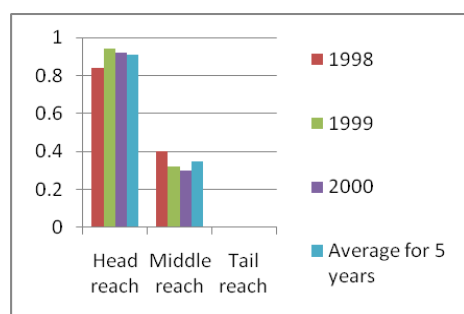


Table - 14

Sl. No	Reach	1998	1999	2000	Average for 5 years
1	Head reach	0.84	0.94	0.92	0.91
2	Middle reach	0.40	0.32	0.30	0.35
3	Tail reach	NA	NA	NA	NA

The irrigated area performance ratio is very poor in the middle reach. No data are available for tail reach.

iii) a) Condition of flow regulating structures

b) Condition of non flow regulating structures

The indicator is to ascertain the flow regulating structures and non-flow regulating category of structures to be repaired or replaced against the total number of same category, as a ratio. The study reveals that, the indicator for flow regulating structures is 0.55 and for non flow regulating structures it is 0.29.

iv) Cropping intensity Or increase In area Of cultivation

The indicator aims at working out the cropping intensity in the command area of Rajolibanda Left Bank Canal in Andhra Pradesh area. The cropping intensity is the total extent of crops grown on an unit command area as a percentage to the total extent. The study reveals the following cropping percentages.

1998-1999	56%
1999-2000	58%
2000-2001	46%

The average cropping intensity for five study years is worked out to 45 per cent only. There is immense need to improve the system to increase the intensity further.

V. AGRICULTURAL PRODUCTION INDICATORS

RDS provides irrigation to an area of about 35,140 ha. Some of the indicators relevant to the present context are discussed below:

(i). Area fully irrigated, partially irrigated and with no irrigation: On the basis of this indicator (OP-II) the area fully irrigated during 1998-99 base year is 50 per cent in kharif and 100 percent in rabi; the area partially irrigated is 3 per cent in kharif and 10 per cent in rabi; and the balance is with no irrigation. In the succeeding two years to base year no area was irrigated during kharif and rabi in 1999-2000 and 2000-2001 respectively. During these two succeeding years the area under partial irrigation is negligible. However, 82 per cent of area in rabi during 1999-2000 and 69 per cent of area in kharif during 2000-2001 is irrigated in full under RDS.

(ii). Number and Types of demonstrations conducted for irrigated wet and irrigated dry crops: The emphasis on package of practices till mid 1990s was shifted to problem oriented crop demonstrations from 1996-97 to 1998-99 and these demonstrations were organized for both irrigated, irrigated dry and rainfed crops. With the implementation of Agricultural Intensification Programme (AIP) the emphasis is shifted to on farm demonstrations in the irrigated commands on plant density, crop sequences and other related problems at different reaches of the main canal and distributary systems.

The size of demonstration plot is 2 ha and the cluster of 6 ha is laid with 2 ha in each reach and It is reported that the crop yield increase is varied between 3-10 per cent in the demonstration plots compared to the controlled plots of different crops. The results of on-farm demonstrations conducted during kharif 1999-2000 in the RDS and It is found that there is an increase in yield up to 26.21 per cent. During kharif 2001-2002 in Mahabubnagar district the average yield of paddy in OFDs is 3,717 kgs per ha as against the control plot yield of 3,295kg / ha showing an increase of 13 per cent.

(iii). On-farm Management Such as Land Leveling, Irrigation Methods and Water Applications: This indicator is arrived based on the household survey conducted for sample of ayacut farmers located at head, middle and tail reaches of the irrigation system. Of the total selected farmers about 93-96 per cent of the selected farmers reported that they are fully depending on canal waters and 3-16 per cent are reported to be supplementing irrigation from other sources like tube well. Among those who reported supplementary source of irrigation, the average area on the supplementary irrigation among the ayacutdars is 1.22 ha. Of the total selected farmers about 100 per cent reported to have invested on-farm management related to land leveling, and irrigation channels.

