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## **DESCRIPTION OF THE SYSTEM AND THE FORMULATION OF OBJECTIVES BASED ON RESPONSE SURVEY ANALYSIS**

# Description of the System and the Formulation of Objectives Based On Response Survey Analysis

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**Abstract – This study is a part of my Ph.D. research and included in my thesis as chapter 3. This study presents an overview of the planning environment relevant to the command area under consideration. Specifically it considers the salient features of the irrigation project along with its physical setting, cropping pattern, geology, climate, ground water status and socio-economic aspects. The constraints in utilizing the resources in the command area are assessed through discussions with project officials at various levels, interactions with farmers' in the form of interviews using a structured questionnaire and available project reports. This helped to understand the existing water management practices better and developed the basis for systematic approach for the improvements of the system.**

## PHYSICAL SETTING

### Location

Mahi Baja Sagar Project (MBSP) is located in Banswara district in southern part of Rajasthan state bordering the states of Madhya Pradesh and Gujarat. The project is situated near a village Borkhera about 16 Km northeast of Banswara town. Global co-ordinates of the dsite are 24°22' N Latitude and 73°19' E Longitude (Water Resources Planning for Mahi River Basin, 2001). The project includes a dam, a system of canals and two MW and PH 2 near Lilvani village with installed capacity of 2x45 MW.

The releases from the reservoir are made through the saddle dams (because of natural depression) constructed at the bank of the reservoir. From the saddle dam, the water goes to PH 1 and then to the Kagdi Pick up Weir From which water is released into LMC and RMC (Nagesh Kumar, 2004)

The MBSP has three main canal systems namely, Left Main Canal (LMC), Right Main Canal (RMC) and Bhungra Canal (BC). Four other canals, namely, Anandpuri canal comes under LMC and Narwali Canal, Jagpura and Bhikha Bhai Sagwara canal comes under LMC and Narwai canal, Jagpura canal and Bhai Sagwara canal come under RMC (MRSP Report on Status June 2002 at a Glance, 2002).

The two canals LMC and RMC takes off from balancing reservoir i.e. Kagdi Pick up Weir, The RMC is an irrigation canal while, LMC is an irrigation cum hydel canal as it transmits the share of water of Gujarat upto PH 2. Bhungra canal takes off from main dam and Anandpuri canal takes off from the tail of the

hydel canal (LMC). Similarly Narwali canal takes off from RMC at 29.34 and Jagpura canal takes off from Narwali canal at 19.43 Km. Bhikha Bhai Sagwara canal starts from the tail of RMC. Location map of MBSP is shown in Fig. 3.1 Index map of MBSP giving the details of canals is presented in Fig. 3.2 Salient features of MBSP and detail of the canal

Fig. 3.2 Index map of Mahi Bajaj Sagar Project (MBSP) (Source: MBSP Report on Report on Status June 2002at a Glance, 2002)

Table 3.1 Salient features of Mahi Bajaj Sagar Project (MBSP)

(Source: MBSP Report on Report on Status June 2002at a Glance, 2002)

Full Reservoir Level	EL 281.50 m
Water Spread Area	142.90 KM <sup>2</sup>
Gross Storage (Live+Dead) Capacity	2180.39Mm <sup>3</sup>
Live Storage Capacity	1829.27Mm <sup>3</sup>
Dead Storage Capacity	351.13 Mm <sup>3</sup>
Sharing of Water	Gujarat State 1132.67Mm <sup>3</sup>
Madhya Pradesh	368.11 Mm <sup>3</sup>
Culturable Command Area (CCA)	80,000 ha (Phase 1)
1,23,500 ha (Phase 2)	
Power House (PH 1) Installed Capacity	2x25 MW

Table 3.2 Detail of canal systems

(Source: MBSP Report on Status June 2002 at a Glance, 2002)

Name of the Canal	Discharge at head (comics)	Length (km)	Culturable Command Area (ha)
Left Main Canal	62.53	36.12	40570
Right Main Canal	30.00	71.72	35940
Bhungra Canal	3.19	39.80	3590
Anandpuri Canal	4.40	39.93	9000
Narwali Canal	17.22	33.09	2055
Jagpura Canal	12.32	12.50	2570
Bhikha Bhai Sagwara Canal	2.06	21.46	4956

## INTER-STATE AGREEMENT

An inter – state bilateral agreement regarding sharing of Mahi water between Rajasthan and Madhya Pradesh was made in 1961 to utilize the Mahi river water potential for Development of most backward tribal region of both states. Similar understanding was also made between the states of Gujarat and Rajasthan in the year 1966. Accordingly it was agreed to reserve 368.11 Mm<sup>3</sup> of mahi water for upstream utilization in Madhya Pradesh and 1132.67 Mm<sup>3</sup> for downstream utilization in Gujarat (Mahi Bajaj sager project Report, 1978).

