DIVERSIFIED CROPPING SYSTEM FOR THE MALAWA PLATEAU OF SAMRAT ASHOK SAGAR PROJECT IN MADHYA PRADESH

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ABSTRACT

Samrat Ashok Sagar Project originally known as Halali Project is located in the Malwa Plateau of Madhya Pradesh. It has the culturable command area (CCA) of 27924 ha. The area proposed for Kharif irrigation was 12545 ha and during Rabi irrigation was 25091 ha with the irrigation intensity of 135%. Cropping pattern proposed was predominantly paddy during Kharif and wheat during Rabi. Unfortunately after the completion of the project, the cropping pattern proposed did not come up. During kharif, soybean became the predominant crop. Comparing paddy, the water requirement of soybean is very low. This created an imbalance in the project water use. This not only adversely affected the water utilisation but also adversely affected the irrigation revenue and agroproductivity of the area. Analysing the water availability, cultivation cost of crops, land features and climatically suitable crops of various use were identified for the project area. Linear programming was used to find the optimal crop pattern being diversified in nature and multiple utility. The optimal diversified crop pattern included 16.22% soybean, 2.45% groundnut, 1.22% maize, 1.22% red gram, 1.22% blackgram, 3.67% green gram, 3.67% paddy, 2.45% sorghum, 1.22% vegetable (Kharif), 2.45% cotton, 2.45% sugarcane, 18.35% wheat (HYV), 18.37% wheat (local) 4.90% gram, 2.45% barley, 2.45% pea, 1.22% lentil, 2.45% mustard, 1.22% linseed, 1.22% safflower, 1.22% berseem, 5.31% potato, 1.22% tomato and 1.31% cauliflower. The average cropping intensity proposed is 146.18% and net benefit is Rs.29.33 crores.

I. INTRODUCTION

The Halali Dam (Samrat Ashok Sagar project) is located in the Malwa Plateau of Madhya Pradesh. Average annual rainfall is 1099 mm. This is highly variable and erratic. The agro-climatic condition prevailing in the region classify this area into SEMIARID (Annonymous, 1978).

In order to ensure the constant water supply to the agriculture in the area and increase its agricultural productivity, the Dam was constructed on the river Halali a tributary of Betwa. In the project proposal, the cropping pattern proposed included paddy, maize, sorghum, pulses, fodder, groundnut and soybean during Kharif and wheat (HYV), wheat (local) during Rabi with a gross irrigated area of 37,636 ha. Construction of the project commenced in 1973-74 and was completed in 1995-96. The project was to irrigate 12546 ha during Kharif and 25091 ha during Rabi. Unfortunately the target of Kharif could never be reached. As a result of it a large quantity of water remained unused and stored in the reservoir. This happened due to mass scale adoption of soybean cultivation in the command (Gupta, 1998). In order to improve the utilisation of water in the project, the National

Water Management Project was launched in 1999 but this also could not make any impact because they also suggested 13,000 ha as soybean during Kharif (Srivastava, 2002).

In view of the above facts this study was attempted to suggest a "Diversified Cropping system for the Malwa Plateau of Samrat Ashok Sagar Project in Madhya Pradesh" which is suppose to be remunerative and self sufficient in agricultural needs of the people in command.

II. DESCRIPTION OF THE PROJECT

The State of Madhya Pradesh lies between latitude 18^{o} to $26^{o}30'$ N and longtitude 74^{o} to 84.5^{o} E . The State can be divided into four regions namely the Northern region, Malwa Plateau, the Narmada Valley and the Satpura ranges. The Malwa plateau covers most part of Malwa the wide table land with a mean elevation of 487.68 meters above sea level and has an area of about 89,614 sq. km. It includes all the area lying between the great Vindhyan barrier and upto the South of Gwalior. The important river systems in the State of Madhya Pradesh are (1) the Chambal, (2) Betwa (3) Sone and (4) Narmada.

The Betwa river of which the mention is made as "Vetravati" in the "Meghdoot" written by Kalidas, has its origin in Bhopal State at an altitude of about 492.44 meters above MSL.

The Halali river is a tributary of the river Betwa. It originates around Bhopal at an altitude of about 487.68 meters above MSL and joins Betwa river near Vidisha after flowing for a length of about 38 km North East. Where it enters a gorge fairly narrow with high hills on both sides. The gorge is about 8 kms in length (Annonymous, 1999).

The Halali river is a seasonal river. The river gets ample supplies only during monsoon months, i.e. from July to September.

