CHAPTER – VI

IRRIGATION PLANNING AND COMMAND AREA DEVELOPMENT

6.0 General

Ken-Betwa Link Project envisages transfer of surplus water from Ken basin to Betwa basin to provide water to water short areas of upper Betwa basin by substitution, keeping the needs of the in-basin requirements of Ken basin involving both the States of UP and MP in view and ensuring equity, optimization of water use and cost effectiveness.

The Ken–Betwa link project (Phase–II) envisages construction of following five dam/ barrages to provide irrigation facilities in Betwa basin in Madhya Pradesh:

Dam

i) Lower Orr dam

Barrages

(i) Neemkheda Barrage

(ii) Barari Barrage

(iii) Kotha barrage with increased pond level i.e. 396 m

(iv) Kesari Barrage

Salient details of above structures are furnished in Table – 6.1.

Table – 6.1
Salient details of dam/barrages proposed under Ken – Betwa link project (Phase – II)

S. No.	Name of the structure	Name of the river	Bed Level (m)	FRL (m)	Submer-gence Area (ha)	Gross Storage Capacity (MCM)	District Benefitted
1	Lower Orr dam	Orr	341	380	2723	371.802	Shivpuri
2	Neemkheda barrage	Betwa	415	426	484	11.06	Raisen
3	Barari barrage	Betwa	397	407.72	597	14.02	Vidisha
4	Kotha barrage	Betwa	384	396	2210	104.60	Vidisha, Sagar & Ashoknagar
5	Kesari barrage	Keotan	395	403.9	362	10.00	Vidisha

The water availability and hydrological yield for the dam/barrages of Ken-Betwa Link (Phase-II) have been carried out by National Institute of Hydrology (NIH) Roorkee. The water availability computed at various dependability for the project as finalised by NWDA at proposed project sites is given in Table -6.2.

Table –6.2

Water availability computed by NIH, Roorkee at various dependability

S. No.	Name of the structure	Dependable flows (MCM)		
		50%	75%	90%
1	Neemkheda	440.19	328.61	257.03
2	Barari	1363.52	1078.32	785.07
3	Kotha	2061.06	1593.99	1184.90
4	Kesari	156.16	120.66	91.55
5	Lower Orr	501.15	362.53	263.98

Based on the simulation study, NIH Roorkee proposed some changes in the command area in their study. After consideration of the design features, changes in planning as per the visit of CWC design team and study of NIH, Roorkee, the command area to be served by the proposed dam and barrages is finalized and given in Table-6.3.

Table-6.3

Command area served by the proposed dam and barrages

S. No.	Name of the structure	River	Planned CCA (ha)	Annual Irrigation (in ha)
1	2	3	4	5
1	Lower Orr	Orr river	45047	67570
2	Neemkheda	Betwa river	3066	3066
3	Barari	Betwa river	4444	4444
4	Kotha	Betwa river	17357	21696
5	Kesari	Keotan river	1479	2070
Total			**71393**	**98846**

6.1 Lower Orr dam/reservoir

Lower Orr reservoir has been planned as a multipurpose reservoir with irrigation as a major benefit whereas drinking water supply and flood moderation are other incidental benefits. Planning of the reservoir has been done in such a way that 75% available yield at Lower Orr dam site will be utilized first for in-basin requirement of upper reaches of Lower Orr dam site. Accordingly, CCA of 45047 ha has been identified in Shivpuri district of Madhya Pradesh. The command area map of Lower Orr dam is given in Figure 6.1.

6.1.1 Lower Orr Dam: Salient Features

Location of Dam	
District	Ashok Nagar/Shivpuri
River/River Basin	Orr/Betwa (Yamuna)
Name of nearest Village	Didauni
Latitude	$24^0$50'50" N
Longitude	$78^0$05'55" E
Topo sheet No.	54 L/1
Dam	
Type of dam	Composite (Concrete cum Earthen)
Canal System	
Length of main canal and feeder canal	91.26 km long main canal
Drinking Water Supply	6 MCM to the ennrute village /town

The FRL, MWL and MDDL of the dam has been proposed as 380.0 m, 380.408 m and 360.50 m respectively with top dam level as 384.0 m. The Gross storage proposed is 371.802 MCM and area under submergence at FRL is 2723.70 ha.

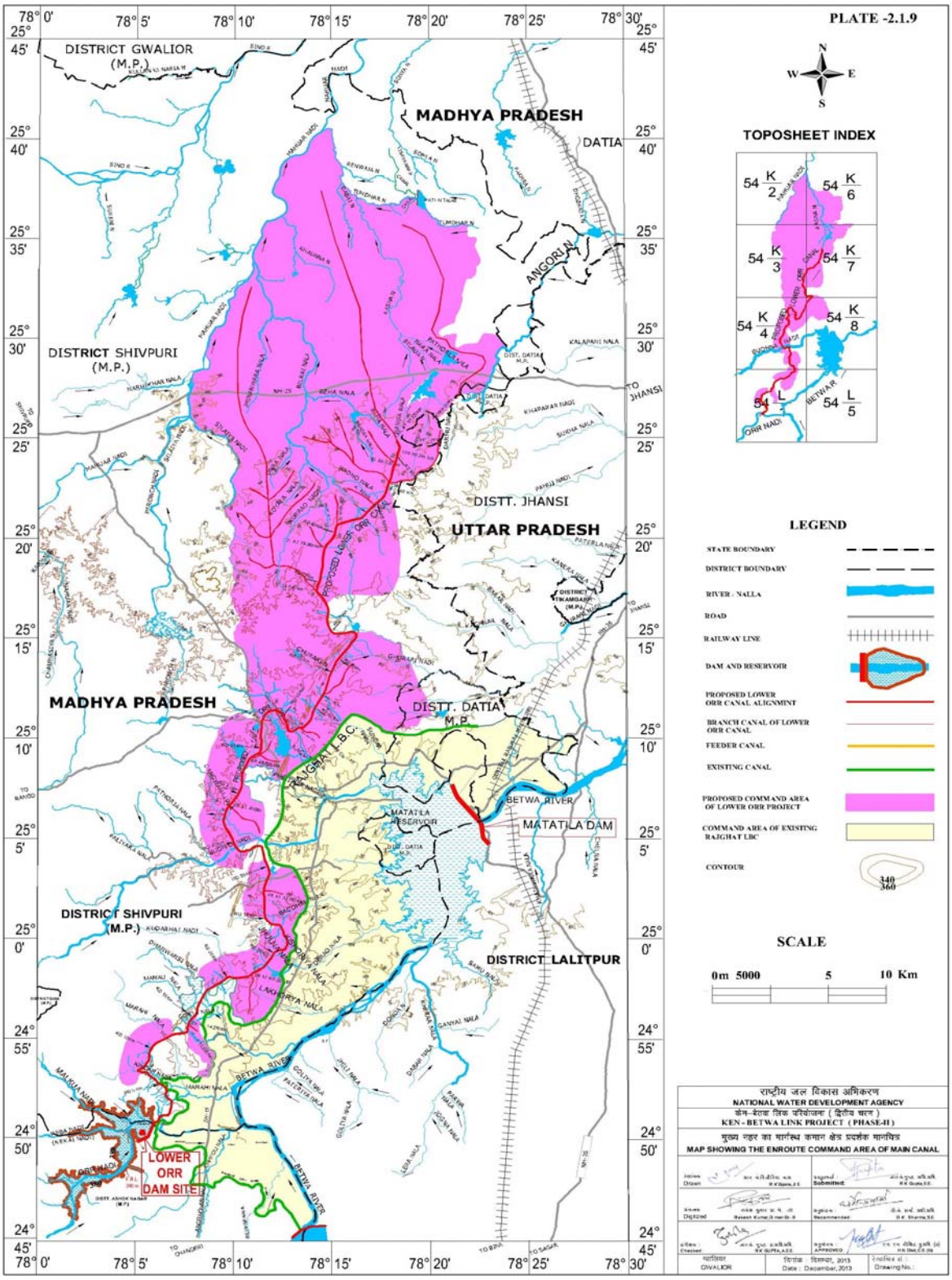

Figure 6.1: COMMAND AREA MAP – LOWER ORR Reservoir

6.1.2 Existing /proposed irrigation facilities

The command area of Lower Orr reservoir has been identified in Shivpuri district of Madhya Pradesh. The existing irrigation facilities in the identified command is mainly through tanks, wells and other sources. The geographical area of Shivpuri district is 1027700 ha out of which 562600 ha area is gross cropped area. An area of 266416 ha is under irrigation from various sources i.e. Canal, Tanks, Wells and Other sources, which is 47.35 % of gross cropped area. Sourcewise irrigation for the year of 2011-12 is furnished at Table 6.4.

Table 6.4
Source wise irrigation of Shivpuri district of Madhya Pradesh for the year 2011-12

S. No.	Source	Gross area irrigated (ha)	Net area irrigated (ha)
1.	Canals	51818	46469
2.	Tanks	11411	11373
3.	Tube Wells	67423	66066
4.	Ordinary Wells	114949	112837
5.	Other sources	20815	19305
	Total	**266416**	**256050**

6.1.3 Land use details of the Shivpuri district

The command area of Lower Orr Project lies in the Shivpuri District of Madhya Pradesh. The Land use deatils of Shivpuri district are furnished in Table 6.5.

Table - 6.5
Land use details of the Shivpuri district for the year 2008-09 (maximum of five years from 2007-08 to 2011-12)

S. No.	Details	Area in 'ha'	% of Geogra-phical area
1	Forest	362406	35.26
2	Area under non-agricultural use	60595	5.90
3	Barren and unculturable land	38097	3.71

S. No.	Details	Area in 'ha'	% of Geogra-phical area
4	Permanent pastures and other grazing land	26229	2.55
5	Land under miscellaneous crop trees & groves	3899	0.38
6	Culturable waste land	72810	7.08
7	Other fallows	30212	2.94
8	Current fallows	20359	1.98
9	Net area sown	413093	40.20
10	Area sown more than once	131911	12.84
11	Total cropped area	545004	53.03
12	**Culturable area**	**540373**	**52.58**
13	**Total Geographical area**	**1027700**	**100.00**

6.1.4 Lower Orr Command

6.1.4.1 Location and classification of land in the command area

The command area of Lower Orr canal is spread in Shivpuri district of MP. The geographical area of Shivpuri district is 1027700 ha, as per land use statistics of the year 2008-09 (maximum of five years from 2007-08 to 2011-12), culturable area in the district is 540373 ha which is 52.58% of geographical area of the district. The details of the command area are furnished in Table-6.6. Command area map is appended as Plate 2.1.9 in Volume-V (Part - 1).

Table - 6.6
Details of GCA, CCA of Lower Orr Project

S. No.	Types of irrigation	Gross Command area (ha)	Culturable Command area (ha)
A	Irrigation by traditional method through Lower Orr canal system	64050	33678
B	Enroute lifting of water by local people in Shivpuri district	4488	2360
C	Pressurized irrigation	17134	9009
		85672	**45047**

6.1.4.2 Existing cropping pattern

Details of cropping pattern generally adopted in Shivpuri district are given in Table-6.7. The important crops grown in the command area of proposed Lower Orr project are Wheat, Soyabeen, Maize, Gram, Groundnut and Pulses, etc.

Table - 6.7
Existing Cropping pattern of Shivpuri district for year 2011-12

S. No.	Name of crops	Percentage
A	**Kharif**	
1	Paddy	1.4
2	Jowar	0.2
3	Maize	3.5
4	Bajra	1.5
5	Other pulses	3.2
6	Soyabean	24.6
7	Ground nut	15.3
8	Vegetable	0.9
9	Til (Sesamum)	2.0
	Total	**52.5**
B	**Rabi**	
1	Wheat	28.8
2	Barley	0.2
3	Gram	7.7
4	Mustard	5.9
5	Other pulses	1.0
6	Tur	0.2
7	Fodder crops	3.4
8	Vegetable	0.1
	Total	**47.3**
C	**Perennial**	
1	Sugarcane	0.2
	Total	**100.0**

6.1.5 Soil surveys

6.1.5.1 Soil capability classification

The land capability classification of Lower Orr Command in Shivpuri district is furnished in Annexure: 6.1.1 of Volume – II.

6.1.5.2 Land irrigability classification

The land irrigability classification of Lower Orr Command in Shivpuri district furnished in Annexure: 6.1.2 of Volume – II.

6.1.6 Proposed cropping pattern in the command of reservoir

The proposed cropping pattern in the command of project has been approved for Shivpuri District by Agriculture department of Madhya Pradesh and considered in the study. Proposed cropping pattern for traditional irrigation and pressurized irrigation are given at Annexure 6.1.3 and 6.1.4 of Volume – II respectively and given in Table-6.8 below:

Table - 6.8
Proposed cropping pattern in the command of Lower Orr reservoir

S. No.	Crop	For traditional irrigation		For pressurized irrigation	
		%Area	Area (in ha)	%Area	Area (in Ha)
	Kharif				
1	Paddy	1	360		0
2	Jowar/Bajara	5	1802		0
3	Fodder	5	1802	6	541
4	Maize	5	1802		0
5	Pulses	20	7207	25	2252
6	Oilseed	10	3604	13	1171
7	Soyabeen	19	6847	7	631
8	Vegetable	4	1441	5	450
9	Other crops/spices	1	360	2	180
	Sub-Total	**70**	**25226**	**58**	**5225**

S. No.	Crop	For traditional irrigation		For pressurized irrigation	
		%Area	Area (in ha)	%Area	Area (in Ha)
	Rabi				0
10	Wheat	60	21622	75	6757
11	Gram	15	5406	15	1351
12	Other /vegetable	2	721	2	180
	Sub-Total	**77**	**27748**	**92**	**8288**
	Perennial				0
13	Sugarcane	3	1081		0
Total		**150**	**54055**	**150**	**13513**
Grand Total		**67568 ha say 67570 ha**			

6.1.6.1 Cropping pattern & Crop calendar proposed for the Lower Orr reservoir.

Cropping pattern & Crop calendar proposed for the Lower Orr reservoir is furnished in Table-6.9.