## CHARACTERISTICS OF THE SOLIDS AND GEOLOGY OF AREA

The soils of the area are categorized under block, red, brown and mixed soils ( Mahi Bajaj sear project report, 1978). The block soils exist along LMC, heard reaches of taking off irrigation subs teems and the patches almond along RMC. Red soils and brown soils are found both in LMC and command. The area is covered mainly by rocks belonging to the Archaean metamorphic complex and the Ravalli super-group of rocks. Alluvium presence is insignificant.

## CLIMATE

The area classified as semi- arid. May is the hottest month of year, with a mean daily maximum and minimum temperature of 40.5 °c and 27.5 °c respectively. The annual range in temperature, i.e., difference between the extreme maximum and minimum temperatures reaches about 42 °c. The mean monthly maximum temperatures, humidity, wind spree, daily sunshine and solar radiation for Banswara staion (representing MBSP) are shown in Table 3.3 (water Resources planning for Mahi river basin, 2001) which is basis for computation of reference evapotranspiratin (ET<sub>0</sub>), THEREBY CROP WATER REQUIREMENTS.

**Table 3.3 Meteorologiceal data of Banswarq station (representing MBSP)**

(Source: Water Resources Planning for Mahi River Basin, 2001)

Month	Min. Temp (°C)	Min. Temp (°C)	Humid ity (%)	Wind Speed (Km/day)	Daily Sun- shine (hrs)	Solar Radiation (MJ/m <sup>2</sup> /d)
January	27.5	12.1	46.6	120.0	7.6	14.8
February	30.2	30.2	14.6	41.7	134.4	7.2
March	34.9	19.3	37.3	146.4	8.4	20.2
April	39.4	24.1	35.2	146.4	8.6	22.2
May	40.5	26.4	52.7	218.4	9.3	24.0
June	37.2	25.8	67.8	235.2	9.2	23.8
July	31.8	24.2	74.4	182.4	9.4	24.0
August	29.9	23.4	81.4	158.4	9.1	23.1
September	32.6	22.8	75.1	105.6	8.3	20.6
October	34.8	20.3	54.6	108.0	8.1	18.1
November	32.4	16.9	47.5	115.2	7.4	15.0
December	28.7	13.3	53.5	117.6	7.4	13.9
Average	33.3	20.3	55.6	149.0	8.3	19.7
Minimum	27.5	12.1	35.2	105.6	7.2	13.9
Maximum	40.5	26.4	81.2	235.2	9.4	24.0

## RESPONSE

SUBTOTAL	64.0		25964.80	23001.60	2233.60
Maize	3.0	1217.10	1078.20	104.70	
Paddy	4.0	1622.80	1437.60	139.60	1047.00
Cotton	9.0	3651.30	3234.60	314.10	146.58
Pulses	5.0	2028.50	1797.00	174.50	879.48
Sugarcane	2.0	811.40	718.80	69.80	66.31
Zaid Crop	2.0	811.40	718.80	69.80	76.78
SUBTOTAL	25.0	10142.50	8985.00	872.50	17.45
TOTAL	89.0	36107.30	31986.60	3106.10	2233.60
Kharif (25%)	Maize	3.0	1217.10	1078.20	104.70
	Paddy	4.0	1622.80	1437.60	139.60
	Cotton	9.0	3651.30	3234.60	314.10
	Pulses	5.0	2028.50	1797.00	174.50
	Sugarcane	2.0	811.40	718.80	69.80
	Zaid Crop	2.0	811.40	718.80	69.80
	SUBTOTAL	25.0	10142.50	8985.00	872.50
TOTAL		89.0	36107.30	31986.60	3106.10

## SURVEY AND ANALYSIS

Farmers' response survey is carried out in sixteen irrigation subsystems of MBSP by designing a structured questionnaire. The objective of the survey is to assess their reaction to irrigation schedules and deliveries, their socio-economic status and constraints faced in the optimum of resources. This also helped in comparing the performances in different reaches of irrigation system based on different criteria. Index map of sixteen irrigation subsystems of MBSP are presented in Fig. 3.3. The hydraulic details, cultural command areas, number of farmers' surveyed and the villages benefited by each irrigation subsystem are shown in Table 3.5.