A SAMRAT ASHOK SAGAR PROJECT

This ia a major irrigation project of Vidisha and Raisen district of Madhya pradesh. The project is constructed as irrigation cum flood protection scheme across Halali river which is a tributary of Betwa. The dam site of the project is 40 km North east of Bhopal and 16 km from Salamatpur Railway station near village Khoa. It is connected by road from Bhopal, Vidisha and Raisen. Most of the command lies in Vidisha district. General location and index map is given in Fig. 1.

The administrative approval to the project was accorded way back in 1963 for Rs.404.27 lakh. The actual execution of the Head Works started in the year 1973. The project was completed in the year 1976 by the Government of Madhya Pradesh Irrigation Department.

The project is comprised of 945 m long and 29.57 m high Earthen Dam across the river Halali. The main canal is takes off from Saddle Dam located on left bank. The Main Canal is 3.24 km long and the Left Bank Canal and Right Bank Canals take off from main Canal at 3.24 km. Salient features of the project are given below :

A 1 SALIENT FEATURES :

1. Location of Dam

1.1	State	Madhya Pradesh

1.2	District	Vidisha & Raisen
1.3	Latitude	23°30' N
1.4	Longtitude	77°33' E
1.5	River	Halali River
1.6	Dam site	Khoa village 16 km from Salamatpur railway station

2. Hydrology

2.1	Catchment area	699 sq.km
2.2	Maximum rainfall	1680 mm
2.3	Minimum rainfall	536 mm

Average rainfall 1108 mm

3. Design Flood

3.1	Standard project flood	4688 cumecs

aximum project flood 5665 cumecs

4. Reservoir Data

4.1	TBL	RL 466.32 m
4.2	MWL (Flood control)	RL 464.19 m
4.3	FRL (Irrigation)	RL 458.4 m
4.4	FRL (Flood control)	RL 459.61 m
4.5	LSL	RL 448.95 m
4.6	Crest of flush bar (Additional spillway)	RL 462.66 m
4.7	Crest of ungated spillway	RL 459.61 m
4.8	Water spread at FRL (Irrigation)	5259 ha
4.9	Gross storage at MWL	67827 ha.m.
4.10	Gross storage at FRL	25285 ha.m.
4.11	Live storage at irrigation FRL	22695 ha.m
4.12	Dead storage	2590 ha.m.

5. Dam

5.1	Type	Earthen dam
5.2	Top width	4.57 m
5.3	Maximum height	29.57 m
5.4	Length of dam	945.0 m

6. Spillway

6.1	Length	41.15 m
6.2	Crest level	RL 459.61 m
6.3	Discharging capacity of MWL	642 cumecs

7. Byewash

7.1	Length	60.96 m
7.2	Crest level	RL 462.66 m
7.3	Discharging capacity	169.92 cumecs

8. Sluice

8.1	Spill level	RL 447.23 m
8.2	No. and size of gate	2 Nos. (2.13 x 2.43 m)
8.3	Discharging capacity	80.99 cumecs

9. Irrigation

9.1	Gross Command Area	37419 ha
9.2	Culturable command area	27924 ha
9.3	Net area served	25091 ha
	Annual irrigation	
9.4	Kharif	12545 ha
9.5	Rabi	25091 ha
9.6	Total	37636 ha
9.7	Intensity of irrigation	135%

10. Canal

10.1	Length of main canal	3.24 km
10.2	Head discharge	22.64 cumecs
10.3	Length of LBC	17.61 kms
10.4	Head discharge	13.73 cumecs
10.5	Length of RBC	23.43 kms
10.6	Head discharge	5.24 cumecs
10.7	Length of distributaries	

10.7.1 Left Bank Canal

1. Sahoda Branch Canal	12.48 km
Head discharge	8.63 cumecs
2. D-1/SBC	9.72 km
Head discharge	2.94 cumecs
3. D-2/LBC	9.0 km
Head discharge	2.88 cumecs
4. D-3/LBC	16.50 km
Head discharge	4.24 cumecs
5. D-4/SBC	19.44 km
Head discharge	4.35 cumecs

10.7.2 Right Bank Canal

1. D-1/RBC	6.75 km
Head discharge	0.853 cumecs
3. D-2/RBC	4.41 km
Head discharge	1.398 cumecs
4. D-3/RBC	10.86 km
Head discharge	1.367 cumecs

10.8	Length of distributaries, Minors & subminors of LBC	
10.9	Length of Distributaries Minors & subminors of RBC	109.48 km
10.10	Length of lhigh level canal	3.22 km
10.11	Discharge of high level canal	0.42 cumecs