iv). Production of three principal irrigated crops: In Rajolibanda Diversion Scheme (RDS) ayacut paddy is the exclusive irrigated crop while, groundnut and sunflower are irrigated dry crops. Of the gross cropped area 20 percent is under paddy, 66.11 per cent under groundnut and 16.97 per cent under sunflower during the base year 1998-99. In terms of production there has been significant decrease in overall production of paddy with 0.60 lakh metric tones in base year kharif 1998-99 to 0.40 lakh metric tones by kharif 2000-01. In rabi the overall production of paddy during base year was 0.08 lakh metric tones which has declined to 0.04 lakh metric tones by rabi 2000-2001. However, there is an increase in paddy production in kharif during 1999-2000 to 0.66 lakh M.tonnes. In case of groundnut, the overall production has increased from 1108 M. tones in 1998-99 to 1222 M. tones by 2001-02 and the production of sunflower also appears to have maintained an increase from 7962 M.tones to 5331 M.tones during the same period.

(v & vi). Changes in crop yields in relation to the previous year / crop yields over the past several years: In Rajolibanda Diversion Scheme (RDS) command the kharif the productivity of paddy/ rice has shown marginal increase with 1890 kgs / ha during 1998-99 to 2349 kgs/ ha by 2001-02 showing an increase of 15 per cent. In case of rabi paddy/rice the per ha yields have increased from 1963 kgs / ha during base year 1998-99 to 2349 kgs/ ha in 2001-02 with about 20 per cent rise. In case of groundnut the yield rates in kharif have shown increasing trend with 416 kg / ha in 1998-99 to 572 kgs/ ha in 2001-02. In rabi also groundnut yield has shown increasing in the consecutive two years to base year. In 1998-99 rabi the yield of groundnut is 720 kgs/ ha and 1412 kgs/ ha in 2001 -02 rabi and in between the yield has increased to 704 kgs / ha in 2000-01. However, sunflower has shown increasing trend in its yield rates in both kharif and rabi over the base year yield of 327 kgs/ ha in kharif 1998 and 369 kgs/ ha in rabi 1998-99.

(vii). Use of Inputs for Principal Crops: In Rajolibanda Diversion Scheme (RDS) paddy is the principal irrigated crop. Most of the paddy area is covered under Krishna Hamsa, BPT 5204, IR 64, Tella Hamsa and PLA-1100. At the district level in Mahabubnagar, the seed distribution of paddy during the base year 1998-99 was 17382 quintals, jowar 15499 quintals, maize 2025 quintals, redgram 941 quintals, bengalgram 214 quintals, groundnut 8074 quintals, sunflower 1995 quintals and others crops with a total seed distribution of 50,654 quintals which has decreased to 46,894 quintals in 2000-01. In case of fertilizers in terms of N, P, K the consumption of fertilizers has increased from 2,04,333 tones to 1,36,784 tones during 1998-99 to 2001-02 **PP Chemicals:** Maximum pesticides are generating used only for paddy. The total pesticide consumption of 275.60 quintals during the base year 1998-99 has decreased to 233.80 quintals by 2000-2001 showing a

substantial decrease in its usage.

(viii). Changes in Cropping Pattern and Cropping Intensity: The area under various crops for the past five years from 1997-98 to 2001-02 has shown that the area under paddy has some variation over these five years. The kharif paddy area in 1998-99 which was about 3499 lakh ha has declined to 3073 lakh ha by 2001-02 and in rabi it was 865 ha during 1998-99 which has also decreased to 612 ha by 2001-02. Similarly the area under kharif groundnut has also declined from 2942 ha in 1998-99 to 2114 lakh ha by 2001-2002. However, rabi groundnut has shown an increasing trend during the same period. Even sunflower as oil seed crop has also shown a declining trend in their respective sown areas during the said period. This is because of crop suitability in black soils, besides assured water and conductive market have facilitated for such change in the cropping pattern in the Rajolibanda Diversion Scheme (RDS) irrigation command. Though there are marginal variations in the area of various crops, the overall performance in terms of cropping intensity has stabilized at 116 per cent from 1997-98 to 2001-02 with regard to cropping intensity.

(ix). Increased Adoption of water saving technology: About 81 per cent of the selected farmers in Rajolibanda Diversion Scheme (RDS) command are reported to have adopted water saving techniques most of whom are diverting water to next field after fulfilling their requirements and the balance 19.2 per cent are utilizing sprinkler irrigation.

(x). Improved Farmer Investment in Equipment and Farm Improvements: The distribution of farm machinery and implements to the farmers under AIP has started from 2000-2001 to 2002-03. In Mahabubnagar district the implementation during the initial year has improved well by 2002-03. The total number of machinery and equipments distributed during 2000-01 is 1406 which has increased to 5225 by 2002-03. The machinery are mostly APAU peddlers, three type of cultivators without wheels and power operated sprayers.