Table - 6.9
Cropping pattern & crop calendar proposed for the Lower Orr reservoir

Gross Command Area = 67570 ha
Culturable Command Area= 45047 ha

	S. No.	Name of the crop	% age of Annual irrigation		Area (ha)	Period		Dura-tion (days)
			Tradi-tional irriga-tion	Press-urised Irriga-tion				
Kharif	1	Paddy	1		360	10th June	10th Oct	123
	2	Jowar	5		1802	1st June	30th Sep	122
	3	Maize	5		1802	1st June	30th Sep	122
	4	Other pulses	20	25	9460	16th June	10th Oct	117
	5	Soyabean	19	7	7478	1st June	15th Oct	137
	6	Other oilseed	10	13	4775	1st June	15th Oct	137

	7	Vegetable	4	5	1892	1st June	15th Oct	137
	8	Other crops/ Spices	1	2	540	-	-	-
	9	Other kharif (Fodder)	5	6	2342	1st June	30th Sep	
		Total			**30451**			
Rabi	1	Wheat	60	75	28380	1st Nov	31st Mar	151
	2	Gram	15	15	6757	1st Nov	15th Mar	135
	3	Vegetable	2	2	901	1st Oct	31st Jan	130
		Total	**77**	**92**	**36038**			
	C	**Perennial**						
	1	Sugarcane	3	0	1081	16th Mar	31st Jan	322
		Grand Total	**150**	**150**	**67570**			

6.1.7 Crop water requirement

The crop water requirements for the Lower Orr command (CCA 45047 ha) has been computed by Modified Penman Method as per the methodology given in the Technical Series-II, a publication of the erstwhile Ministry of Irrigation. The irrigation demand for Lower Orr command works out as 329.812 MCM.

6.1.7.1 Reference Potential Evapo-transpiration (ETo)

A copy of the Scientific Report No. 136 (February 1971) has been obtained from IMD regarding Potential Evapo-transpiration over India. The Reference Evapo-transpiration (ETo) values in mm for Jhansi IMD station of Uttar Pradesh as given in Table-6.10 have been considered in the crop water requirement computation:

Table-6.10
Evapo-transpiration (ETo) values in mm for Jhansi IMD station

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
ETo in mm	63.5	84.9	138.3	172.3	215.1	201.1	136.5	116.3	127	122.8	79.1	58.6	1516

6.1.7.2 Crop Coefficients

Crop coefficients for various crops have been considered as per table 27 of Technical Series-II, a publication of erstwhile Ministry of Irrigation.

6.1.7.3 Pre-sowing & Transplantation Water Demands

Pre-sowing water demands for various crops has been considered as 65 mm. The transplantation water demands for crop of paddy have been considered as 150 mm.

6.1.7.4 Effective Rainfall

Annual rainfall in the command area is 895.5 mm. The effective rainfall component in the crop water requirement has been computed as per the Table 10 of Technical Series-II, a publication of erstwhile Ministry of Irrigation.

Month	Jan	Feb	Ma	Apr	May	Jun
Average Rainfall	16.4	8.5	4.5	3.1	9.2	85.4

Month	Jul	Aug	Sep	Oct	Nov	Dec	Total
Average Rainfall	301	292.5	162	28.3	8.5	6.1	925.5

6.1.7.5 Irrigation Efficiency

The water application efficiency has been considered as 65% for normal ID crops and 85% for crop of paddy. For crop under micro-irrigation system, the field application efficiency has been considered as 85%. Conveyance efficiency has been considered as 75% for proposed lined canal system in the project.

6.1.7.6 Irrigation Demand for Lower Orr command

Crop water requirement computations for crops has been done as per modified penman method and details are given in Annexure 6.1.5 of Volume – II. Monthwise irrigation water demand as computed by Irrigation Management Organisation, CWC for Lower Orr command are given in Table-6.11.

Table-6.11
Monthwise irrigation water demand for Lower Orr command
Unit MCM

Month	Drinking Water Demand	Irrigation Demand (for traditional irrigation)	Irrigation Demand (for pressurize irrigation)	Total irrigation demand
Jun	0.5	31.78	5.18	36.97
Jul	0.5	10.36	1.56	11.91
Aug	0.5	11.27	1.71	12.98
Sep	0.5	29.66	3.84	33.50
Oct	0.5	30.97	2.03	33.01
Nov	0.5	26.24	9.74	35.98
Dec	0.5	24.09	4.85	28.94
Jan	0.5	30.92	6.72	37.63
Feb	0.5	37.90	9.73	47.62
Mar	0.5	20.24	6.56	26.80
Apr	0.5	2.70	0.00	2.70
May	0.5	19.90	1.73	21.63
Total	**6.00**	**276.03**	**53.64**	**329.67**

6.1.8 Environmental flow at Lower Orr dam

For the proposed Lower Orr dam under Ken-Betwa Link project (Phase-II) in the Lower Betwa basin, the environmental flows have been computed from the estimated monthly flow pattern in the project sub-basin. For the monsoon months from June to October, 75% dependable flows have been computed on monthly basis and 20% of the 75% dependable flows in each monsoon month have been reserved for environmental and ecological purposes. However, for the non-monsoon months, average monthly flows have been worked out and 15% of the average monthly flows in different non-monsoon months have been reserved for environmental and ecological purposes. About 44.898 MCM of water is assessed for environmental and ecological purposes. Month wise environmental flow demand at Lower Orr is given in Table-6.12.

Table-6.12
Monthwise environmental flow demand at Lower Orr Dam

Month	Environmental Flow (MCM)
Jun	0.449
Jul	0.635
Aug	0.260
Sep	0.026
Oct	0.001
Nov	0.000
Dec	6.422
Jan	24.180
Feb	9.633
Mar	1.157
Apr	1.179
May	0.956
Total	**44.898**

6.1.9 Simulation study of Lower Orr command

The Lower Orr project has FRL of 380 m and MDDL has been kept as 360.50 m. While carrying out the simulation study by Irrigation Planning (South), Directorate of CWC, Irrigation demand of 329.67 MCM, domestic water supply demand of 6 MCM and environmental flow requirements of 44.898 MCM have been considered. The monthly evaporation estimates of Guna meteorological station have been used.

The net yield series for Lower Orr Dam site have been developed by NIH, Roorkee from Year 1901-02 to 2008-09. For assessing the success of the project in meeting the projected water demands, the working tables for period of 50 years are considered sufficient. Working tables for Lower Orr dam have been prepared for 55 years (1954-55 to 2008-09) and the success rate of the project in meeting the irrigation demands is 75%. The results of simulations / working tables are tabulated in Table-6.13.

Table-6.13

The results of simulations / working tables of Lower Orr Dam

S. No.	Year			inflow	Irrigation Demand Met	S/F	Drinking Demand Met	S/F	Evaporation	Spills
1	1954	-	1955	486.979	329.673	S	6.00	S	34.584	47.297
2	1955	-	1956	661.213	329.673	S	6.00	S	37.489	229.406
3	1956	-	1957	633.044	329.673	S	6.00	S	38.358	223.394
4	1957	-	1958	387.992	329.673	S	6.00	S	35.059	2.963
5	1958	-	1959	622.107	329.673	S	6.00	S	37.822	165.191
6	1959	-	1960	724.233	329.673	S	6.00	S	37.584	319.240
7	1960	-	1961	440.665	329.673	S	6.00	S	36.356	30.545
8	1961	-	1962	953.522	329.673	S	6.00	S	38.515	499.112
9	1962	-	1963	548.538	329.673	S	6.00	S	36.919	174.414
10	1963	-	1964	524.86	329.673	S	6.00	S	35.601	112.837
11	1964	-	1965	745.95	329.673	S	6.00	S	36.228	319.503
12	1965	-	1966	263.981	164.354	F	6.00	S	31.212	0.000
13	1966	-	1967	361.424	329.673	S	6.00	S	35.238	37.904
14	1967	-	1968	739.536	329.673	S	6.00	S	36.037	278.952
15	1968	-	1969	582.947	329.673	S	6.00	S	36.084	195.206
16	1969	-	1970	950.798	329.673	S	6.00	S	37.175	512.011
17	1970	-	1971	542.149	329.673	S	6.00	S	35.848	132.935
18	1971	-	1972	835.568	329.673	S	6.00	S	38.908	393.363
19	1972	-	1973	530.965	329.673	S	6.00	S	36.051	146.446
20	1973	-	1974	763.613	329.673	S	6.00	S	36.599	340.659
21	1974	-	1975	547.365	329.673	S	6.00	S	37.093	115.418
22	1975	-	1976	737.559	329.673	S	6.00	S	38.62	303.501
23	1976	-	1977	185.637	164.354	F	6.00	S	28.293	0.000
24	1977	-	1978	349.363	329.673	S	6.00	S	31.218	0.000
25	1978	-	1979	491.385	329.673	S	6.00	S	34.118	52.351
26	1979	-	1980	29.261	74.797	F	2.00	F	16.503	0.000
27	1980	-	1981	290.987	135.299	F	6.00	S	28.814	0.000
28	1981	-	1982	370.125	329.673	S	6.00	S	35.853	13.930
29	1982	-	1983	668.782	329.673	S	6.00	S	34.967	241.571
30	1983	-	1984	871.283	329.673	S	6.00	S	37.846	411.475
31	1984	-	1985	355.222	329.673	S	6.00	S	35.278	0.000
32	1985	-	1986	845.332	329.673	S	6.00	S	37.061	378.303
33	1986	-	1987	259.206	278.544	F	6.00	S	30.919	0.000
34	1987	-	1988	902.259	329.673	S	6.00	S	37.7	422.747
35	1988	-	1989	280.152	329.673	S	6.00	S	30.575	0.000
36	1989	-	1990	322.782	261.215	F	4.50	F	24.722	0.000
37	1990	-	1991	591.112	304.273	F	6.00	S	34.717	123.649

S. No.	Year			inflow	Irrigation Demand Met	S/F	Drinking Demand Met	S/F	Evaporation	Spills
38	1991	-	1992	502.695	329.673	S	6.00	S	33.178	149.408
39	1992	-	1993	416.722	314.280	F	6.00	S	32.329	0.000
40	1993	-	1994	779.071	318.497	F	6.00	S	35.219	321.701
41	1994	-	1995	558.841	329.673	S	6.00	S	36.188	197.188
42	1995	-	1996	738.552	329.673	S	6.00	S	35.967	289.553
43	1996	-	1997	705.286	329.673	S	6.00	S	36.598	293.440
44	1997	-	1998	581.199	329.673	S	6.00	S	37.128	144.253
45	1998	-	1999	316.153	326.854	F	6.00	S	29.086	0.000
46	1999	-	2000	715.313	292.707	F	5.50	F	35.179	241.833
47	2000	-	2001	498.219	329.673	S	6.00	S	36.84	123.737
48	2001	-	2002	437.922	329.673	S	6.00	S	35.417	19.741
49	2002	-	2003	351.51	327.453	F	6.00	S	29.024	0.000
50	2003	-	2004	684.82	293.872	F	6.00	S	34.797	219.970
51	2004	-	2005	449.515	329.673	S	6.00	S	35.961	59.411
52	2005	-	2006	447.243	329.673	S	6.00	S	35.843	34.672
53	2006	-	2007	528.42	329.673	S	6.00	S	35.457	109.203
54	2007	-	2008	291.339	282.375	F	5.00	F	24.263	0.000
55	2008	-	2009	403.35	329.673	S	6.00	S	28.733	0.000

* S: Success F: Failure

6.1.10 Water Planning

As per simulation study of Lower Orr reservoir, about 335.67 MCM of water can be utilized in to Lower Orr Left bank canal from Lower Orr reservoir after meeting the upstream demand and releasing about 44.898 MCM water for environmental and ecological purposes. The evaporation losses for the reservoir have already been considered in the simulation study. Provision of 6 MCM (@ 0.5 MCM per month) of water is kept for drinking purpose in the enroute villages/towns. Therefore, remaining 329.67 MCM of water is available for irrigation and using 0.5106 m Delta for traditional irrigation system and 0.397 m Delta for pressurized irrigation system, about 67570 ha (45047 CCA) can be irrigated from the Lower Orr dam. Out of which, about 33677 ha CCA (50516 ha annual irrigation) using 257.96 MCM of water is proposed to be irrigated in the command by traditional irrigation. Besides above, about 2950 ha CCA (4425 ha annual irrigation) will be covered in the vicinity of the Lower Orr main canal in the

initial reaches of 50 km length through pumping by the local people. Out of which 2360 ha CCA (3540 ha annual irrigation) will be covered by traditional irrigation using 18.08 MCM of water. Provision of 53.64 MCM water has been kept for pressurized irrigation in the Shivpuri district for irrigating about 9009 ha (13514 ha annual irrigation) which is about 20% of total CCA of 45047 ha.

6.1.11 Introduction of Pressurized Irrigation System in the command area

The pressurized irrigation, which is also known as micro irrigation, consists of drip and sprinkler irrigation systems. One of the demand management strategies introduced recently to control water consumption in Indian agriculture is pressurized irrigation or micro-irrigation. Under micro-irrigation, unlike flood methods of irrigation, water is supplied at a required interval and quantity using pipe network, emitters and nozzles. Therefore, the conveyance and distribution losses are reduced completely which results in higher water use efficiency under micro-irrigation. Incidentally the micro-irrigation also effectively controls the problem of water logging and salinity in the command area of an irrigation project. In view of the above cited advantage of micro-irrigation over flood irrigation method the Government of India is promoting micro-irrigation in the command area of major and medium irrigation projects. So it is proposed to provide pressurized irrigation system in 20% area of command of this project as a pilot scheme. Accordingly 9009 ha area (about 20% of 45047 ha CCA) is proposed under Lower Orr Project under pressurized irrigation. Main crops namely Maize, Jowar, Fodder, Pulses, Groundnut/Oilseed and Vegetables are in Kharif season, Wheat, Gram, Vegetables and sunflower/oilseed are suggested in Rabi season and Sugarcane as perennial crop are suggested through channel irrigation in the proposed command area in Shivpuri district of Madhya Pradesh. The sprinkler irrigation system can be introduced for these crops except for Jowar and Sugarcane. Drip irrigation is suitable for horticulture crops such as Commercial crops, Vegetables, tuber crops, Leafy vegetables, Fruits, Spices & Condiments, and Medicinal Plants. Since, drip irrigation is not familiar in the area, few patches may be added for drip irrigation as a model.