**Table 3.5 Details of irrigation subsystems of Mahi Bajaj Sagar Project**

(Source: MBSP Report on Status June 2002 at a Glance, 2002)

IS. No.	Irrigation Subsystem	Discharge (Cumecs)	Length (Km)	CCA (ha)	Total No. of Farmers' Interviewed	No. of Farmers' after screening	Villages covered by the irrigation subsystem
IS1	Banka	2.14	13.70	952.00	16	15	Khupda, Ganpatpura Somaliya, Puthiya
IS2	Chhich	9.76	44.22	9130.00	21	14	Bansla, Chackla, Shambupura, Talwada, Gopinath ka gara
IS3	Gopinath Ka Gara	1.85	24.00	3150.00	16	11	Jholna, Malwa, KHUWADIYA, parahera, Gopinath ka gara
IS4	Parsoliya	2.49	21.72	7855.00	19	14	Chittori, Raiyana, Ratanpura, Jhadasi, Parsoliya
IS5	Arthuna	7.98	40.80	5881.00	19	14	Bodigama, Bathaar, Nahli, Khadwal, Govindpur
IS6	Badiya	0.58	9.75	1619.00	15	12	Tehoyrm Cgudutawas
IS7	Udpura	0.82	6.12	2327.00	17	12	Udpura, Kuwania
IS8	Bhawarwad	0.68	4.23	2139.00	16	12	Amarvor, Charla, Nawai
IS9	Narwali	16.98	33.09	10722.00	24	16	Ghatol, Vadanpura Hawani, Bhemroll, Rayali, Sarodiya,
IS10	Jagpura	0.88	8.30	1312.00	14	12	Surpur, Makanpura, Amarjala, Jagpura
IS11	Karan Pur	0.76	7.05	2095.00	17	14	Sundhanim Nilariya, Moyawasa
IS12	Ganoda	0.99	6.47	1977.00	16	15	Chirrol, Ganoda, Saltiya, Kakarji Ka Para, Khudara
IS13	Loharia	0.46	12.43	1562.00	14	11	Bhuwasa, Loharia, Barsi
IS14	Badi Saderi	0.84	10.50	2302.31	18	11	Parkhelia, Baitika, Khagariya Ka Gara
IS15	Asoda	1.09	12.69	3328.00	18	11	Samagara, Paloda, Thikariya
IS16	Khodan	1.22	26.07	3944.41	20	14	Metwala, Pickora, Rohania, Agarpura, Bhankawara, Lohania
Total				60295.72	280	208	

The questionnaire is designed in such a way that all the questions were simple, direct and unambiguous. The questionnaire was prepared in Hindi for meaningful interaction with the farmers'. A large number of farmers' were requested to participate in the response survey. The response from the farmers' was very encouraging. Efforts were made to select the farmers'. Who had minimum educational qualifications and those who had enough knowledge of their respective irrigation subsystems? Care had been taken to choose farmers' from head, middies and tail reaches of each irrigation subsystem. Hypothetical examples regarding answering the questions were orally demonstrated to them. Farmers' response survey questionnaire was distributed to the farmers' of sixteen irrigation subsystems of MBSP. Opinions of 208 farmers' out of 280 interviewed were considered after screening their responses. Farmers' response survey questionnaire is translated from Hindi into English and presented in Appendix A.

The response survey questionnaire consists of five sections.

**Section 1-General Details, Location and Water source:** Details such as farmer's name, name of the village in which the irrigation subsystem is located, area and location of the field i.e., head, middle or tail end are required to be provided in this section. Information such as source of water namely, authorized off take, ruse of drains, wells or other sources if any are also to be provided.