(xi). Changes of Farm Income: Changes in farm income for the base year and consecutive two years are worked-out by considering the farm harvest prices, crop yield estimates, market prices of inputs and the scale of finance issued by the commercial banks during the respective years. Accordingly farm incomes are estimated for paddy, and groundnut and the normal yields are taken for the purpose of arriving at the changes in farm income.

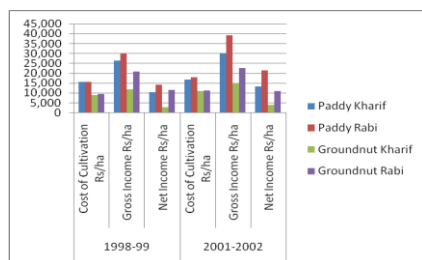


Table - 15

Sl. No	Crop	Season	1998-99			2001-2002		
			Cost of Cultivation Rs/ha	Gross Income Rs/ha	Net Income Rs/ha	Cost of Cultivation Rs/ha	Gross Income Rs/ha	Net Income Rs/ha
1.	Paddy	Kharif	15,760	26,300	10,540	16,870	30,100	13,230
		Rabi	15,560	29,840	14,280	17,871	39,300	21,429
2.	Groundnut	Kharif	9,030	12,000	2,970	10,900	15,000	4,100
		Rabi	9,530	21,000	11,470	11,400	22,500	11,100

(xii). Amount and Value of Three Principal Crops as a Ratio of Water Deliveries per Unit of Water : Paddy, groundnut and sunflower are the principal crops in Rajolibanda Diversion Scheme (RDS). Paddy occupied over 50 per cent of the area in kharif. The amount and value of paddy against the water deliveries as a ratio is assessed at constant prices, Rs. 495 per ha as water cess in kharif and Rs. 370 per ha in rabi. The yield rates per ha and the value of crop production per quintal are also taken into consideration. Based on these parameters the total recoverable water cess for the cultivated area in kharif wet is assessed as per the analysis made in Engineering Indicators for OP-II indicator arrived on the basis of Modified Penman Method. The total reasonable amount for paddy and other crops as a water cess and its total value of produce is taken for arriving at the ratio between amount of water cess and the value of crop produce and the following ratios are arrived.

Table - 16

Year/Season	Paddy	Groundnut	Total
1998-1999			
Kharif	22.9	3	25.9
Rabi	-	19.3	19.3
2000-2001			

Kharif	30.2	-	30.2
Rabi	-	33.4	33.4

(xiii). **Amount of Water Received per Crop Irrigation Effective as a Ratio of Crop Water Requirement:** The ratio between actual and planned water releases are arrived for both kharif and rabi by taking into consideration the crop water requirements as per Modified Penman Method (MPM) and the ratios are presented below:

Table - 17

Year/Season	Actual Area Irrigated (ha)		Total Water requirement as per MPM in '000 cum	Ratio of Actual Area Irrigated
	Wet	ID		
1998-99				
Kharif	5920	-	68315	0.07
Rabi	-	6395	14352	0.14
2000-2001				
Kharif	6973	-	90369	0.12
Rabi	-	4345	-	-

(xv). **Increased Cost Recovery According to Schedule:** The total water cess recovered during 1998-99 was Rs. 30151 lakhs which has declined to Rs. 9989 lakhs by 2002-03 showing substantial decrease of water cess towards cost recovery in the Rajolibanda Diversion Scheme (RDS) irrigation command due to inadequate water releases.

VI. SOCIO-ECONOMIC INDICATORS

(i). **Farmer Categories:** Among the ayacutdars 43.33 per cent are small farmers, 27.78 per cent medium farmers, 28.89 per cent big farmers and 10.0 per cent female farmers. Further, 27.78 per cent of the farmers belong to scheduled castes and scheduled tribes. Similarly in the case of non-ayacutdars 33.33 per cent are small farmers, 33.33 per cent medium farmers and balance 33.33 per cent are big farmers. Among the selected farmers 16.67 per cent are female farmers and 30 per cent are from SCs and STs among non-ayacutdars.