Beside above crops, suggested under canal irrigation, some, commercial crops and fruits etc. may be introduced in the area proposed under pressurized irrigation. About 40% and 70% water will be saved by sprinkler irrigation and drip irrigation system respectively. Therefore, cropping pattern suggested in consultation with the Agriculture Department of MP (Krasi Vigyan Kendra) for 9009 ha of command is proposed under pressurized irrigation.

6.1.12 Designed head discharge of canal system

The capacity at the canal head of Lower Orr Left bank canal is 31.80 cumecs. A provision of 10% irrigation demand has been made towards rush irrigation demand in canal capacity.

6.1.13 Details of distributary wise command area of Lower Orr Project

Nineteen (19) distributary/minors are proposed along the Lower Orr Left bank canal for releasing waters to the command area from the canal. Distributary wise command areas of Lower Orr project are furnished in Annexure 6.1.6 of Volume – II.

6.1.14 Ground water

6.1.14.1 Conjunctive use/ground water support

The National Water Policy 2012 recognized the need for conjunctive use and recommended that the conjunctive use of surface and ground water should be ensured from project planning stage and should form an essential part of the irrigation project. This will ensure optimum utilization of water resources in the command area and permits flexibility of system operation. With the increasing irrigation intensity and tendency on the part of the farmers to over supply irrigation from surface water, the problem of water logging and salinity is growing in the irrigated commands. The conjunctive use of surface and ground water is planned to mitigate the effects of deficits of canal water supplies, increase dependability of existing water availability, alleviate problems of rising water levels, soil salinity, minimize damages due to drought and increase agricultural productivity.

Conjunctive use of surface and groundwater may be planned as sufficient balance replenishable groundwater is available in the command area.

Ground water resources for the Shivpuri district of Lower Orr command has been assessed as per guideline adopted by Central Ground Water Board are given in Annexure 6.1.7 of Volume – II. In the present planning, use of ground water is not proposed in any of the command. However, the available ground water resource can be utilized in future for further intensification or augmentation of the irrigation facilities in various commands, particularly to meet the irrigation requirement during lean season.

6.1.15 Command Area Development

6.1.15.1 Details of Lower Orr command

(i) Location

The command area of Lower Orr reservoir lies in the Khaniyadana, Pichhore and Karera tehsils of Shivpuri district of Madhya Pradesh. The CCA under this project is 45047 ha.

6.1.15.2 Classification of land (forest, grass land, cultivable and, cultivable waste, barren land)

The classification of land in the command area is furnished in Table-6.14.

Table - 6.14

Land use deatils of Lower Orr command for the Year 2008-09 (maximum of five years from 2007-08 to 2011-12)

S. No.	Details	Area (ha)	% of GCA
1	Forest	30210	35.26
2	Area under non-agricultural use	5051	5.90
3	Barren and unculturable land	3176	3.71
4	Permanent pastures and other grazing land	2187	2.55
5	Land under miscellaneous crop trees & groves	325	0.38
6	Culturable waste land	6070	7.08

S. No.	Detrails	Area (ha)	% of GCA
7	Other fallows	2519	2.94
8	Current fallows	1697	1.98
9	Net area sown	34437	40.20
10	Area sown more than once	10996	12.84
11	Total cropped area	45433	53.03
12	**Culturable area**	**45047**	**52.58**
13	**Total Geographical area**	**85672**	**100.00**

6.1.15.3 Size of land holding

The size of land holding and area in Shivpuri district which falls in the Lower Orr reservoir command area during the year 2005-06 is given in **Table-6.15.**

Table - 6.15

Size of land holding in Shivpuri district of Lower Orr reservoir command

Description	Land holding	
	No.	Area
Marginal farmers less than 1 ha	93000	50800
Small farmers more than 1 ha less than 2 ha	69303	96834
Below medium farmers 2-4 ha	49165	134680
Medium farmers 4-9.99 ha	23751	136467
Big farmer 10 to 20 ha	3502	55652
Total	**238721**	**474433**

6.1.16 Climate of the command area

(a) Rainfall: The command area receives most of its rainfall during the monsoon from July to September from the southwest monsoon. The maximum and minimum rainfall of Jhansi IMD station is 1495.80 mm to 314.7 mm respectively.

(b) Temperature: The climate of the area is characterized by a hot summer and a mild winter. The climate is hot during summer with the temperature of Jhansi IMD station as high as 45.4 ^{0}C and lowest is 3.8 ^{0}C.

(c) Relative humidity: The mean monthly relative humidity observed at Jhansi IMD observatory, which is close to the command area varies between 76% to 18%.

(d) Wind velocity: The monthly mean wind velocity observed at Jhansi IMD observatory varies between 2.8 km/hr to 6.7 km/hr.

6.1.17 Irrigation

(a) Present sources of irrigation in the command

The present sources of irrigation in the proposed command area are mainly through age-old tanks and ponds, which collect the rainwater during the monsoon season. Besides these, privately owned open wells and tube wells also provide water for irrigation to very small areas.

(b) Methods of irrigation followed

At present, the conventional method of applying water through minor irrigation channels, distributaries and water courses is being followed in this area. However, sometimes electric/diesel pump sets are also used to lift water from the wells.

(c) Status of land development for irrigated area

(i) Condition of channels

The condition of existing irrigation channels in the command area is generally satisfactory except in some reaches where proper maintenance is required. Most of the channels are unlined, hence susceptible to loss of water through seepage.

(ii) Longitudinal slope of field

The slopes in agricultural fields where irrigation channels are located, are adequate and irrigation water reaches almost every nook and corner of the field.

(iii) Status of field channels

Field channels constructed by farmers for irrigating land by pumping river water are found to be existing in some areas.

6.1.18 Socio-economic aspects

Govt. of Madhya Pradesh has carried out the Socio-economic aspects study for the Lower Orr reservoir through Hamidia College, Bhopal. The details of socio-economic aspects are furnished in **Table-6.16.**

Table - 6.16
Socio-economic aspects in the Lower Orr reservoir command

S. No	Description	Shivpuri
1	Population density per sq.km.	171
2	Sex ratio (females per 1000 male)	877
3	SC	18.78 %
4	ST	11.19 %
5	Literacy rate	62.55%

6.1.19 Infrastructure facilities

(a) Roads and railways

Shivpuri district headquarters is well connected by rail and roads. However, the roads in rural areas are generally kachcha roads.

(b) Marketing facilities

Most of the villages in the command are dependent on the marketing facilities available in Shivpuri, Jhansi and Gwalior district headquarters.

(c) Agro-industries

No major agro-based industries are available within the command. However few oil mills and flour mills are located in the command which cater the needs of common people.

(d) Banks/credit societies etc.

Nationalized Banks exist at district & tehsil head quarters. However, few Gramin Banks are also functioning in rural areas.

6.1.20 Topography and soils

(i) Topography

Isolated hill tops, valleys, forests and streams are dominating in the area. Coarse grained formations are predominantly found in the command area.

(ii) Land slopes

The slopes of the land in the command area are moderate and in few places, it is steep.

(iii) Soils

Based on the information provided by National Bureau of Soil Survey and Land Use Planning (ICAR), Nagpur, the soils in the Lower Orr command area in Shivpuri district can be broadly classified into ten categories. Details are furnished below:

1. Moderately deep, well drained, calcareous, clayey soils on gently sloping undulating plateau with severe erosion, associated with: Shallow, somewhat excessively drained, loamy-skeletal soils on gently sloping with severe erosion and slightly stony.

2. Very shallow, well drained, loamy soils on moderately sloping residual hills with isolated hillocks with severe erosion, associated with: Shallow, well drained loamy soils on gently sloping with severe erosion and slightly stony.

3. Very shallow, somewhat excessively drained, loamy soils on moderately sloping residual hills with dykes with severe erosion and strongly stony, associated with: Shallow, somewhat excessively drained, loamy soils on moderately steep sloping with severe erosion and moderately stony

4. Slightly deep, well drained loamy soils on gently sloping undulating upland with mounds with moderate erosion, associated with:

Shallow, somewhat excessively drained, loamy soils on gently sloping with severe erosion

5. Very shallow, well drained, loamy soils on gently sloping undulating upland (slightly dissected) with severe erosion, associated with: Moderately deep, well drained, clayey soils on very gently sloping with moderate erosion.

6. Shallow, well drained, loamy soils on gently sloping undulating upland with valleys with moderate erosion associated with: Moderately deep, well drained, sandy soils on gently sloping with severe erosion and slightly stony.

7. Shallow, well drained, loamy soils on gently sloping undulating upland with valleys with moderate erosion associated with: Very shallow, well drained, loamy soils on moderately sloping with severe erosion.

8. Slightly deep, well drained loamy soils on gently sloping plain land with moderate erosion, associated with: Moderately deep, somewhat excessively drained, sandy soils on moderately sloping with severe erosion.

9. Slightly deep, well drained, loamy soils on gently sloping plain land (slightly dissected) with severe erosion, associated with: Moderately deep, well drained, loamy soils on very gently sloping with moderate erosion.

10. Deep, well drained, calcareous clayey soils on moderately sloping Flood plain (moderately dissected) with severe erosion, associated with: Deep, well drained, calcareous loamy soils on moderately steep sloping with very severe erosion.

6.1.21 Drainage

The command area has good surface drainage and sub-surface drainage. The water holding capacity being low to medium is expected in clay patches. With the network of a number of tributaries namely Newman, Sagar, Bah, Keotan etc., the command area has quite good draining facilities.

6.1.22 Agriculture

The classification of lands and the present land use has already been discussed in the chapter. Land use will change due to increase in cultivated area and increase in developmental activities due to this project.

6.1.23 Farmers' attitude towards improved agricultural practices

The farmers' attitude towards improved agricultural practices is positive. However, due to non-availability of water even from the existing tanks, they find it difficult to carry out cultivation in the entire area.

(i) Use of improved implements and seeds

The use of bullock power for ploughing of land is common in the area of proposed command. The use of tractor is also done in these areas but the percentage is very low. Likewise, the use of traditional types of implements is also very common among majority of the farmers.

(ii) Use of fertilizers, insecticides, pesticides, etc.

Although about 25% of the farmers use fertilizers and manures for increasing the yield, very few of them are particular about use of insecticides/pesticides for control of plant diseases.

(iii) Extension services

Occasional extension services are provided by the State Agriculture Department to educate the farmers about the use of improved and modern agriculture technology and cultivation of high value crops viz. Groundnut, Soyabean, Sunflower, Chillies etc. But due to various reasons including inadequate financial resources, the extension services are yet to become popular among the farmers of proposed command area.

6.1.24 Identification of problems in command area

(i) Land slopes: The land is generally undulating; therefore, canal distribution system has to be aligned accordingly.

(ii) Soil depth: There should be no problem on this account, as sufficient soil depth is available in the area for providing canal irrigation.

(iii) Salinity/Alkalinity: Since the Lower Orr river water is proposed to be used for irrigation in these areas, which does not have

salinity problem, it need not be a cause of concern. However, slight alkaline nature of the soils of the region is considered rather suitable for crops like Jowar, Soyabean, Wheat and Moong.

In general, the soils in these areas are stable and not prone to erosion. However, in certain area, the soils may be prone to erosion due to their coarse texture. Such soils can be stabilized by putting them under permanent pastures and grazing lands.

(iv) Water logging: No water-logging problem of serious nature has been reported from the area.

(v) Drainage: Looking the general condition and topography of the command special care should be taken for construction of field channels and drainage, which can be managed by the Agricultural Department at farmer's cost or loans from the various land development banks.

6.1.25 Financial problems

There are number of wells and tanks in the area but due to less recharge in the area, these wells and tank either have less water or no water during lean season. Farmers should be provided fund assistance for renovation of these tanks and wells for better irrigation.

6.1.26 Proposed cropping pattern, with justification based on land irrigability classification, agro climatic conditions developed irrigated cropping pattern in adjoining project/area etc.

Proposed cropping pattern of Lower Orr command has been suggested by Agriculture Department, Govt. of Madhya Pradesh on the basis of Land irrigation and capability classification of the area and crops grown presently in the surrounding of the command of Lower Orr Project.

6.1.27 Land development work proposals

A provision of Rs. 1126 lakh has been kept in the estimate for land development works. At the time of implementation of the project, detailed survey of each command will be done and based on the requirement land development works will be taken up. This work will be done by State

Irrigation Department or State Agriculture Department or Command Area Development Authority (to be decided by State Government).

At present fairly good extension services exist in the command area and number of commercial banks and co-operative banks have their branches there. Branches of land development banks are also located in some rural areas of the command. Moreover, the agricultural materials like seeds, fertilizers, insecticide, pesticides etc. are provided to the farmers by the concerned government department at subsidized rates through different sale booths or fair price shops. However, due to numerous reasons, especially inadequacy of financial resources, extension services have not yet become very popular.

6.1.28 Ayacut roads

Suitable provision of CD structures will be made to avoid traffic disruptions through Ayacut roads.

6.1.29 Benefits

(i) Crop wise increase in yield per ha and total estimated output from the command

The per hectare yield of various crops in the Shivpuri district is suggested by the Agriculture department of Govt. of Madhya Pradesh. The same is given at Annexure 6.1.8 of Volume – II. The crop wise yield in pre & post project scenarios are given in Table-6.17.

Table - 6.17

Cropwise yield under pre and post project scenarios

S. No.	Name of crop	Pre project scenario			Post project scenario		
		Area (ha)	Yield Qtls / ha	Gross yield in Qtls	Area of (ha)	Yield Qtls / ha	Gross yield in Qtls
A	**Kharif**						
1	Paddy	631	15	9465	360	50	18000
2	Jowar	90	12	1080	1802	35	63070
3	Maize	1532	14	21448	1802	40	72080
4	Bajra	676	0	0	0	0	0
5	Other pulses	1441	5	7205	9460	15	141900

6	Soyabean	11081	8	88648	7478	23	171994
7	Ground nut	6892	10	68920	4775	22	105050
8	Vegetable	406	30	12180	1892	50	94600
9	Til (Sesamum)	901	4	3604	0	9	0
10	Other crops/spices	0	4	0	540	9	4860
11	Other kharif (Fodder)	0	200	0	2342	500	1171000
	Total	**23650**			**30451**	0	**1842554**
B	**Rabi**						
1	Wheat	12973	15	194595	28380	40	1135200
2	Barley	90	9	810	0	19	0
3	Gram	3469	8	27752	6757	20	135140
4	Mustard	2658	6	15948	0	16	0
5	Other pulses	450	5	2250	0	12	0
6	Tur	90	5	450	0	20	0
7	Fodder crops	1532	200	306400	0	400	0
8	Vegetable	45	30	1350	901	50	45050
	Total	**21307**			**36038**		**1315390**
C	**Perennial**						
1	Sugarcane	90	200	18000	1081	500	540500
	Total	**45047**			**67570**		**3698444**

(i) Estimated cost of increased production

The yield in pre and post project scenarios has been assessed in Table-6.17. Based on the increased production, cost of increased production has been assessed in Annexure 10.6.4 of Volume - II.