**Section 2- cropping Intensity and yields:** crop(s) that are grown in Kharif, Rabi and others in irrigation subsystem are to be provided. Similarly, the yield status of each crop is also to be given. In the response survey questionnaire, the information can be given in the form of qualitative characteristics such as very good, average, satisfactory and unsatisfactory due to non-availability of precise numerical values.

**Section 3- Water Supply:** Information related to water supply is to be provided. Questions such as whether the amount of rainfall in the irrigation subsystem is more than average, average or less than average are posed to farmers'. Similar questions on canal water are also posed. This essential to assess distribution pattern of water with economic considerations.

**Section 4- Miscellaneous:** The posed questions are related to operation and maintenance work, formation of farmers' group at pipe/ distributor's level, critical periods of crops, awareness of the government and quality of water supplied. Similarly, farmers' were also asked whether post project era has helped them in terms of increasing agricultural production, income or more employment.

**Section 5- Assessment of performance criteria:** Queries relevant to performance criteria that are important for the formulation of the payoff matrix are posed. These are regarding change in irrigated area (as compared to pre-project era), change in wages of agricultural laborers (as compared to pre-project era), crop productivity per unit of water, crop diversification, status of land leveling and development work, supply of other inputs, status of conjunctive use of water resources, farmers'partipation, economic impact of irrigated agriculture, crop productivity and environmental conservation. The summary of the response survey questionnaire helped in understanding the various characteristics of the irrigation subsystems more effectively

Appendix B presents irrigation subsystem-wise responses of farmers' which is self-explanatory. Table 3.6 presents the summarized report of farmers' response survey. It includes 208 farmers' opinions (head, middle, tail-wise) of the sixteen irrigation subsystems of the Mahi Bajaj sagar project with reference to Appendix B Table 3.7 presents summarized report of farmers' response survey (percentage-wise)

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It is observed that 46% of the farmers' use water for irrigation from wells during peak season. It is felt that the canal water canal water cost is reasonable and the quality of water supplied is satisfactory. Farmers' are aware of the critical periods of the crops grown in the command area and are interested in

participating in the operation and maintenance of the canals.

While approximately 84% of farmers' agree that the irrigation project has benefited them in the post-project era by way of increasing agriculture production, 93% of them of increasing income and 99% of farmers' getting employment. During interactions, number of officials of the project also gave their overall opinion and information about analyze the system better.

Some of the responses which emanated from the formal and informal discussions with the farmers' and officials of mahi bajaj sagar project are:

- Farmers' felt that double cropping is essential to satisfy the increasing food demands of the region.
- Farmers' opined that whenever there are releases from the reservoir, the farmers' in head have sufficient water whereas those in tail end suffer due to lack of water.
- Farmers' at tail end felt that water remains as the main constraint but not the land. Lack of reliable water supply prevents them from planning their crops in advance with more reliability.
- Farmers' are interested in effective water user's association.
- Farmers' face minor difficulties in land development works in certain parts of command area.
- It is felt by the officials that the cropping pattern should be based on available water resources and food requirements.
- Officials opined that price of water should not depend on the crop grown per hectare (existing practice) but to be based on the quantity of water used. They also felt that the water rates are to be revised significantly to avoid the wastage of water.
- Both farmers' and officials felt that incentives are to be given to the farmer(s) who saves considerable amount of water.
- Both farmers' and officials felt that training to farmers' and officials regarding improved knowledge of irrigation system, inter-disciplinary approach to operation and management is essential for sustainable irrigation planning.

## OBJECTIVES THE STUDY

In the light of the outcome from response surveys, interviews, social and economic conditions of the farmers' and possible improvements as discussed in Chapter 1, the following objectives are formulated in two parts for modeling and planning of the MBSP command area:

## PART 1: OPTIMAL RESERVOIR OPERATION FOR IRRIGATION PLANNING

1. Formulation of irrigation planning model considering conjunctive use of surface and ground water resources with the objective of achieving maximum annual net benefits.
2. Study the applicability of four non-traditional optimization techniques, namely, Real-coded Genetic Algorithm (RGA), differential Evolution (DE), Simulated Annealing (SA) and Simulated Quenching (QS) for the irrigation planning model and assessing their potentiality in solving high dimensional problems.
3. Comparative assessment of annual net benefits, cropping pattern, release, storage and ground 3.6 presents the summarized report of farmers' response survey. It includes 208 farmers' opinions Appendix B presents irrigation subsystem-wise responses of farmers' which is self-explanatory.
4. Extensive sensitivity analysis of various parameters employed in four non-traditional optimization techniques to assess their effect on annual net benefits.