(ii). **Annual Income:** The average annual income of the households among the ayacutdars is Rs. 53,877/-. The average annual income of the non-ayacutdars among the selected households is Rs. 46,333/-. The income distribution among ayacutdars and non-ayacutdars shows about 82 per cent among ayacutdars and about 83.3 per cent among non-ayacutdars are within the income range of Rs. 26,000 to Rs. 1, 00,000. **Sources of Income:** The major source of income among the ayacutdars is mostly from primary sector and the income from other sectors is negligible both among ayacutdars and non-ayacutdars. Agriculture crop production contributes about 80.47 per cent of the total annual income, agricultural wage labour about 16.75 per cent and income from sale of milk is about 0.76 per cent and the income from other sources is about 1.90 per cent. This shows that about 98.01 per cent of annual income among the selected farmers in the ayacut area is from primary sector alone. Among the non-ayacutdars also similar pattern is observed with 97.56 per cent of the income from primary sector of which agricultural crop production constitute 70 per cent and agricultural wage labour 25.83 per cent and the income from other sources is about 4.18 per cent.

(iii). **Annual Expenditure:** Of the total income about 71.51 per cent goes for consumption expenditure among the selected farmers in the ayacut area and 76.30 per cent in case of selected farmers in the non-ayacut area. In other words roughly about 72 to 76 per cent goes for consumption expenditure for various purposes and the balance income is mostly spent on agricultural operations. The total annual household expenditure is Rs. 31360/- among ayacutdars. In case of non-ayacutdars the total annual expenditure is Rs. 26280/-. **Housing:** All the selected farm households both in ayacut and non-ayacut have own houses. Of the total owned houses 76.67 per cent are having electricity in both the ayacut area and non-ayacut areas. The balance houses do not have electricity. Of the total households about 20 per cent are pucca houses, about 54.81 per cent semi pucca and balance 25.91 per cent kutcha houses in the ayacut area. In non-ayacut area 20 per cent are pucca houses, 48.89 per cent semi-pucca houses and 31.11 per cent are kutcha houses.

(iv). **Size of Holding:** The average size of the holding among the ayacutdars is 4.80 acres while it is 4.17 acres among the non-ayacutdars. Most of the area (93 to 97 per cent) is under irrigation among the ayacutdars. In case of non-ayacutdars the average irrigated area is 0.20 acres and rainfed is 3.97 together constituting the average size of 4.17 acres holding.

(v). **Other Sources of Irrigation:** In almost all irrigation systems the farmers besides utilising the canal waters also go in for supplementation of irrigation as and when required. In Rajolibanda Diversion Scheme (RDS) irrigation command 93 per cent of the farmers in head reach, 97er cent in middle reach and 73 per cent in tail reach have fully utilized canal waters, while the balance have utilized supplementary irrigation sources of like tube wells, bore well, dug well and other sources.

The average area under supplementary irrigation is 1.21 acres among the ayacutdars. In case of non-ayacutdars the entire area is under supplementary sources of irrigation like tube well and bore well which is 0.10 acres.

(vi).Land Lease: Among the selected two farmers in tail reach have taken irrigated dry land on lease. The average size of land has been 3 acres. In case of non-ayacutdars none has taken land for lease.

vii).Cropping Pattern: The most predominant crop grown in 1998-99 during kharif and rabi in the command is paddy higher per cent of the cropped area. However, at the tail reach sunflower is grown in 100 acres.. In 2002-2003 with paddy as the most predominant crop followed by groundnut, sunflower, jowar, cotton, etc. In the non-ayacut among the selected farmers sunflower, groundnut are the important irrigated crops during 1998 kharif. During 2002-2003 similar cropping patterns as in 1998 kharif is visible in non-ayacut areas

Land Productivity Index can be expressed in terms of kg of crop produced per ha or acre of land irrigated

1. Crop Yields: The crop yield of paddy is 18.44 quintals per acre at the head reach, 16.64 quintals per acre at the middle reach and 13.38 quintals per acre at the tail reach in 1998-1999. During 2002-03 the paddy yield per acre on an average in kharif at the head, middle and tail reaches has taken between 15-16 quintals. In case of non-ayacutdars groundnut being the predominant seasonal crop mostly grown in kharif its average yield is 5.39 quintals per acre in kharif 1998-99. **Crop production utilities:** About 16-18 per cent of kharif paddy produce is kept for household consumption and 82-83 per cent of the paddy produce is sold in the market during kharif and 92-100 per cent paddy produce in rabi is also marketed outside. The spoilage is negligible during the crop seasons among ayacutdars. Among the non-ayacutdars about 62 per cent of the produce is kept for household consumption and the balance 33 per cent is sold out during kharif 1998-1999. In case of oilseeds 98 per cent is sold out. More or less similar pattern is observed among non-ayacutdars.