(ii) Likely socio-economic aspects

Due to increase in food grain production, the socio-economic condition of farmers will improve in general. Agricultural labourers will get employment in the nearby area. Situation of livestock will improve. Farmers will try to establish agro-based industries in the area.

6.2 Details of four barrages proposed in Upper Betwa region

6.2.1 Existing /proposed irrigation facilities

Since all the four barrages are proposed in the Upper Betwa catchment (upto Rajghat dam), combined description is furnished in the following paragraphs. The geographical area of Upper Betwa sub-basin is 16,87,650 ha, out of which culturable land is 10,97,695 ha. The irrigation from existing, ongoing and proposed projects in the catchment is given in Table-6.18.

Table - 6.18

Details of areas irrigated by existing, ongoing and proposed projects in Upper Betwa basin

S. No.	Status of the project	Area irrigated (ha)	Water use (MCM)
1.	Existing	70,071	535.24
2.	Ongoing	49,261	381.56
3.	Proposed	4,89,557	2973.15
	Total	**6,08,889**	**3889.95**

6.2.1.1 Source wise irrigation in the Upper Betwa region

Main sources of irrigation in upper Betwa region are canal, tanks, open wells, tube wells and other sources. Since all the barrages are proposed in Raisen and Vidisha districts of MP, the details of source wise irrigation in the districts are furnished in Table-6.19.

Table - 6.19

Source wise irrigation in the Raisen and Vidisha districts of Madhya Pradesh for year of 2011-12

Unit in ha

S. No.	Source of irrigation	Raisen district		Vidisha district	
1	**Geographical area**	846600		737100	
2	**Gross cropped area**	284354		307550	
3	**Sourcewise irrigation**	**Gross**	**Net**	**Gross**	**Net**
i)	Canals	76387	76387	34674	34674

ii)	Tanks	7653	7653	7052	7052
iii)	Tube Wells	112243	112243	77137	77137
iv)	Ordinary Wells	47678	47678	61996	61996
v)	Other sources	40393	40393	126691	126691
	Total	**284354**	**284354**	**307550**	**307550**

6.2.2 Existing Cropping pattern

The existing cropping pattern in command areas of Neemkheda, Barari, Kotha and Kesari barrages in Upper Betwa sub-basin is given in Table-6.20.

Table - 6.20

Existing cropping pattern in Upper Betwa sub-basin for the year 2011-12

S.No.	Name of crops	% age of area of Raisen district	% age of area of Vidisha district
A	**Kharif**		
1	Paddy	4.6	0.1
2	Jowar	0.0	0.0
3	Maize	0.6	0.4
4	Bajra	0.0	0.0
5	Other pulses	0.6	6.2
6	Soyabean	27.6	30.7
7	Cotton (Fiber)	0.0	0.0
8	Ground nut	0.0	0.2
9	Vegetable	0.4	0.2
10	Til (Sesamum)	0.0	0.0
11	Other kharif	0.0	0.0
	Total	**33.8**	**37.8**
B	**Rabi**	35.0	30.8
1	Wheat	0.0	0.0
2	Barley	17.6	21.1
3	Gram	0.0	0.1
4	Mustard	0.1	0.0

5	Linseed	0.0	0.0
6	Other oilseeds	5.6	8.4
7	Other pulses	0.0	0.0
8	Other Rabi	6.6	0.8
9	Tur	1.0	0.8
10	Fodder crops	0.1	0.2
11	Vegetable	**66.0**	**62.2**
	Total		
C	**Perennial**		
1	Sugarcane	0.2	0.0
	Total	**100**	**100**

6.2.3 Rainfall during monsoon (Maximum, Minimum & Normal rainfall)

The average annual rainfall in the Upper Betwa sub basin is 1120 mm out of which the monsoon rainfall is 1064 mm. The rainfall generally increase from North - West to South - East in the Sub basin. About 95% of the annual rainfall occurs in monsoon period (June to October). The variation in the annual rainfall is appreciable in the sub-basin, the maximum rainfall of 1708.33 mm occurred in the year 1969-70 and the minimum rainfall of 608.2 mm occurred in the year 1979-80.

6.2.3.1 Rainfall during non-monsoon (Maximum, Minimum & Normal rainfall)

Very little rainfall occurs during the period from October to March in Upper Betwa sub-basin. The average non-monsoon rainfall is about 56 mm.

6.2.4 Soil Survey

6.2.4.1 Soil capability classification

Soil survey in the command area was carried out by the State Agriculture Department and a preliminary report had been submitted by the Joint Director of Agriculture, Sagar district. The water holding capacity is low to medium. The pH value of the soil is between 7 to 8. The soils have good response to fertilizers and irrigation.

6.2.4.2 Land irrigability classification

Land irrigability & capability classification has been carried out by State Government in respect upper Betwa command at the time of preparation of DPR of Ken-Betwa Link Project during 2008. The same has been placed at Annexure: 6.2.1 & 6.2.2 of Volume – II. Land irrigability classification and land capability classification carried out for Makodia dam (now dropped) is now being considered for nearest Neemkheda barrage.

6.2.4.3 Land use particulars of Raisen and Vidisha districts

The proposed command area of the barrages lies in the Raisen and Vidisha district of Madhya Pradesh. The land use particulars' of Raisen and Vidisha districts are given in Table-6.21.

Table - 6.21
Land use particulars of the districts of Raisen and Vidisha (maximum of five years from 2007-08 to 2011-12)

Unit in ha

S. No	Particulars	Raisen for the year 2008-09	% of Geogra-phical area	Vidisha for the year of 2007-08	% of Geogra-phical area
1	Forest	331504	39.16	116518	15.81
2	Area under non-agricultural use	39800	4.70	38843	5.27
3	Barren and unculturable land	3496	0.41	8243	1.12
4	Permanent pastures and other grazing land	24455	2.89	21243	2.88
5	Land under miscellaneous crop trees & groves	105	0.01	183	0.02
6	Culturable waste land	10186	1.20	14249	1.93
7	Other fallows	2670	0.32	3321	0.45
8	Current fallows	907	0.11	2348	0.32
9	Net area sown	433477	51.20	532152	72.20
10	Area sown more than once	128404	15.17	196722	26.69
11	Total cropped area	561881	66.37	728874	98.88
12	**Culturable area**	**447345**	**52.84**	**552253**	**74.92**
13	**Total Geographical area**	**846600**	**100**	**737100**	**100**

6.2.5 Proposed Command for Upper Betwa barrages

Four barrages have been proposed in the upper Betwa Command. These are Kesari barrage on Keotan River, a tributary of Betwa River, three barrages namely Neemkheda, Barari and Kotha on Betwa River. The simulation of all these barrages have been carried out by NIH, Roorkee and as per availability of water, the annual irrigation under these barrages works out to 31276 ha. Intensity of irrigation in case of Kesari and Kotha is 140% & 125% respectively, where as that in respect of remaining two barrages proposed of Betwa River is 100%.

6.2.5.1 Scope for double and multiple cropping pattern and change in cropping pattern on the basis of latest available data

Since intensity of Irrigation in Upper Betwa command is more than 100%, double cropping pattern is feasible in these areas. So far cropping pattern is concerned, it has been adopted as per the suggestion of State Agricultural Department.

6.2.5.2 Soils

Following type of soils exist in Upper Betwa command:

1. **Deep Black soils** – These soils are generally found in Raisen, Vidisha, Bhopal and Sagar districts of MP

2. **Medium Black soils** - These soils are found in Vidisha, Sagar, Guna and Bhopal districts of MP

3. **Skeletal soil** – This type of soil is found in very small patch in Raisen district.

6.2.5.3 Agro – climatic conditions

As per agro climatic zoning of Madhya Pradesh, the upper Betwa command falls in Vidisha district and Raisen district which is deficit in water. The climate of the region is tropical. The climate remains hot and is pleasant in winter. The temperature normally varies from 45^0C in summer to 4^0C in winter.

6.2.5.4 Water and other inputs like seeds, fertilizers etc.

It is seen from the survey conducted by the NCAER that the farmers use sufficient inputs to take full advantage of the good situation particularly in irrigation condition. The use of manure and fertilizers is common in all the areas. Similarly, the use of pesticides and weedicides is also popular in the command areas. It also confirms the use of modern agricultural technology in the proposed command areas.

6.2.5.5 Irrigation crops in the adjoining area

The irrigated crops grown in the adjoining area of command are mainly Paddy, Jowar, Bajra, Maize, Arhar, Wheat, Pulses, Potato and other green vegetables. In some areas, farmers have switched over to cash crops due to availability of irrigation facilities.

6.2.5.6 Attitude of farmers towards modern irrigated agricultural practices

The proposed command area lies in Raisen and Vidisha districts of Madhya Pradesh and the economic condition of farmers is inferior. Therefore, majority of farmers are keen to adopt modern agricultural practices, which would naturally improve their economic condition through better and efficient irrigation.

6.2.6 Barrage wise Command Area Details

6.2.6.1 Neemkheda barrage

The command area of Neemkheda barrage is in the vicinity of pondage of barrage and lies in Raisen district of Madhya Pradesh. The gross command area under Neemkheda barrage is 5802 ha. As per land use statistics of the year of 2008-09 (maximum five years from 2007-08 to 2011-12) the culturable command area in the district is 52.84%. Geographical area of Raisen district is 846600 ha. The gross command area of the project is about 0.69% of geographical area of the Raisen district.

6.2.6.2 Barari Barrage

The command area of Barari barrage has been identified under Barari canal which lies in Vidisha district of Madhya Pradesh. The gross command area under Barari barrage is 5932.26 ha. The gross command

area of the project is about 0.81% of geographical area of the Vidisha district.

6.2.6.3 Kotha Barrage

The command area of Kotha barrage is in the vicinity of pondage of barrage and with the canal system lies in Vidisha district of Madhya Pradesh. The gross command area under Kotha barrage is 23167.38 ha. The gross command area of the project is about 3.14 % of geographical area of the Vidisha district.

6.2.6.4 Kesari Barrage

The command area of Kesari barrage is identified under Right Bank canal lies in Vidisha district of Madhya Pradesh. The gross command area under Kesari barrage is 1973.44 ha. The gross command area of the project is about 0.27% of geographical area of the Vidisha district.

6.2.7 Proposed cropping pattern and crop water requirement

The cropping pattern and month wise crop water requirement of the 3 barrages namely Barari, Kotha and Kesari have been duly approved by Govt. of Madhya Pradesh and are furnished in Annexure: 6.2.3.1 to 6.2.3.3 of Volume – II. However, the cropping pattern and month wise crop water requirement for the Neemkheda barrage has not been received from Govt. of Madhya Pradesh. Therefore, the cropping pattern and month wise crop water requirement for the Neemkheda barrage has been considered similar to the nearest Parariya barrage and furnished in Annexure: 6.2.3.4 of Volume – II.

6.2.8. Neemkheda Barrage

6.2.8.1 Proposed cropping pattern

The proposed cropping pattern for providing irrigation in the command under Neemkheda barrage is given in Table-6.22.

Table-6.22

Proposed cropping pattern in the command of Neemkheda barrage

S. No.	Crop	Area	Crop Period
	Rabi		
1	Wheat	613	1st Nov to 20th March
2	Hyv. Wheat	1528	1st Nov to 10th March
3	Gram	925	1st Nov to 1st March
	Total	**3066**	

6.2.8.2 Crop Water Requirement

The crop water requirement for the Neemkheda Barrage command (CCA 3066 ha) has been computed by Modified Penman Method as per the methodology given in the Technical Series-II, a publication of the erstwhile Ministry of Irrigation. The irrigation demand for Neemkheda Barrage command works out as 16.609 MCM.

6.2.8.3 Reference Potential Evapo-transpiration (ETo)

A copy of the Scientific Report No. 136 (February 1971) has been obtained from IMD regarding Potential Evapo-transpiration over India. The Reference Evapo-transpiration (ETo) values in mm for Bhopal IMD station (near to Raisen district) of Madhya Pradesh is tabulated in Table-6.23 and have been considered in the crop water requirement computation.

Table-6.23

Evapo-transpiration (ETo) values for Bhopal IMD station

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
ETo in mm	79.6	99.4	149	183	236	191	118.4	104.9	115.3	119.6	85.5	70.5	**1553.5**

6.2.8.4 Crop Coefficients

Crop coefficients for various crops have been considered as per table 27 of Technical Series-II, a publication of erstwhile Ministry of Irrigation.

6.2.8.5 Pre-sowing & Transplantation Water Demands

Pre-sowing water demands for various crops has been considered as 65 mm.

6.2.8.6 Effective Rainfall

Annual rainfall in the Raisen district is about 1226 mm and the same have been considered computation of effective rainfall for various crops. The effective rainfall component in the crop water requirement has been computed as per the Table 10 of Technical Series-II, a publication of erstwhile Ministry of Irrigation. The month wise normal rainfall in the command area is as under:

Month	Jan	Feb	Ma	Apr	May	Jun
Average Rainfall	17.50	10.00	6.30	0.00	6.70	131.40

Month	Jul	Aug	Sep	Oct	Nov	Dec	Total
Average Rainfall	388.80	406.90	206.30	31.50	12.70	8.400	1226.50

6.2.8.7 Irrigation Efficiency

Not all the applied irrigation water is utilized by the plants and some part of irrigation water is lost due to percolation in field during irrigation. Therefore, the water application efficiency has been considered as 65% for conventional surface irrigation methods followed for all crops. The loss of water in conveyance system i.e. canal, branch canal, distributaries etc. is considered in the conveyance efficiency, adopted as 75% for proposed lined canal system in the project.