**Table 3.6 Summarized report of farmers' response survey (Head, Middle, Tail-wise)**

		Head	Middle	Tail			
Number of Farmers'		Total: 208	82	49	77		
S.N	Questions						
1.	Most of the Irrigation is taken from						
	➤ Authorized Off take	82	49	77			
	➤ Reuse of Drains	0	1	1			
	➤ Wells	41	17	38			
	➤ Others	0	1	0			
2.	Is the rainfall amount						
	➤ More then Average	0	0	1			
	➤ Average	80	44	75			
	➤ Less than Average	2	5	1			
		Yes	No	Yes	No	Yes	No
3.	Are you of opinion that canal water cost is reasonable?	82	0	48	1	76	1
4.	Are You interested to participate in O&M works?	82	0	48	0	77	0
5.	Have farmers' group been formed at the pipe/distributor level?	0	82	0	49	0	77
6.	Are you aware of the critical periods of the crops grown by you?	80	2	48	1	76	1
7.	Are you aware of the crop and input price policies of Government?	79	3	45	4	75	2
8.	Are you satisfied with the quality of water being supplied to you	81	1	49	0	77	0
9.	Would you say that irrigation project has benefited the farmers' in the project area						
	➤ By way of increasing agricultural Production	70	12	41	8	63	14
	➤ By way of increasing income	80	2	42	7	72	5
	➤ By way of getting employment	82	0	48	1	75	2



**Table 3.7 Summarized report of farmers' response survey(Percentage-wise)**

Number of Farmers'		Total:
S.N	Questions	208
1.	Most of the Irrigation is taken from	
	➤ Authorized Off take	100
	➤ Reuse of Drains	0.96
	➤ Wells	46.15
	➤ Others	0.48
2.	Is the rainfall amount	
	➤ More then Average	0.48
	➤ Average	95.67
	➤ Less than Average	3.85
		Yes No
3.	Are you of opinion that canal water cost is reasonable?	99.04 0.96
4.	Are You interested to participate in O&M works?	100 0
5.	Have farmers' group been formed at the pipe/distributor level?	0 100
6.	Are you aware of the critical periods of the crops grown by you?	98.08 1.92
7.	Are you aware of the crop and input price policies of Government?	95.67 4.33
8.	Are you satisfied with the quality of water being supplied to you	99.52 0.48
9.	Would you say that irrigation project has benefited the farmers' in the project area	
	➤ By way of increasing agricultural Production	83.65 16.35
	➤ By way of increasing income	93.27 6.35
	➤ By way of getting employment	98.56 1.44

## PART 2: PERFORMANCE EVALUATION STUDIES FOR IRRIGATION SUBSYSTEMS

5. Formulation of payoff matrix (irrigation subsystems versus performance criteria) based on farmers' responses and analyst's perception.

6. Weight age estimation of the various performance criteria by Analytic Hierarchy Process (AHP).

7. Grouping of the irrigation subsystems based on the Kohonen Artificial Neural Networks (KANN) methodology.

8. Ranking of the irrigation subsystems by different Multicriterion Decision Making (MCDM) techniques, namely,

1. Multicriterion Q-Analysis 2(MCQA-2)
2. Multi Attribute Utility Theory (MAUT)
3. Compromise Programming (CP)
9. Assessing the correlation between different MCDM techniques using Spearman Rank Correlation (SRC) technique.

The above two methodologies (Part 1,2) are validated through case study of Mahi Bajaj Sagar Project, Rajasthan, India and presented in Figs. 3.4 and 3.5.

(head, middle, tail-wise) of the sixteen irrigation subsystems of the Mahi Bajaj sagar project with reference to Appendix B Table 3.7 presents summarized report of farmers' response survey (percentage-wise)

**Fig.3.4 Methodology of the proposed work (Part 1)**