2. Sources of Irrigation-Crop-wise: In Rajolibanda Diversion Scheme (RDS) irrigation command 96 per cent of the paddy cropped area is from canal irrigation and about 4-20 per cent is under supplementary irrigation during 1998-99. During 2002-03, 66.67 per cent of paddy area under tail end is irrigated through canals and the balance 33.33 per cent is through supplementary sources. In the non-ayacut among the selected farmers the sources of irrigation for different crops is mostly from existing surface streams and in the upland areas lifting water from the canals constitute about 100 per cent for paddy crop during 1998-99 and 2002-03.

3. Water Charges: The Government of Andhra Pradesh levied water charges at the rate of Rs. 150 per acre. The average water charges paid by each farming household at head reach, middle and tail reach is varying between Rs. 133 to Rs. 155 in kharif 1998-99. During 2002-2003 the water charges paid by the farmers is varying between Rs. 70 to Rs. 212 during kharif.

Other Purchases : The farmers in the irrigated area have also incurred expenditure for various purposes like bags, containers, plastic sheets, etc. The average cost per such expenditure ranged between Rs. 580 to Rs. 810 during 1998-1999 in head, middle and tail reaches and it is ranging between Rs. 614 to Rs. 870 during 2002-2003 per family. **Land Selling**

Price: The land selling price among the ayacutdars is varying between Rs. 25,433/- at the tail reach to Rs. 37,833/- at the head reach, while the middle reach being Rs.32,333/- per acre. The overall average land price in Rajolibanda Diversion Scheme (RDS) irrigation command is Rs. 0.31 lakh during 1998-99. By 2002-2003 the land price has increased varying between Rs. 0.324 lakh at the tail reach to Rs.0.602 lakh in the head reach and the middle reach being Rs. 0.442 lakh with overall cost of Rs. 0.456 lakh. Among the non-ayacutdars the land rate is about Rs. 0.130 lakh in 1998-99 and it is Rs.0.184 lakh during 2002-2003.

VII. WATER DELIVERY SYSTEM STATUS

Payment of Water Charges : About 85 per cent of the farmers have expressed that they are aware of water charges and almost all of them are paying it to the revenue officials and no farmer is paying directly to the WUA. It is the joint responsibility of revenue department, irrigation department and agricultural department to recover the water cess from the farmers in the ayacut. Over 46.67 per cent of the farmers are paying water cess in time during all the years after the formation of the WUAs. There has been decrease in the recovery of water cess. The total water charges paid by the selected farmers during 1998-99 were Rs. 30,151 which has declined to Rs. 9,989/- by 2002-03. About 50 per cent of the total selected farmers have expressed that they are in awareness of the time to time decisions taken by the WUAs in maintenance and management of irrigation waters in its jurisdiction.

Satisfaction: About 45 per cent of the farmers expressed their satisfaction with the WUA leader and their policies in the entire sample households in the ayacut. **Selection of Maintenance Works:** About 54 per cent of the farmers selected have expressed their satisfaction of the maintenance works undertaken by the WUAs. About 4.35 per cent of the selected farmers have expressed that the quality of maintenance works as poor, about 76.81 per cent as normal quality, and about

18.84 per cent expressed as good quality. About 46 per cent of the selected farmers expressed that the water distribution is more equitable after the formation of WUAs. About 53 per cent in the head reach, 59 per cent in the middle reach and 25 per cent tail reach have expressed their satisfaction while the balance expressed no equity in water distribution after the formation of WUAs. Among the selected farmers in the ayacut 27.59 per cent have expressed that the reliability of water supply has improved after the formation of WUAs and about 72.41 per cent have disagreed. About 28.74 per cent of the selected farmers in the entire irrigation command have expressed that there is an increase in the average annual income from the irrigated land after the introduction of PIM. Among the selected farmers about 36.78 per cent are reported to have involved in management of the irrigation system after the formation of WUAs as part of participatory irrigation management.