6.2.8.8 Irrigation Demand for Neemkheda barrage command

Crop water requirement computations for crops has been computed as by modified penman method and details are given in Annexure 6.2.4 of Volume – II. Month wise irrigation water demands for Neemkheda barrage command are given in Table-6.24.

Table-6.24

Month wise irrigation water demands for Neemkheda barrage

Month	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
Irrigation Demand in MCM	0	0	0	0	0	6.468	3.56	3.267	2.716	0.598	0	0	16.609

6.2.8.9 Environmental flow at Neemkheda barrage

The environmental flows have been considered as computed by NIH, Roorkee based on estimated monthly flow pattern in the sub-basin. For the monsoon months from June to October, 75% dependable flows have been computed on monthly basis and 20% of the 75% dependable flows in each monsoon month have been reserved for environmental and ecological purposes. However, for the non-monsoon months, average monthly flows have been worked out and 15% of the average monthly flows in different non-monsoon months have been reserved for environmental and ecological purposes. About 37.277 MCM of water is assessed for environmental and ecological purposes. Details of environmental flow of Neemkheda barrage is given in Table-6.25.

Table - 6.25
Environmental flow at Neemkheda barrage

Month	Water Demand for Environmental Releases at Neemkheda barrage (MCM)
Jun	0
Jul	5.723
Aug	19.477
Sep	7.936
Oct	0.475
Nov	1.37
Dec	1.026
Jan	0.426
Feb	0.621
Mar	0.22
Apr	0.003
May	0
Total	**37.277**

6.2.8.10 Simulation / Working Tables

The net yield series for Neemkheda barrage site have been developed by NIH, Roorkee from Year 1901-02 to 2008-09. For assessing the success of the barrage in meeting the projected water demands, the working tables for period of 50 years are considered sufficient. Working tables for Neemkheda barrage have been prepared for 55 years (1954-55 to 2008-09) and the success rate of the barrage in meeting the irrigation

demands is 92.7%. The results of simulations / working tables are tabulated in Table-6.26.

Table-6.26

Simulations / working tables of Neemkheda barrage

S. No.	Year			Inflow	Irrigation Demand Met	S/F*	Environmental Releases	S/F*	Evaporation
1	1954	-	55	619.31	16.609	S	37.277	S	7.783
2	1955	-	56	887.004	16.609	S	37.277	S	9.039
3	1956	-	57	438.214	16.609	S	37.277	S	8.753
4	1957	-	58	333.698	16.609	S	37.277	S	7.608
5	1958	-	59	439.104	16.609	S	37.277	S	8.171
6	1959	-	60	662.964	16.609	S	37.277	S	8.981
7	1960	-	61	379.79	16.609	S	37.277	S	8.38
8	1961	-	62	946.475	16.609	S	37.277	S	8.87
9	1962	-	63	465.804	16.609	S	37.277	S	8.795
10	1963	-	64	522.629	16.609	S	37.277	S	8.962
11	1964	-	65	534.247	16.609	S	37.277	S	9.142
12	1965	-	66	288.348	16.609	S	29.002	F	5.949
13	1966	-	67	273.454	16.609	S	37.277	S	4.747
14	1967	-	68	404.537	16.609	S	37.277	S	7.168
15	1968	-	69	440.1	16.609	S	37.277	S	8.418
16	1969	-	70	715.12	16.609	S	37.277	S	8.978
17	1970	-	71	845.854	16.609	S	37.277	S	9.326
18	1971	-	72	397.512	16.609	S	37.277	S	8.675
19	1972	-	73	372.475	16.609	S	36.859	F	6.467
20	1973	-	74	945.794	16.609	S	37.277	S	8.47
21	1974	-	75	563.989	16.609	S	37.277	S	9.101
22	1975	-	76	612.212	16.609	S	37.277	S	9.145
23	1976	-	77	460.036	16.609	S	37.277	S	8.765
24	1977	-	78	629.448	16.609	S	37.277	S	9.164
25	1978	-	79	584.315	16.609	S	37.277	S	9.207
26	1979	-	80	53.551	1.581	F	33.611	F	2.216
27	1980	-	81	353.644	16.609	S	37.277	S	4.995
28	1981	-	82	300.142	16.609	S	37.277	S	5.203
29	1982	-	83	534.534	16.609	S	37.277	S	7.532
30	1983	-	84	912.029	16.609	S	37.277	S	8.851
31	1984	-	85	562.091	16.609	S	37.174	F	3.8
32	1985	-	86	615.471	16.609	S	37.277	S	7.823
33	1986	-	87	721.603	16.609	S	37.277	S	9.163
34	1987	-	88	352.898	16.609	S	37.277	S	6.928
35	1988	-	89	300.766	16.609	S	37.277	S	5.532
36	1989	-	90	346.074	16.609	S	31.554	F	4.814
37	1990	-	91	543.205	16.609	S	37.277	S	8.187
38	1991	-	92	355.885	14.717	F	35.938	F	2.593
39	1992	-	93	391.372	16.609	S	37.277	S	6.287
40	1993	-	94	522.841	16.609	S	37.277	S	8.001
41	1994	-	95	589.247	16.609	S	37.277	S	8.872
42	1995	-	96	328.607	16.609	S	37.277	S	6.28

S. No.	Year			Inflow	Irrigation Demand Met	S/F*	Environmental Releases	S/F*	Evaporation
43	1996	-	97	624.862	16.609	S	37.277	S	7.933
44	1997	-	98	414.871	16.609	S	37.277	S	7.977
45	1998	-	99	502.435	16.609	S	37.277	S	7.951
46	1999	-	00	883.146	16.609	S	37.277	S	8.908
47	2000	-	01	252.974	16.076	F	36.727	F	4.272
48	2001	-	02	270.261	16.609	S	37.277	S	3.938
49	2002	-	03	466.399	16.609	S	31.554	F	6.458
50	2003	-	04	481.277	16.609	S	37.277	S	7.989
51	2004	-	05	418.204	16.609	S	37.277	S	7.763
52	2005	-	06	439.378	16.609	S	29.51	F	7.28
53	2006	-	07	937.227	16.609	S	37.277	S	8.616
54	2007	-	08	245.316	16.609	S	37.274	F	4.785
55	2008	-	09	216.489	14.849	F	36.433	F	3.397

* S: Success F: Failure

6.2.9 Barari barrage

6.2.9.1 Proposed cropping pattern

The proposed cropping pattern for providing irrigation in the command under Barari barrage as detailed in Table-6.27.

Table - 6.27
Proposed cropping pattern in the command of Barari barrage

S. No.	Name of the Crop	Area (ha)	Crop Period
	Rabi		
1	Ord. Wheat	890	1st Nov to 15th March
2	HYV Wheat	3110	1st Nov to 15th March
3	Gram	444	1st Nov to 1st March
	Total	**4444**	

6.2.9.2 Crop Water Requirement

The crop water requirements for the Barari barrage command (CCA 4444 ha) has been computed by Modified Penman Method as per the methodology given in the Technical Series-II, a publication of the erstwhile Ministry of Irrigation. The irrigation demand for Barari barrage command works out as 24.531 MCM.

6.2.9.3 Reference Potential Evapo-transpiration (ETo)

A copy of the Scientific Report No. 136 (February 1971) has been obtained from IMD regarding Potential Evapo-transpiration over India. The Reference Evapo-transpiration (ETo) values in mm for Bhopal IMD station (near to Vidisha district) of Madhya Pradesh is tabulated in Table-6.28 and have been considered in the crop water requirement computation.

Table - 6.28

Evapo-transpiration (ETo) values for Bhopal IMD station

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
ETo in mm	79.6	99.4	149	183	236	191	118.4	104.9	115.3	119.6	85.5	70.5	**1553.5**

6.2.9.4 Crop Coefficients

Crop coefficients for various crops have been considered as per table 27 of Technical Series-II, a publication of erstwhile Ministry of Irrigation.

6.2.9.5 Pre-sowing & Transplantation Water Demands

Pre-sowing water demands for various crops has been considered as 65 mm.

6.2.9.6 Effective Rainfall

Annual rainfall in the Raisen district which is near to Vidisha district is about 1226 mm and the same have been considered computation of effective rainfall for various crops. The crops are proposed to be irrigated in Rabi season and contribution of rainfall in meeting water demands is negligible. The effective rainfall component in the crop water requirement has been computed as per the Table 10 of Technical Series-II, A publication of erstwhile Ministry of Irrigation. The month wise normal rainfall in the command area is as under:

Month	Jan	Feb	Ma	Apr	May	Jun
Average Rainfall	17.50	10.00	6.30	0.00	6.70	131.40

Month	Jul	Aug	Sep	Oct	Nov	Dec	Total
Average Rainfall	388.80	406.90	206.30	31.50	12.70	8.400	1226.50

6.2.9.7 Irrigation Efficiency

Not all the applied irrigation water is utilized by the plants and some part of irrigation water is lost due to percolation in field during irrigation. Therefore, the water application efficiency has been considered as 65% for conventional surface irrigation methods followed for all crops. The loss of water in conveyance system i.e. canal, branch canal, distributaries etc. is considered in the conveyance efficiency, adopted as 75% for proposed lined canal system in the project.

6.2.9.8 Irrigation Demand for Barari barrage command

Crop water requirement for crops has been computed as by Modified Penman method and details are given in Annexure 6.2.9.1 of Volume – II. Monthwise irrigation water demands for Barari barrage command are given in Table-6.29.

Table - 6.29

Month wise irrigation water demands for Barari barrage

Month	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
Irrigation Demand in MCM	0	0	0	0	0	9.427	5.233	4.827	4.003	1.041	0	0	24.531

6.2.9.9 Environmental flow at Barrari barrage

The environmental flows have been considered as computed by NIH, Roorkee based on estimated monthly flow pattern in the project sub-basin. For the monsoon months from June to October, 75% dependable flows have been computed on monthly basis and 20% of the 75% dependable flows in each monsoon month have been reserved for environmental and ecological purposes. However, for the non-monsoon months, average monthly flows have been worked out and 15% of the

average monthly flows in different non-monsoon months have been reserved for environmental and ecological purposes. About 132.526 MCM of water is assessed for environmental and ecological purposes as given in Table – 6.30.

Table-6.30
Environmental flow at Barari barrage

Month	Water Demand for Environmental Releases at Barari barrage (MCM)
Jun	0
Jul	25.323
Aug	69.292
Sep	27.259
Oct	2.843
Nov	2.819
Dec	2.298
Jan	1.097
Feb	1.176
Mar	0.399
Apr	0.02
May	0
Total	**132.526**

6.2.9.10 Simulation / Working Tables

The net yield series for Barari barrage site have been developed by NIH, Roorkee from Year 1901-02 to 2008-09. For assessing the success of the barrage in meeting the projected water demands, the working tables for period of 50 years are considered sufficient. Working tables for Barari barrage have been prepared for 55 years (1954-55 to 2008-09) and the success rate of the barrage in meeting the irrigation demands is 98.2%. The results of simulations / working tables are tabulated in Table-6.31.

Table - 6.31

Simulations / working tables of Barari barrage

Unit: MCM

S.N.	Year			Inflow	Irrigation Demand Met	S/F*	Environmental Releases	Evaporation	Spills
1	1954	-	55	1916.063	24.531	S	132.526	9.777	1738.448
2	1955	-	56	2708.33	24.531	S	132.526	11.218	2540.48
3	1956	-	57	1669.176	24.531	S	132.526	11.756	1500.888
4	1957	-	58	859.665	24.531	S	132.526	9.38	698.467
5	1958	-	59	1573.401	24.531	S	132.526	10.456	1400.41
6	1959	-	60	2097.809	24.531	S	132.526	11.698	1928.872
7	1960	-	61	1273.82	24.531	S	132.526	11.756	1105.428
8	1961	-	62	3163.39	24.531	S	132.526	11.66	2993.875
9	1962	-	63	1339.69	24.531	S	132.526	11.732	1171.699
10	1963	-	64	1421.826	24.531	S	132.526	11.634	1253.135
11	1964	-	65	1955.64	24.531	S	132.526	11.756	1786.827
12	1965	-	66	1087.662	24.531	S	132.526	11.26	922.429
13	1966	-	67	696.693	24.531	S	132.526	7.023	537.97
14	1967	-	68	1486.956	24.531	S	132.526	10.127	1311.331
15	1968	-	69	1279.443	24.531	S	132.526	11.635	1110.758
16	1969	-	70	2595.067	24.531	S	132.526	11.646	2426.208
17	1970	-	71	2708.63	24.531	S	132.526	11.77	2539.337
18	1971	-	72	1419.158	24.531	S	132.526	11.765	1250.872
19	1972	-	73	1189.772	24.531	S	127.662	10.967	1029.703
20	1973	-	74	3106.778	24.531	S	132.526	11.083	2935.401
21	1974	-	75	1605.202	24.531	S	132.526	11.732	1437.218
22	1975	-	76	1809.058	24.531	S	132.526	11.756	1639.994
23	1976	-	77	1182.374	24.531	S	132.526	11.695	1015.139
24	1977	-	78	2259.404	24.531	S	132.526	11.611	2088.99
25	1978	-	79	1601.557	24.531	S	132.526	11.751	1433.229
26	1979	-	80	182.239	5.816	F	117.497	2.715	67.332
27	1980	-	81	1115.289	24.531	S	132.526	9.799	940.884
28	1981	-	82	902.798	24.531	S	132.526	10.218	737.212
29	1982	-	83	1717.217	24.531	S	132.526	10.897	1545.489
30	1983	-	84	2711.734	24.531	S	132.526	11.612	2542.266
31	1984	-	85	1489.144	24.531	S	128.397	11.104	1327.654
32	1985	-	86	2053.431	24.531	S	132.526	11.371	1883.373
33	1986	-	87	1854.791	24.531	S	132.526	11.751	1686.33
34	1987	-	88	1210	24.531	S	132.526	11.646	1041.297
35	1988	-	89	976.879	24.531	S	132.526	11.673	809.791
36	1989	-	90	923.042	24.531	S	126.095	8.512	768.378
37	1990	-	91	1753.578	24.531	S	132.526	10.91	1580.185
38	1991	-	92	1195.695	24.531	S	132.526	11.637	1028.4
39	1992	-	93	1363.521	24.531	S	132.526	11.346	1193.896
40	1993	-	94	1928.184	24.531	S	132.526	11.733	1758.867
41	1994	-	95	2012.907	24.531	S	132.526	11.748	1844.452
42	1995	-	96	1148.126	24.531	S	132.526	11.646	979.423
43	1996	-	97	2408.156	24.531	S	132.526	11.646	2239.079
44	1997	-	98	1549.974	24.531	S	132.526	11.684	1381.603

S.N.	Year			Inflow	Irrigation Demand Met	S/F*	Environmental Releases	Evaporation	Spills
45	1998	-	99	1569.303	24.531	S	132.526	11.756	1400.494
46	1999	-	00	3152.452	24.531	S	132.526	11.77	2982.846
47	2000	-	01	930.527	24.531	S	132.526	10.095	768.147
48	2001	-	02	859.595	24.531	S	132.526	8.975	694.478
49	2002	-	03	1203.299	24.531	S	112.233	9.561	1055.4
50	2003	-	04	1337.042	24.531	S	132.526	11.034	1165.844
51	2004	-	05	1112.069	24.531	S	132.526	11.64	945.618
52	2005	-	06	1356.678	24.531	S	132.526	11.339	1186.036
53	2006	-	07	2543.45	24.531	S	132.526	11.66	2374.285
54	2007	-	08	746.277	24.531	S	132.526	8.638	587.428
55	2008	-	09	628.044	24.531	S	132.526	6.812	466.309

* S: Success F: Failure

6.2.10 Kesari Barrage

6.2.10.1 Simulation / Working Tables

The proposed cropping pattern for providing irrigation in the command under Kesari barrage is given in Table-6.32.