11. Financial

11.1	Cost of project (March 1993)	Rs.2471.10 lakhs
11.2	Cost/ha (On annual irrigation)	Rs.6566/-
11.3	Cost/ha (On CCA)	Rs.8850/-
11.4	Benefit cost Ratio	2.68

12. Completion of project

12.1	Commencement	1973-74
12.2	Completion of work	
	Main Dam	1976-77
	Main canal	1977-78
	Distribution network	1995-96

In order to improve water utilisation in the existing irrigation scheme, the Govt. of India launched the National Water Management Project with the assistance of World Bank. Accordingly the Govt. of Madhya Pradesh joined the project in February 1999.Salient features suggested by NWMP are as follows:

A 2 SALIENT FEATURES (AS PER NWMP)

1. Reservoir Data

FRL irrigation	459.61 M
Crest of additional spillway	458.40 M
Water spread at FRL (Irrigation)	6059 ha
Gross storage at FRL	33303 ha-m
Live storage	30713 ha-m
Dead storage	2590 ha-m

2. Additional Spillway

Crest level	458.40 M
Discharging capacity at MWL	966 cumecs

3. Irrigation

Net area served		26000 ha
Annual irrigation :		
(a)	Kharif	13000 ha
(b)	Rabi	26000 ha
	Total	39000 ha
Intensity of irrigation		140%

4. Canal

Main canal

Head discharge	25.58 cumecs
LBC discharge	19.17 cumecs
RBC discharge	6.41 cumecs

Note : Remaining features are same as given in Section A1.

A 3 ENGINEERING FEATURES :

The command area of Samrat Ashok Sagar Project is fairly flat. The distributaries take off from main canal and minors take off from the distributaries. The distributaries and minors in general have been aligned on the ridges to cover the maximum command under irrigation. Schematic diagram showing the layout of main canal and distribution system is given in Fig. 2.

Main Canal

The main canal takes off from the sluice located on the left bank of Halali river. The length of main canal is 3.24 kms. The main canal goes in deep cut of the order of 15 meters in the initial reach, which gradually reduces to 4 meters at the tail end. Because of poor shear properties of soil there are heavy slips on side slopes.

Left Bank Canal (LBC)

The left bank canal is 17.16 km long. LBC is aligned as contour canal from R.D. 0 meter to 13560 m and thereafter follows the ridge between Halali river and Sahodara Drain. It is in filling where it crosses valley, hence to control excessive seepage pre-cast concrete slab lining has been done in between R.D. 7500 m to 17160 m under NWMP works. In filling reaches the banks have settled in patches. Canal is in heavy cutting from R.D. 1890 m to 2310 m. The bed of canal gets raised due to heavy slippage of the embankments which are removed every year.

Sahodara Branch Canal

Sahodara branch canal (SBC) takes off from LBC of RD 12430 m. The name of canal is on the Sahodara drain. Its length if 12.33 km. At the end, it bifurcates into the Distributary no. 1 and Distributary No.4.

There are 80 numbers of minors and 41 numbers of subminors in this system. The total length of the distribution system (Minors and subminors) is 309 kms.

Right Bank Canal

The right bank canal in the initial reaches irrigates the area between Pawwa Drain and Left Bank of Halali river. This canal is 23.43 kms long and crosses Halali river by an aqueduct at RD 10350 m to 10700 m. Masonry conduit canal has been constructed in length of one km between RD 12200 m to 13200 m, where the canal passes along the hill toe, just downstream of aqueduct on Halali River. It is in general aligned as a contour canal.

Under RBC system the command area is served by three distributaries namely D1, D2 & D3. There are 26 numbers of minors and 18 numbers of subminors in this system. The total length of the distribution system is 110 km.

III. SOILS

In general the soil is Deep Black Cotton (vertisol) at the surface. The texture of the soil is heavy. There are patches of land with distinctly grey colour throughout the profile. The soil in the area is formed as the result of weathering of basaltic trap rock. The soil is deep except for a small patch towards the south near the river Halali and Betwa and in the north near the village Noagai, where it is comparatively less deep.

The presence of lime Kankar nodules mixed with gravel material, i.e., coarser fraction retained on 2 mm dia is noticeable in the surface soil at some sites as high as 30% of that coarser soil fraction is present all along the soil depth.

The catchment area as well as the command of the project is a part of Malwa Plateau with mean elevation of about 426.7M above mean sea level. The plateau is covered with fertile black soil (Kali Mitti) and clayey soil. All these soils are significantly retentive of moisture to grow all crops like paddy, jawar, pulses, wheat, sugarcane and garden crops with irrigation.