The respondents constituting about 55.32 per cent have expressed satisfaction on the Participatory Irrigation Management (PIM), 14.89 per cent expressed Good, 10.64 percent as fair and the balance 19.15 per cent are unsatisfied expressing it as poor and very poor. Equity, timeliness and reliability of water supply from head to tail reach motivates the farmers to go for higher farm investments for better crop production. Overall 39.08 per cent in the entire command have informed that they made investments on farm management. No farmers is reported to have made payment of special fee to WUA. About 19.2 per cent of selected farmers are using sprinkler irrigation as a measure of conjunctive use of water. Some of the farmers (44.86%) have expressed that they are making other contributions by way of labour and donations in kind. Of these total respondents 84.6 per cent expressed that they are making contributions in the form of (Human Labour)/ shramadanam in canal and field channel repairs like desilting, weed removal, repairs to canal, canal revetment, etc.

VIII. ENVIRONMENTAL INDICATORS

1. There are wide fluctuations in water levels during pre and post monsoon seasons in Mahabubnagar district. The 23OB wells showed a variation of 0.99 mt to 12.98 m in the post - monsoon season of 1997-98. The data available for one OB well in pre monsoon was 2.95 mt.

During the base year 1998-99 the trend of water levels in pre-monsoon season was 0.39 to 12.80 mt and in post-monsoon it was ground level to 2.63. In the subsequent years 1999-2000 to 2001-2002 the water levels in pre monsoon season fluctuated between 0.90 to 15.10 mt and in the post monsoons season the variation was between 0.45 mt to 9.90 mt.

2. Water logged and Prone to water logging areas : According to the norms of Government of India an area is said to be water logged where the water table in the wells is varying between 0.00 mt to 2.00 mt and an area is said to be prone to water logging if the water table is between 2.00 mt to 3.00 mt. The analysis of the data in Mahabubnagar district for 23wells showed that during 1997-98 about 4.3 per cent wells were under water logged condition during pre-monsoon season and 12.1 per cent were under water logged conditions in the post monsoon season. During 1998-99 (Base year)8.6 per cent wells both in pre and post monsoon seasons were under water logged conditions. During 2001-2002, the percentage of wells was under water logged condition in pre-monsoon season increased to 17.3 per cent while 126.1 per cent wells were under water logged conditions in post monsoon season at 2001-2002. The percentage of wells prone to water logging in pre-monsoon season is varying between 4.3 to 17.1 per cent while in post-monsoon season it was more than 21 per cent. The State Ground Water Department, is suggesting establishment of dug/open wells, bore wells etc. to overcome the problems of water logging in the district.

3. Quality of Ground Water : The State Ground Water Department regularly undertakes chemical analysis of ground water from various irrigation projects. The State Ground Water Department, is monitoring the quality of water in respect of 13 parameters by conducting the standard analytical methods are used to determine the chemical composition of the representative water samples.

4. pH: The data available for 6 observation wells in pre-monsoon during 1997 to 2000 indicated that pH is within the permissible limit (6.5 to 8.50) in all the wells in the command area mandals. Data from no observation wells in the post-monsoon was available **EC** : About 60-70 per cent of the OB wells in pre-monsoon are within the permissible limit in terms of EC. **TDS** : In 1998 the base year 100 per cent of wells in pre-monsoon season are showing TDS within the permissible limit while in the year 2000, only 50 per cent wells had TDS within the permissible limit. **SAR** : The SAR values are within the permissible limits in 100 per cent of the wells in pre monsoon in all the years . **Chloride**: From 1997-2000 the chloride level in pre in 100 per cent wells are within the permissible limit. **Flouride**: The groundwater in the observatory wells during 1997 to 2000 have shown 0.66.67 per cent of wells in pre monsoon are within the permissible limit in terms of flouride content in ground water. The intensity of flouride content in the observatory wells during the said period have shown that large majority of the groundwater wells in pre monsoon are well 'above' permissible limit of flouride content indicating the harmful nature of the groundwater in terms of flouride in the study area mandals. **Nitrates** : Nitrate is one of the chemical component which affects the groundwater due to excessive use of fertilizers in irrigated agriculture. However, from 1998 to 2000 all the observatory wells in pre-monsoon are having the groundwater within the permissible limit of nitrate content. **Calcium** : During 1997-2002 the ground water in the observatory wells within the command area mandals of

Mahabubnagar district have shown that 100 per cent of OB wells in pre monsoon season are having calcium within the permissible limit. **Magnesium** : During 1998 to 2000 all the OB wells in pre monsoon are having permissible limits of magnesium in ground water. **Sodium**: Like Magnesium the sodium levels in the ground water of all the OB wells in pre are within the permissible limit. **Potassium** : Potassium content in the groundwater in 100 per cent observatory wells both in pre and post monsoon during 1997 to 2000 are having potassium below the permissible limit. **Total Hardness** : In 100 per cent of OB wells the total hardness of groundwater is within the permissible limit during 1997-2000 in pre - monsoon in the mandals covered by the command .