Table - 6.32
Proposed cropping pattern in the command of Kesari barrage

S. No.	Name of the Crop	Area (ha)	Crop Period
1	**Kharif**		
2	Soyabean	592	1st Jun to 30th Sep
3	**Rabi**		
4	Ord. Wheat	295	1st Nov to 15th March
5	HYV Wheat	1035	1st Nov to 15th March
6	Gram	148	1st Nov to 1st March
	Total	**2070**	

6.2.10.2 Crop Water Requirement

The crop water requirements for the Kesari barrage command (CCA 1478 ha) has been computed by Modified Penman Method as per the methodology given in the Technical Series-II, a publication of the erstwhile Ministry of Irrigation. The irrigation demand for Kesari Barrage command works out as 10.028 MCM.

6.2.10.3 Reference Potential Evapo-transpiration (ETo)

A copy of the Scientific Report No. 136 (February 1971) has been obtained from IMD regarding Potential Evapo-transpiration over India. The Reference Evapo-transpiration (ETo) values in mm for Bhopal IMD station (near to Vidisha district) of Madhya Pradesh is tabulated in Table-6.33 and have been considered in the crop water requirement computation.

Table - 6.33

Evapo-transpiration (ETo) values for Bhopal IMD station

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
ETo in mm	79.6	99.4	149	183	236	191	118.4	104.9	115.3	119.6	85.5	70.5	**1553.5**

6.2.10.4 Crop Coefficients

Crop coefficients for various crops have been considered as per table 27 of Technical Series-II, a publication of erstwhile Ministry of Irrigation.

6.2.10.5 Pre-sowing & Transplantation Water Demands

Pre-sowing water demands for various crops has been considered as 65 mm.

6.2.10.6 Effective Rainfall

Annual rainfall in the Raisen district which is near to Vidisha district is about 1226 mm and the same have been considered computation of effective rainfall for various crops. The crops are proposed to be irrigated in Rabi season and contribution of rainfall in meeting water demands is negligible. The effective rainfall component in the crop water requirement has been computed as per the Table 10 of Technical Series-II, a publication of erstwhile Ministry of Irrigation. The month wise normal rainfall in the command area is as under:

Month	**Jan**	**Feb**	**Ma**	**Apr**	**May**	**Jun**
Average Rainfall	17.50	10.00	6.30	0.00	6.70	131.40

Month	Jul	Aug	Sep	Oct	Nov	Dec	Total
Average Rainfall	388.80	406.90	206.30	31.50	12.70	8.400	1226.50

6.2.10.7 Irrigation Efficiency

Not all the applied irrigation water is utilized by the plants and some part of irrigation water is lost due to percolation in field during irrigation. Therefore, the water application efficiency has been considered as 65% for conventional surface irrigation methods followed for all crops. The loss of water in conveyance system i.e. canal, branch canal, distributaries etc. is considered in the conveyance efficiency, adopted as 75% for proposed lined canal system in the project.

6.2.10.8 Irrigation Demand for Kesari barrage command

Crop water requirement for crops has been computed as by modified penman method and details are given in **Annexure 6.2.4**. Monthwise irrigation water demands for Kesari barrage command are given in Table-6.34.

Table-6.34

Month wise irrigation water demands for Kesari barrage

Month	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
Irrigation Demand in MCM	1.133	0.275	0.245	0.222	0	3.133	1.739	1.603	1.332	0.346	0	0	**10.028**

6.2.10.9 Environmental flow at Kesari Barrage

The environmental flows have been considered as computed by NIH, Roorkee based on estimated monthly flow pattern in the sub-basin. For the monsoon months from June to October, 75% dependable flows have been computed on monthly basis and 20% of the 75% dependable flows in each monsoon month have been reserved for environmental and ecological purposes. However, for the non-monsoon months, average monthly flows have been worked out and 15% of the average monthly flows in different non-monsoon months have been reserved for environmental and ecological purposes. About 15.747 MCM of water is assessed for environmental and ecological purposes as given in Table – 6.35.

Table - 6.35
Environmental flow at Kesari barrage

Month	Water Demand for Environmental Releases at Kesari barrage (MCM)
Jun	0
Jul	2.995
Aug	8.342
Sep	2.899
Oct	0.304
Nov	0.401
Dec	0.326
Jan	0.156
Feb	0.218
Mar	0.092
Apr	0.012
May	0.002
Total	**15.747**

6.2.10.10 Simulation / Working Tables

The net yield series for Kesari barrage site have been developed by NIH, Roorkee from Year 1901-02 to 2008-09. For assessing the success of the barrage in meeting the projected water demands, the working tables for period of 50 years are considered sufficient. Working tables for Kesari barrage have been prepared for 55 years (1954-55 to 2008-09) and the success rate of the barrage in meeting the irrigation demands is 94.50 %. The results of simulations / working tables are tabulated in Table-6.36.

Table-6.36

Simulations / working tables of Kesari barrage

S.N.	Year			Inflow	Irrigation Demand Met	S/F*	Environmental Releases	Evaporation	Spills
1	1954	-	55	181.137	8.895	F	15.747	4.721	146.22
2	1955	-	56	273.598	10.028	S	15.747	6.411	239.099
3	1956	-	57	334.455	10.028	S	15.747	6.704	301.563
4	1957	-	58	104.158	10.028	S	15.747	4.715	79.13
5	1958	-	59	185.211	10.028	S	15.747	5.161	151.375
6	1959	-	60	260.506	10.028	S	15.747	6.415	226.282
7	1960	-	61	142.244	10.028	S	15.747	5.137	114.84
8	1961	-	62	326.749	10.028	S	15.747	6.348	290.61
9	1962	-	63	154.369	10.028	S	15.747	5.288	126.944
10	1963	-	64	152.295	10.028	S	15.747	4.802	121.807
11	1964	-	65	190.169	10.028	S	15.747	5.468	157.528
12	1965	-	66	122.119	10.028	S	15.747	4.687	94.149
13	1966	-	67	73.682	10.028	S	15.747	3.014	47.999
14	1967	-	68	176.627	10.028	S	15.747	4.848	140.875
15	1968	-	69	110.332	10.028	S	15.747	4.508	82.432
16	1969	-	70	293.485	10.028	S	15.747	6.205	256.453
17	1970	-	71	272.399	10.028	S	15.747	6.746	240.071
18	1971	-	72	243.901	10.028	S	15.747	6.595	212.023
19	1972	-	73	110.719	10.028	S	15.747	4.37	85.449
20	1973	-	74	271.331	10.028	S	15.747	6.062	234.184
21	1974	-	75	175.879	10.028	S	15.747	5.269	147.415
22	1975	-	76	220.296	10.028	S	15.747	6.174	186.733
23	1976	-	77	86.649	10.028	S	15.747	4.268	61.301
24	1977	-	78	276.81	10.028	S	15.747	6.399	238.857
25	1978	-	79	196.622	10.028	S	15.747	6.007	166.705
26	1979	-	80	30.045	9.95	F	15.641	2.744	7.899
27	1980	-	81	123.939	10.028	S	15.747	4.239	90.477
28	1981	-	82	99.863	10.028	S	15.747	3.935	70.888
29	1982	-	83	284.534	10.028	S	15.747	6.218	247.169
30	1983	-	84	262.143	10.028	S	15.747	6.5	230.201
31	1984	-	85	114.514	10.028	S	15.747	4.366	89.455
32	1985	-	86	250.235	10.028	S	15.747	5.963	213.633
33	1986	-	87	120.6649	10.028	S	15.747	3.386	98.5489
34	1987	-	88	225.696	9.384	F	15.747	5.429	188.638
35	1988	-	89	110.025	10.028	S	15.747	4.676	83.974
36	1989	-	90	129.858	10.028	S	15.747	4.448	98.527
37	1990	-	91	139.671	10.028	S	15.747	4.806	108.748
38	1991	-	92	136.072	10.028	S	15.747	4.562	106.332
39	1992	-	93	148.009	10.028	S	15.747	4.788	116.517
40	1993	-	94	311.707	10.028	S	15.747	6.385	275.76
41	1994	-	95	232.636	10.028	S	15.747	6.514	201.297
42	1995	-	96	156.666	10.028	S	15.747	5.196	128.286
43	1996	-	97	244.376	10.028	S	15.747	6.08	209.771
44	1997	-	98	156.165	10.028	S	15.747	5.229	127.884
45	1998	-	99	119.653	10.028	S	15.747	4.561	90.634

S.N.	Year			Inflow	Irrigation Demand Met	S/F*	Environmental Releases	Evaporation	Spills
46	1999	-	00	290.051	10.028	S	15.747	6.33	253.25
47	2000	-	01	155.796	10.028	S	15.747	5.225	128.64
48	2001	-	02	132.415	10.028	S	15.747	4.926	102.108
49	2002	-	03	166.77	10.028	S	14.869	4.629	136.372
50	2003	-	04	220.632	10.028	S	15.747	5.898	186.931
51	2004	-	05	122.015	10.028	S	15.747	4.752	95.066
52	2005	-	06	178.945	10.028	S	15.747	5.235	145.76
53	2006	-	07	227.311	10.028	S	15.747	6.002	193.929
54	2007	-	08	104.888	10.028	S	15.747	4.712	78.639
55	2008	-	09	83.099	10.028	S	15.747	4.327	53.804

* S: Success F: Failure

6.2.11 Kotha barrage

6.2.11.1 Proposed cropping pattern

The proposed cropping pattern for providing irrigation in the command under Kotha barrage is given in Table-6.37.

Table-6.37
Proposed cropping pattern in the command of Kotha barrage

S. No.	Name of the Crop	Area (ha)	Crop Period
1	**Kharif**		
2	Soyabean	4340	1st Jun to 30th Sep
3	**Rabi**		
4	Ord. Wheat	3476	1st Nov to 15th March
5	HYV Wheat	8689	1st Nov to 15th March
6	Gram	5192	1st Nov to 1st March
	Total	**21697**	

6.2.11.2 Crop Water Requirement

The crop water requirements for the Kotha Barrage command (CCA 17357 ha) has been computed by Modified Penman Method as per the methodology given in the Technical Series-II, a publication of the erstwhile Ministry of Irrigation. The irrigation demand for Kotha barrage command works out as 107.772 MCM.

6.2.11.3 Reference Potential Evapo-transpiration (ETo)

A copy of the Scientific Report No. 136 (February 1971) has been obtained from IMD regarding Potential Evapo-transpiration over India. The Reference Evapo-transpiration (ETo) values in mm for Bhopal IMD station (near to Vidisha district) of Madhya Pradesh is tabulated in Table-6.38 and have been considered in the crop water requirement computation:

Table - 6.38

Evapo-transpiration (ETo) values for Bhopal IMD station

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
ETo in mm	79.6	99.4	149	183	236	191	118.4	104.9	115.3	119.6	85.5	70.5	**1553.5**

6.2.11.4 Crop Coefficients

Crop coefficients for various crops have been considered as per table 27 of Technical Series-II, a publication of erstwhile Ministry of Irrigation.

6.2.11.5 Pre-sowing & Transplantation Water Demands

Pre-sowing water demands for various crops has been considered as 65 mm.

6.2.11.6 Effective Rainfall

Annual rainfall in the Raisen district which is near to Vidisha district is about 1226 mm and the same have been considered computation of effective rainfall for various crops. The crops are proposed to be irrigated in Rabi season and contribution of rainfall in meeting water demands is negligible. The effective rainfall component in the crop water requirement has been computed as per the Table 10 of Technical Series-II, a publication of erstwhile Ministry of Irrigation. The month wise normal rainfall in the command area is as under:

Month	Jan	Feb	Ma	Apr	May	Jun
Average Rainfall	17.50	10.00	6.30	0.00	6.70	131.40

Month	Jul	Aug	Sep	Oct	Nov	Dec	Total
Average Rainfall	388.80	406.90	206.30	31.50	12.70	8.400	1226.50

6.2.11.7 Irrigation Efficiency

Not all the applied irrigation water is utilized by the plants and some part of irrigation water is lost due to percolation in field during irrigation. Therefore, the water application efficiency has been considered as 65% for conventional surface irrigation methods followed for all crops. The loss of water in conveyance system i.e. canal, branch canal, distributaries etc. is considered in the conveyance efficiency, adopted as 75% for proposed lined canal system in the project.