The ground water table observed during 1999-2000 in the command is shown below :

Description	**Average depth of water table**	
	October-November	**May-June**
Left command	5.20 m	8.65 m
Right command	3.00 m	9.40 m

IV. CROP PLAN DESIGNED AND EXISTING

Cropping pattern proposed at the time of the formulation of the project is given in Table 4.1.

Table 4.1 : Crop Plan Designed and Existing in Samrat Ashok Sagar Project

Crop	**Designed crop area (ha)**	**Existing crop area (ha) (1999-2000)**
Kharif		
1. Paddy	5017	-
2. Maize & Jwar	1255	250
3. Pulses	1255	-
4. Fodder	1255	-
5. Groundnut	1255	-
6. Soybean	2508	12500
7. Red gram	-	250
8. Total	12545	13000
Rabi		
7. Wheat (HYV)	12546	8750
8. Wheat (local)	12545	6250
9. Gram	-	7500
10. Pea	-	500
11. Lentil	-	2000
Total	25091	25000
Grand Total	37636	38000

The major emphasis was given to paddy crop during Kharif while designing the project. There was a provision of 18% paddy in the project design. On development of irrigation from Samrat Ashok Sagar Project, it is experienced that during Kharif the farmers have not come forward for paddy crop but switched over to soybean which was not popular at the time of preparation of project.

In fact, for the paddy cultivation level fields are needed, where water can stand uniformly. On farm development work has not been undertaken. The soil of command is difficult for paddy cultivation. The soils are very sticky and they can not be tilled by bullock drawn implements in wet condition. Again after harvest of paddy, soil gets so hard that the bullock are unable to draft the plough for Rabi cultivation. There is acute shortage of labour at the time of transplanting weeding and harvest of rice crops. These may be some of the reasons for no allowing the coming up of paddy crop in Samrat Ashok Sagar command

The cropping intensity of Rabi is proposed to be 90% against the total intensity of project of 135%.

There is no provision of summer irrigation in the project command,although sufficient water is available in the reservoir.

Crop Plan as per National Water Management Project (NWMP)

In order to improve utilisation of water the Govt. of India launched the National Water Management Project with assistance of World Bank. In view of above, a cropping pattern was proposed based on past and present cultivation practices. Main crops proposed was soybean in Kharif

while wheat and gram in Rabi with 140% cropping intensity. The cropped area proposed by NWMP is soybean (13,000 ha), wheat HYV (10,000 ha), wheat Desi (8000 ha) and Gram (8000 ha).

V. SOCIO ECONOMIC STATUS

Socio-economic status and fooding habits of the people affect cultivation and selection of crop. The tenancy status is another important factor influencing farm developments and intensification of crop cultivation. Nearly 56% of the farm families, covering 19% of land in the command are of size less than 1 ha while only about 5% of farm families covering 35% of the total land are larger than 4 ha. This reveals the fact that there is a great disparity in the size of holding. The distribution of land holding is given in table 5.1.

The average net benefit obtained by the farmers in the cultivation of various crops in the command as reported by Srivastava (2002) is Rs.5825 in soybean, Rs.6350 in groundnut, Rs.3780 in maize, Rs.6030 in redgram, Rs.5030 in Blackgram, Rs.5030 in green gram, Rs.6178 in paddy, Rs.4190 in sorghum, Rs.4405 in vegetable, Rs,10960 in cotton, Rs.24,450 in sugarcane, Rs.6375 in wheat HYV, Rs.4170 in wheat local, Rs.9750 in gram, Rs.3980 in barley, Rs.6150 in pea, Rs.5130 in lentil, Rs.7950 in mustard, Rs.7950 in linseed, Rs.8210 in safflower, Rs.12780 in berseem, Rs.16880 in potato, Rs.8560 in tomato and Rs.14760 in cauliflower.

Table 5.1 : Distribution of Land holding size in command

Sl.No.	Average size of holding in ha		Total no. of land holding	Percentage
1.	0 –1 ha	Marginal	7019	56.00%
2.	1-2 ha	Small	2781	22.00%
3.	2-4 ha	Medium	2300	18.50%
4.	4.40 ha	Large	370	3.00%
5.	Above 40 ha		65	0.50%

VI. CLIMATE

The climate of the project area has well defined seasons and is suitable for cultivation throughout the year. This area receives rainfall entirely from the south-west monsoon which breaks in by the second week of June and lasts till end of September and the climate remains dry during rest of the year. Over 90% of the total rainfall takes place during June to September and is uniformly distributed. The minimum temperature is in the months of December to February with an average temperature ranging from 9^{o}C to 30^{o}C. It begins to rise by middle of February and attains the maximum during May which is the hottest month of the year. The temperature ranges from 12^{o}C to 44^{o}C. The maximum average humidity of 87% (morning) and 77% (evening) is observed in the month of August. Humidity is very low in dry weather season and is maximum in monsoon season.