IX. REMOTE SENSING APPLICATIONS

The Remote sensing component of the study under Andhra Pradesh Economic Restructuring Project - Irrigation Component Baseline Survey in the Rajolibanda Diversion Scheme- a Major Irrigation Project irrigation command is spreadover 78 Villages in 6 mandals of Mahabubnagar and Kurnool districts. The sub-components of the study are: (i) Cropped area estimation - kharif and rabi seasons; (ii) Crop area estimation under principal crops; (iii) Crop yield estimation based on vegetative index method; (iv) Saline/alkaline lands delineation; (v) Water logged areas and areas prone to water logging.

1. Land Use Land Cover: Based on the RS data processing and GIS applications, the map on Land use Land cover of Rajolibanda Diversion Scheme- a Major Irrigation Project area for the year 1999 are generated and the extent of area under different land uses shows that the total Geographical area of the command is 80,405 ha. The land use and land cover pattern in the command during the year 1999 shows that the agricultural land is occupying 66,788 ha (83.06%), built-up land 1,105 ha (1.43%), plantations is 53 (0.07%), Barren/rocky/stony waste 59 ha (0.07%), **salt affected lands are found in Ieeja, Alampur, Wadepalli and Kurnool mandals with an area of 3962 ha (4.93%), tanks and streams/canals constitute 6,662 ha (8.29%),** double cropped area is 22,598 (28.11%). **Cropped Area:** The cropped area for kharif is 66,788 ha and rabi is estimated at 22,598 ha during base year 1998-99.

2. Crop Area Estimation: The principal crops grown in Rajolibanda Diversion Scheme are paddy, groundnut, sorghum. The crop area estimation in the study area has been made for paddy, groundnut crops. Paddy was grown in an area of 3,504 ha , groundnut 5,671 ha together constituting 9,175 ha in rabi 1998-99.

3. Crop Yield Estimation: The study provides crop yields at desegregate level or sub-strata level namely command area and mandal levels for the experimental crops paddy and groundnut in rabi. The yield estimates are made for paddy, jowar and groundnut crops in rabi 1998-99 showing high, medium and low yielding mandals in the irrigation command.

X. RESULTS AND CONCLUSIONS

Based on the irrigation system evaluation procedures on conveyance, application, irrigation efficiencies keeping in view of equity, uniformity adequacy and timeliness as main criteria etc for scheduling & irrigation management ,the baseline survey carried out to evaluate the performance of Rajolibanda Diversion Scheme (RDS). certain issues requiring corrective measures for continuity of monitoring during the course of implementation of the scheme from time to time as well as evaluation of the overall system performance at different points of time. Some of the issues that needs to be modernization of the system or taken care of are: (i) Planned and actual dates of opening and closing may be planned realistically ; (ii)Development of three tier operational plan; (iii) Rescheduling of water budget considering the rainfall precipitation; (iv) Maintenance of distributary wise flow data; (v)Discourage age old irrigation practices; (vi) Maintenance of water readings in the irrigation systems; (vii) Maintenance of cross sections of the canal systems; (viii) Strict vigilance on illegal conversions; (ix) Planned water requirements into the main canal has to be made at its border; (x) Repairs and replacements to be attended promptly; (xi) Earmarking of grant as per canal ranges ; (xii) Steps may be taken to improve irrigation efficiency; (xiii) Separate budgetary provision to be made for works; (xiv) Preparation of Hydraulic Particulars; (xv) Demarcation of Ayacut with No Irrigation; (xvi) Cost of Cultivation data (xvii) Motivation of Farmers to pay timely Water Cess; (xviii) Increase the number of Observatory Wells in Irrigation Commands; (xix) Subsidised Remote Sensed Micro-Wave data ; (xx)Crop Yield estimations at disaggregate levels.

XI. SCOPE OF THE STUDY

A new planning can also be developed to improve the performance of the RDS canal system, by modelling ,for canal scheduling based on equity ,uniformity ,adequacy and timeliness criteria and irrigation management and accordingly can suggest the optimal crop plan to increase the net benefits

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International eJournal of Mathematics and Engineering 141 (2011) 1273 - 1292

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