6.2.11.8 Irrigation Demand for Kotha barrage command

Crop water requirement for crops has been computed as by modified penman method and details are given in Annexure 6.2.4 of Volume – II. Month wise irrigation water demands for Kotha barrage command are given in Table-6.39.

Table-6.39

Month wise irrigation water demands for Kotha barrage

Month	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
Irrigation Demand in MCM	8.298	2.02	1.798	1.632	0	36.616	20.156	18.498	15.366	3.388	0	0	107.772

6.2.11.9 Environmental flow at Kotha barrage

The environmental flows have been considered as computed by NIH, Roorkee based on estimated monthly flow pattern in the sub-basin. For the monsoon months from June to October, 75% dependable flows have been computed on monthly basis and 20% of the 75% dependable flows in each monsoon month have been reserved for environmental and ecological purposes. However, for the non-monsoon months, average monthly flows

have been worked out and 15% of the average monthly flows in different non-monsoon months have been reserved for environmental and ecological purposes. About 198.154 MCM of water is assessed for environmental and ecological purposes as given in Table 6.40.

Table - 6.40
Environmental flow at Kotha barrage

Month	Water Demand for Environmental Releases at Kotha barrage (MCM)
Jun	0
Jul	35.553
Aug	113.126
Sep	43.325
Oct	3.003
Nov	1.231
Dec	0.991
Jan	0.319
Feb	0.396
Mar	0.195
Apr	0.013
May	0.002
Total	**198.154**

6.2.11.10 Simulation study / Working Tables

The net yield series for Kotha barrage site have been developed by NIH, Roorkee from Year 1901-02 to 2008-09. For assessing the success of the barrage in meeting the projected water demands, the working tables for period of 50 years are considered sufficient. Working tables for Kotha barrage have been prepared for 55 years (1954-55 to 2008-09) and the success rate of the barrage in meeting the irrigation demands is 85.5%. The results of simulations/working tables are tabulated in Table-6.41.

Table-6.41

Simulations / working tables of Kotha barrage

S.N.	Year			Inflow	Irrigation Demand Met	S/F*	Environmental Releases	Evaporation	Spills
1	1954	-	1955	2672.318	99.474	F	198.154	19.889	2341.736
2	1955	-	1956	4022.553	107.772	S	198.154	25.193	3670.346
3	1956	-	1957	3085.221	107.772	S	198.154	25.219	2765.827
4	1957	-	1958	1319.943	107.772	S	198.154	21.208	1005.526
5	1958	-	1959	2318.903	107.772	S	198.154	20.704	1990.6
6	1959	-	1960	3275.933	107.772	S	198.154	24.221	2933.143
7	1960	-	1961	1870.17	107.772	S	198.154	21.526	1556.573
8	1961	-	1962	4799.565	107.772	S	198.154	32.204	4416.889
9	1962	-	1963	2127.435	107.772	S	198.154	24.084	1841.075
10	1963	-	1964	2061.056	107.772	S	198.154	10.036	1740.965
11	1964	-	1965	2775.954	107.772	S	198.154	21.854	2449.257
12	1965	-	1966	1537.353	107.772	S	198.154	20.74	1215.164
13	1966	-	1967	933.269	107.772	S	198.154	19.643	610.948
14	1967	-	1968	2247.959	105.837	F	198.154	20.385	1919.805
15	1968	-	1969	1834.841	107.772	S	198.154	20.514	1509.858
16	1969	-	1970	4015.485	107.772	S	198.154	26.543	3658.102
17	1970	-	1971	4012.017	107.772	S	198.154	29.279	3676.386
18	1971	-	1972	2541.393	107.772	S	198.154	24.607	2231.261
19	1972	-	1973	1617.584	107.772	S	197.593	18.094	1302.43
20	1973	-	1974	4641.13	106.114	F	198.154	30.919	4263.627
21	1974	-	1975	2419.285	107.772	S	198.154	23.736	2127.872
22	1975	-	1976	3026.987	107.772	S	198.154	23.277	2690.901
23	1976	-	1977	1503.048	107.772	S	198.154	19.562	1187.417
24	1977	-	1978	3433.88	107.772	S	198.154	25.045	3086.008
25	1978	-	1979	2538.016	107.772	S	198.154	22.792	2223.222
26	1979	-	1980	296.207	106.29	F	188.991	13.329	0
27	1980	-	1981	1567.781	107.772	S	198.154	18.087	1233.923
28	1981	-	1982	1388.012	107.772	S	198.154	19.584	1063.25
29	1982	-	1983	2875.284	107.772	S	198.154	21.069	2539.784
30	1983	-	1984	4085.47	107.772	S	198.154	28.306	3731.262
31	1984	-	1985	1887.318	107.772	S	198.154	20.295	1592.401
32	1985	-	1986	3212.065	105.961	F	198.154	23.273	2869.828
33	1986	-	1987	2443.596	107.772	S	198.154	20.768	2132.211
34	1987	-	1988	2224.567	106.418	F	198.154	20.659	1893.346
35	1988	-	1989	1482.365	107.772	S	198.154	21.07	1159.231
36	1989	-	1990	1409.362	107.772	S	193.684	18.57	1089.416
37	1990	-	1991	2303.948	107.772	S	198.154	21.255	1976.931
38	1991	-	1992	1664.304	107.772	S	198.154	18.733	1346.782
39	1992	-	1993	1877.227	102.362	F	198.154	20.093	1549.173
40	1993	-	1994	3309.725	107.772	S	198.154	24.068	2966.912
41	1994	-	1995	3066.685	107.772	S	198.154	25.688	2739.906
42	1995	-	1996	1910.921	107.772	S	198.154	21.355	1591.725

S.N.	Year			Inflow	Irrigation Demand Met	S/F*	Environmental Releases	Evaporation	Spills
43	1996	-	1997	3602.69	107.772	S	198.154	24.772	3256.049
44	1997	-	1998	2175.963	107.772	S	198.154	21.871	1864.279
45	1998	-	1999	2084.035	107.772	S	198.154	20.47	1758.667
46	1999	-	2000	4451.282	107.772	S	198.154	30.592	4077.781
47	2000	-	2001	1637.073	107.772	S	198.154	22.845	1345.913
48	2001	-	2002	1315.902	107.772	S	198.154	20.964	987.648
49	2002	-	2003	1874.761	107.546	F	162.601	18.776	1584.852
50	2003	-	2004	2267.229	107.772	S	198.154	21.497	1937.04
51	2004	-	2005	1725.728	107.772	S	198.154	20.888	1403.232
52	2005	-	2006	2071.339	107.772	S	198.154	20.833	1743.005
53	2006	-	2007	3955.312	107.772	S	198.154	26.586	3600.341
54	2007	-	2008	1181.899	107.772	S	198.154	21.562	881.42
55	2008	-	2009	889.363	107.772	S	198.154	21.037	560.047

* S: Success F: Failure

6.2.11.11 Command area planning on the basis of simulation studies

Command area of the 4 barrages has been planned on the basis of water availability for utilization computed by simulation study. The CCA, Annual Irrigation, water utilization details are furnished in Table-6.42.

Table - 6.42
CCA, Annual Irrigation, Annual Utilisation under barrages

S. No.	Name of the barrages	CCA (ha)	Annual Irrigation (ha)	Water utilization (MCM)
1	Neemkheda	3066	3066	16.61
2	Barari	4444	4444	24.53
3	Kotha	17357	21696	107.77
4	Kesari	1479	2070	10.03
	Total	**26346**	**31276**	**158.94**

6.2.11.12 Designed head discharge of canal systems

The canal capacities at the canal head for the different canals have been computed assuming the 21 days canal running day in a month and furnished below in Table-6.43.

Table - 6.43
Carrying capacity at head

Dam/ barrage	Canal	CCA (ha)	Annual Irrigation (ha)	Water Utilisation (MCM)	Peak in utilization (MCM)	Capacity* (Cumecs)
Kesari barrage	Right Bank Canal	1478.50	2069.90	10.028	3.133 (November)	1.90 (1.72+0.18)
Barari barrage	Right Bank Canal	4444.45	4444.45	24.531	9.427 (November)	5.72 (5.20+0.52)
Kotha barrage	Left Bank Canal	8078	10098	50.158	17.041 (November)	10.33 (9.39+0.94)
Kotha barrage	Right Bank Canal	9278	11599	57.614	19.575 (November)	11.87 (10.79+1.08)

*A provision of 10% of irrigation demand has been made towards rush irrigation demand in canal capacity.

6.2.12 Ground water

6.2.12.1 Ground water quality

Majority of water bearing formations of command area of proposed barrages consists of crystalline rocks, which by virtue of being consolidated in nature do not pose any adverse chemical effect on water. Chemical quality of ground water, thus, observed to be within limits prescribed for domestic and irrigation purposes. It varies from 300 to 1500 micro mhos/cm at 25^0C. There may, however, be localized concentrations of trace elements in the water, which are harmful for drinking purposes. This aspect could not be ascertained due to non-availability of requisite data.

In order to make an economic and efficient use of available water resources, it is essential that a judicious mix of surface and ground water are resorted for irrigation purposes. There is considerable scope to further intensify the irrigation in the command areas by making use of the ground water resources available. This may further facilitate in checking the hazards of water logging and soil salinity in the command.

6.2.12.2 Conjunctive use / ground water support

District wise and command wise ground water resources for the districts of upper Betwa command assessed as per guideline adopted by Central Ground Water Board in Ken-Betwa Link Phase-I are as given in Annexure 6.2.5 of Volume – II. In the present planning, no use of ground water is proposed in any of the command. However, the available ground water resources can be utilized in future for further intensification or augmentation of the irrigation facilities in various commands, particularly to meet the irrigation requirement during lean season.

6.2.13 Command Area Development

6.2.13.1 Command area details

(i) Location

The Upper Betwa command area is covered under three barrages on Betwa river, namely Neemkheda, Kotha and Barari barrage and Kesari barrage on Keotan river proposed in the Upper Betwa region. These areas are covered in the districts of Raisen, Vidisha, Sagar and Ashoknagar of Madhya Pradesh. The CCA has been worked out under these projects as 26346 ha.

6.2.14 Classification of land (forest, grass land, cultivable and, cultivable waste, barren land)

The classification of land in the command area is furnished in Table-6.44.

Table - 6.44

Districtwise land use particulars in Upper Betwa command

Unit: Ha

Type of land	Raisen district	Vidisha district	Total
Gross command Area	2963	13163	16127
Forest land	0	0	0
Land under non-agriculture use	145	499	644
Barren land	13	212	225
Grass land	90	215	305
Culturable waste land	27	110	137
Fallow land	7	52	59
Net sown area	2620	11896	14516
Other land	61	180	241

6.2.15 Size of land holding

The size of land holding and area in the districts lying in the command area of 4 barrages during the year 2005-06 is given in Table-6.45.

Table - 6.45

Size of land holding in the command area of Upper Betwa barrages

Description	Vidisha		Raisen	
	No.	Area	No.	Area
Marginal farmers less than 1 ha	40774	20814	40748	22943
Small farmers more than 1 ha less than 2 ha	41069	59005	52666	80438
Below medium farmers 2-4 ha	37317	105148	39348	109174
Medium farmers 4-9.99 ha	31690	196460	27757	163713
Big farmer 10 to 20 ha	9285	165024	4017	63471
Total	**160135**	**546451**	**164536**	**439739**

6.2.16 Climate of the command area

(a) Rainfall: The command area receives most of its rainfall during the monsoon from July to September from the southwest monsoon.

The coefficient of variation in annual rainfall is appreciable i.e. 22.05. The maximum and minimum rainfall in the area is 1700 mm to 600 mm respectively.

(b) Temperature: The climate of the area is characterized by a hot summer and a mild winter. The climate is hot during summer with the temperature as high as 45^0C.

(c) Relative humidity: The mean monthly relative humidity observed at Bhopal IMD observatory, which is close to the command area varies between 22% to 78%.

(d) Wind velocity: The monthly mean wind velocity observed at Bhopal IMD observatory varies between 6.9 km/hr to 19.4 km/hr.

6.2.17 Irrigation

(a) Present sources of irrigation in the command

The present sources of irrigation in the proposed command area are mainly the age-old tanks and ponds, which collect the rainwater during the monsoon season. Besides these, privately owned open wells and tube wells also provide water for irrigation to very small areas.

(b) Methods of irrigation followed

At present, the conventional method of applying water through minor irrigation channels, distributaries and water courses is being followed in these areas. However, sometimes electric/diesel pump sets are also used to lift water from the wells.

(c) Status of land development for irrigated area

(i) Condition of channels

The condition of existing irrigation channels in the command area is generally satisfactory except in some reaches where proper maintenance is required. Most of the channels are unlined, hence susceptible to loss of water through seepage.

(ii) Longitudinal slope of field

The slope in agricultural fields where irrigation channels are located, are adequate and irrigation water reaches almost every nook and corner of the field.

(iii) Status of field channels

Field channels constructed by farmers for irrigating land by pumping river water are found to be existing in some areas.

6.2.18 Socio-economic aspects

M/s Agricultural Finance Corporation Limited, Hyderabad has carried out studies for socio-economic aspects in the command area of 4 barrages. The same is reproduced in Table-6.46.

Table - 6.46

Districtwise socio-economic aspects in the Upper Betwa command

S. No.	Description	Vidisha	Raisen
1	Population density per sq.km.	166	133
2	Sex ratio (females per 1000 male)	875	881
3	SC	24.28%	23.26%
4	ST	4.31%	3.50 %
5	Literacy rate	55.73%	53.30%
6	Educational institutions	2705	2465
7	Medical and health facilities	900	816
8	Drinking water supply		
9	Problematic villages	760	1080
10	Tap water supply	3	64
11	Tube/pump well supply	865	1064

6.2.19 Infrastructure facilities

(a) Roads and railways

Vidisha and Raisen district headquarters are connected by rail and roads. However, the roads in rural areas are generally kachcha roads.

(b) Marketing facilities

Most of the villages in the command are dependent on the marketing facilities available in Vidisha, Raisen and Bhopal.

(c) Agro-industries

No major agro-based industries are available within the command. However, few oil mills and flour mills are located in the common which cater to the needs of command people.

(d) Banks/credit societies etc.

Nationalized Banks are exists at district head quarters and tehsils. However, few Gramin Banks are functioning in rural areas.

6.2.20 Topography and soils

(i) Topography

Isolated hill tops, valleys, forests and streams are dominating in the area. Coarse grained formations are predominantly found in the command area.

(ii) Land slopes

The slopes of the land in the command area are moderate and in few places it is steep.

(iii) Soils

Based on the information provided by National Bureau of Soil Survey and Land Use Planning (ICAR), Nagpur, the soils in the command area can be broadly classified into three categories. They are soil in hills and hill ranges, plateau soils, pediment soils, soils of level alluvial plain and undulating flood plain and soils of dissected flood plan. Details are given below:-

1. Deep, moderately well drained, clayey soils on very gently sloping plain lan with moderate erosion, associated with:Deep, moderately well drained, calcareous, clayey soils on very gently sloping with moderate erosion.

2. Deep, moderately well drained, clayey soils on very gently sloping plains with valleys with valleys with moderate erosion, associated

with: Deep, moderately well drained, calcareous, clayey soils on very gently sloping with moderate erosion.

3. Shallow, well drained, loamy soils on gently sloping undulating upland with hummocks with moderate erosion, associated with Very shallow, somewhat excessively drained, loamy soils on moderately sloping with severe erosion.

6.2.21 Drainage

The command area has good surface drainage and sub-surface drainage. The water holding capacity being low to medium is expected in clay patches. With the network of a number of tributaries namely Newman, Sagar, Bah, Keotan etc., the command area has quite good draining facilities.

6.3.22 Agriculture

The classification of lands and the present land use has already been discussed in the chapter. Land use will change due to increase in cultivated area and increase in developmental activities due to this project.

6.2.23 Farmers' attitude towards improved agricultural practices

This farmers' attitude towards improved agricultural practices is positive. However, due to non-availability of water even from the existing tanks, they find it difficult to carry out cultivation in the entire area.

(a) Use of improved implements and seeds

The use of bullock power for ploughing of land is common in the area of proposed command. The use of tractor is also done in these areas but the percentage is very low. Likewise, the use of traditional types of implements is also very common among majority of the farmers.

(b) Use of fertilizers, insecticides, pesticides, etc.

Although about 25% of the farmers use fertilizers and manures for increasing the yield, very few of them are particular about use of insecticides/pesticides for control of plant diseases.

(c) Extension services

Occasional extension services are provided by the State Agriculture Department to educate the farmers about the use of improved and modern agriculture technology, and cultivation of high value crops viz. Groundnut, Soyabean, Sunflower, Chillies etc. But, due to various reasons including inadequate financial resources, the extension services are yet to become popular among the farmers of proposed command area.

6.2.24 Identification of problems in command area

(i) Land slopes: the land is generally undulating; therefore, canal distribution system has to be aligned accordingly.

(ii) Soil depth: There should be no problem on this account, as sufficient soil depth is available in the area for providing canal irrigation.

(iii) Salinity/Alkalinity: Since the waters of Betwa river and its tributaries are proposed to be used for irrigation in these areas, which do not have salinity problem, it need not be a cause of concern. However, slight alkaline nature of the soils of the region is considered rather suitable for crops like Jowar, Soyabean, Wheat and Moong.

In general, the soils in these areas are stable and not prone to erosion. However, in certain area, the soils may be prone to erosion due to their coarse texture. Such soils can be stabilized by putting them under permanent pastures and grazing lands.

(iv) Water logging: No water-logging problem of serious nature has been reported from the area.

(v) Drainage: Looking the general condition and topography of the command, special care should be taken for construction of field channels and drainage, which can be managed by the Agricultural Department at farmer's cost or loans from the various land development banks.

6.2.25 Financial problems

There are number of wells and tanks in the area but due to less recharge in the area, these wells and tanks either have less water or no water during lean season. Farmers should be provided fund assistance for renovation of these tanks and wells for better irrigation.

6.2.25 Proposed cropping pattern, with justification based on land irrigability classification, agro climatic conditions developed irrigated cropping pattern in adjoining project/area etc.

Proposed cropping pattern for 4 barrages has been supplied by Govt. of Madhya Pradesh in consultation with Agriculture Department of Govt. of Madhya Pradesh and same has been considered in the study.

6.2.27 Land development work proposals

A provision of Rs. 527 lakh has been kept in the estimate for land development works. At the time of implementation of the project, detailed survey of each command will be done and based on the requirement, land development works will be taken up. This work will be done by state Irrigation Department or state Agriculture Department or Command Area Development Authority (to be decided by State Government).

At present, fairly good extension services exists in the command area and number of commercial banks and co-operative banks have their branches there. Branches of land development banks are also located in some rural areas of the command. Moreover, the agricultural materials like seeds, fertilizers, insecticides, pesticides etc. are provided to the farmers by the concerned government department at subsidized rates through different sale booths or fair price shops. However, due to numerous reasons, especially inadequacy of financial resources, extension services have not yet become very popular.

6.2.27.1 Ayacut roads

Suitable provisions for CD structures will be made to facilitate traffic movement through Ayacut roads.

6.2.28 Benefits

(i) Crop wise increase in yield per ha and total estimated output from the command

The crop wise yield in pre & post project scenarios for 4 barrages is furnished in Table-6.47 to 6.50.

(ii) Estimated cost of increased production

The yield in pre and post project scenarios have been assessed in Table-6.47 to 6.50. Based on the increased production cost of increased production has been assessed in Annexure 10.6.4 of Volume – II.

(iii) Likely socio-economic aspects

Due to increase in food grain production, the socio-economic condition of farmers will improve in general. Agricultural labourers will get employment in the nearby area. Situation livestock will improve. Farmers will try to establish agro-based industries in the area.

Table - 6.47
Total Output of agricultural production under pre & post project scenario of Neemkheda barrage

Sl.	Name of	Pre project scenario				Post project scenario				Remark
No.	crop	% of crop	Area	Yield	Gross yield in	% of crop	Area	Yield	Gross yield in	
			ha	qtls/ha	qtls		ha	qtls/ha	qtls	
A.	**Kharif**									
1.	Paddy	4.60	141	15	2115	4.60	141	15	2115	Rainfed
2.	Maize	0.60	19	14	266	0.60	19	14	266	Rainfed
3.	Other pulses	0.60	19	5	95	0.60	19	5	95	Rainfed
4.	Soyabean	27.60	845	8	6760	27.60	845	8	6760	Rainfed
5.	Vegetable	0.40	13	30	390	0.40	13	30	390	Rainfed
	Total	**33.80**	**1037**		**9626**	**33.80**	**1037**		**9626**	
B.	**Rabi**									
1.	Wheat	35.00	1072	15	16080	70.00	2146	40	85840	
2.	Gram	17.60	539	8	4312	30.00	920	20	18400	
4.	Linseed	0.10	4	5	20	0.00	0	15	0	
5.	Other pulses	5.60	171	5	855	0.00	0	12	0	
6.	Tur	6.60	202	5	1010	0.00	0	20	0	
7.	Fodder crops	1.00	31	200	6200	0.00	0	400	0	
8.	Vegetable	0.10	4	30	120	0.00	0	50	0	
	Total	**66.00**	**2023**		**28597**	**100.00**	**3066**		**104240**	
C.	**Perennial**									
1.	Sugarcane	0.20	6	200	1400	0.20	7	500	**3500**	
	Total	**100**	**3066**		**39423**	**134**	**4110**	**500**	**117366**	

Table - 6.48
Total Output of agricultural production under pre & post project scenario of Barari barrage

S.	Name of	Pre project scenario				Post project scenario				Remark
No.	crop	% of crop	Area	Yield	Gross yield in	% of crop	Area	Yield	Gross yield in	
			ha	qtls/ha	qtls		ha	qtls/ha	qtls	
A.	**Kharif**									
1.	Paddy	0.10	5	15	75	0.10	5	15	75	Rainfed
2.	Maize	0.40	18	14	252	0.40	18	14	252	Rainfed
3.	Other pulses	6.20	275	5	1375	6.20	275	5	1375	Rainfed
4.	Soyabean	30.70	1364	8	10912	30.70	1364	8	10912	Rainfed
5.	Ground nut	0.20	9	10	90	0.10	9	10	90	Rainfed
6.	Vegetable	0.20	9	30	270	0.20	9	30	270	Rainfed
	Total	**37.80**	**1680**		**12974**	**37.70**	**1680**		**12974**	
B.	**Rabi**									
1.	Wheat	30.80	1368	15	20520	90.00	4000	40	160000	
2.	Gram	21.10	937	8	7496	10.00	444	20	8880	
3.	Mustard	0.10	5	6	30	0.00	0	16	0	
4.	Linseed	0.00	0	5	0	0.00	0	15	0	
5.	Other pulses	8.40	373	5	1865	0.00	0	12	0	
6.	Tur	0.80	36	5	180	0.00	0	20	0	
7.	Fodder crops	0.80	36	200	7200	0.00	0	400	0	
8.	Vegetable	0.20	9	9	81	0.00	0	50	0	
	Total	**62.20**	**2764**		**37372**	**100**	**4444**		**168880**	
C.	**Perennial**									
1.	Sugarcane	0.00	0	200	0	0	0	500	0	
	Total	**100**	**4444.0**		**50346.0**	**137.7**	**6124.0**		**181854.0**	

Table - 6.49
Total Output of agricultural production under pre & post project scenario of Kesari barrage

S. No.	Name of crop	Pre project scenario				Post project scenario				Remark
		% of crop	Area ha	Yield qtls/ha	Gross yield in qtls	% of crop	Area ha	Yield qtls/ha	Gross yield in qtls	
A.	**Kharif**									
1.	Paddy	0.10	2	15	30	0.10	2	15	30	Rainfed
2.	Maize	0.40	6	14	84	0.40	6	14	84	Rainfed
3.	Other pulses	6.20	92	5	460	6.20	92	5	460	Rainfed
4.	Soyabean	30.70	454	8	3632	40.00	592	23	13616	
5.	Ground nut	0.20	3	10	30	0.10	3	10	30	Rainfed
6.	Vegetable	0.20	3	30	90	0.20	3	30	90	Rainfed
	Total	**37.80**	**560**		**4326**	**47.00**	**698**	**97**	**14310**	
B.	**Rabi**									
1.	Wheat	30.80	454	15	6810	90.00	1331	40	53240	
2.	Gram	21.10	312	8	2496	10.00	148	20	2960	
3.	Mustard	0.10	2	6	12	0.00	0	16	0	
4.	Linseed	0.00	0	5	0	0.00	0	15	0	
5.	Other pulses	8.40	124	5	620	0.00	0	12	0	
6.	Tur	0.80	12	5	60	0.00	0	20	0	
7.	Fodder crops	0.80	12	200	2400	0.00	0	400	0	
8.	Vegetable	0.20	3	30	90	0.00	0	50	0	
	Total	**62.20**	**919.00**		**12488.00**	**100.00**	**1479.00**	**573.00**	**56200.00**	
C.	**Perennial**									
1.	Sugarcane	0.00	0	200	0	0	0	500	0	
	Total	**100**	**1479.00**		**16814.00**	**147.00**	**2177.00**	**1170.0**	**70510.00**	

Table - 6.50
Total Output of agricultural production under pre & post project scenario of Kotha barrage

Sl.	Name of	Pre project scenario				Post project scenario				Remark
No.	crop	% of crop	Area	Yield	Gross yield in	% of crop	Area	Yield	Gross yield in	
			ha	qtls/ha	qtls		ha	qtls/ha	qtls	
A.	**Kharif**									
1.	Paddy	0.10	18	15	270	0.10	18	15	270	Rainfed
2.	Maize	0.40	70	14	980	0.40	70	14	980	Rainfed
3.	Other pulses	6.20	1076	5	5380	6.20	1076	5	5380	Rainfed
4.	Soyabean	30.70	5328	8	42624	30.70	5328	23	122544	**25% irrigated + 5.7 % rainfed**
5.	Ground nut	0.20	35	10	350	0.10	35	10	350	Rainfed
6.	Vegetable	0.20	35	30	1050	0.20	35	30	1050	Rainfed
	Total	**37.80**	**6562**		**50654**	**37.70**	**6562**		**130574**	
B.	**Rabi**									
1.	Wheat	30.80	5345	15	80175	90.00	15621	40	624840	
2.	Gram	21.10	3662	8	29296	10.00	1736	80	34720	
3.	Mustard	0.10	18	6	108	0.00	0	16	0	
4.	Linseed	0.00	0	5	0	0.00	0	18	0	
5.	Other pulses	8.40	1457	5	7285	0.00	0	12	0	
6.	Tur	0.80	139	5	695	0.00	0	20	0	
7.	Fodder crops	0.80	139	200	27800	0.00	0	400	0	
8.	Vegetable	0.20	35	30	1050	0.00	0	50	0	
	Total	**62.20**	**10795**		**146409**	**100**	**17357**		**659560**	
C.	**Perennial**									
1.	Sugarcane	0.00	0	200	0	0	0	500	0	
	Total	**100**	**17328**		**193534**	**138**	**23905**		**879343**	

6.3 Brief of command area development and irrigation planning of Ken-Betwa Link Project(Phase-II)

The total culturable command area covering by 4 barrages and Lower Orr dam is 71393 ha (annual irrigation of 98846 ha) utilizing about 488.61 MCM water. Details at a glance are furnished in Table-6.51.

Table - 6.51

Details of Pond level/FRL, CCA, Annual irrigation and water utilization of all 5 structures proposed under Ken–Betwa Link Project (Phase-II)

S. No.	Name of Structure	Name of river	Pond level / FRL (m)	CCA (ha)	Annual irrigation (ha)	Water utilization (MCM)
	Barrages upstream of Rajghat dam					
1	Neemkheda barrage	Betwa	426.00	3066	3066	**16.61**
2	Barari barrage	Betwa	407.70	4444	4444	**24.53**
3	Kotha barrage	Betwa	396.00	17357	21696	**107.77**
4	Kesari barrage	Keotan	403.90	1479	2070	**10.03**
	Sub – Total:			**26346**	**31276**	**158.94**
	Dam in downstream of Rajghat dam					
1	Lower Orr dam	Orr	380	45047	67570	**329.67**
	Sub – Total:			**45047**	**67570**	**329.67**
	Grand Total:			**71393**	**98846**	**488.61**