Weather data 1991-2000 of the command was collected and evapotranspiration of the reference crop (ETo) was calculated by Modified Penman method (Doorenbos & Pruitt, 1977). The annual average Eto was worked out to be 1775.80 mm. Monthly details are presented in Table 6.1.The average annual rainfall was also worked out to be 1099.47 mm. Monthly details are given in Table 6.1. The area can be agroclimatically classified as SEMIARID.

Crop Water Requirement Estimation

The crop water requirement was estimated for various crops proposed in different cropping patterns as per the Design Series Technical Circular No.25 Published by M.P. Irrigation Department.

Water availability at the project head was also determined from the daily discharge recorded and shown in Table 6.1. The estimate furnished in Table 6.1 shows that the total availability of water in the command is 22695 ha.m and the proposed all cropping patterns need less than this amount Since the area is very poor in ground water potential the same was not considered.

Table 6.1: Monthly ETo (mm), Rainfall (mm), Water available (ha-m) and water requirements for different cropping patterns in Samrat Ashok Sagar Command.

Months	Total (mm)		Water Availa-ble (ha-m)	Crop Water Required for different Cropping Patterns (ha.m)					
	ETo	Rain		Desig-ned	NWMP	Prop.1	Prop.2	Prop.3	Prop.4
Jan	112.5	9.1	1000	155.6	0	199.6	310.0	383.4	495.8
Feb	119.6	8.0	1500	1092.6	1625.0	2062.1	1584.9	1492.7	1264.2
March	151.6	11.3	500	1545.4	0	430	430	430.0	462.1
April	168.1	7.7	0	0	0	0	0	0	0
May	190.7	12.6	500	842.8	0	284.5	234.5	255.7	297.1
June	153.4	123.4	1500	1766.8	1600	1086.6	1092.9	1537.5	1923.2
July	120.5	356.3	3822	3652.8	3482.4	3455.2	3687.0	3520.6	3986.4
Aug.	108.2	326.0	3000	3215.8	3422.6	2778.1	2949.0	2971.1	3285.9
Sept.	122.9	178.8	4303	4715.4	4848.2	4133.0	4200.0	4304.8	4295.8
Oct.	131.5	47.4	4303	4061.6	3893.4	3535.3	3503.2	3647.5	3309.3
Nov.	117.4	2.6	1800	2097.4	1640.0	2028.2	1861.7	2106.9	1602.4
Dec.	111.2	16.3	467	349.6	0	175.9	696.5	339.8	607.3
Total	**1597.6**	**1099.7**	**22695**	**23495.3**	**20511.5**	**20168.4**	**20549.8**	**20990.0**	**21529.6**

VII. LINEAR PROGRAMMING MODEL FOR THE STUDY AREA

The model is formulated for the command area of Samrat Ashok Sagar project, District Vidisha, Madhya Pradesh in order to suggest an optimal cropping pattern for the project command.

Objective Function: Maximization of net benefits

The cropping pattern is proposed keeping in view the food habits, climate, marketability, cultivation practices etc. for the command. Net benefit from each crop is calculated and given in section. The formulated objective function in the otpimization run VI is as follows :

Maximize $Z = 5825\ X_1 + 6350\ X_2 + 3780\ X_3 + 6030\ X_4 + 5030\ X_5$
$+ 5030\ X_6 + 6178\ X_7 + 4190\ X_8 + 4405\ X_9 + 10960\ X_{10}$
$+ 24450\ X_{11} + 6375\ R_1 + 4170\ R_2 + 9750\ R_3 + 3980\ R_4$
$+ 6150\ R_5 + 5130\ R_6 + 7950\ R_7 + 7950\ R_8 + 8210\ R_9$
$+ 12780\ R_{10} + 16880\ R_{11} + 8560\ R_{12} + 14760\ R_{13}$

whereas $X_1, X_2 \ldots\ldots X_{11}$ and
$R_1, R_2 \ldots\ldots R_{13}$ are assigned to areas)ha) under following crops respectively.

Kharif crops		**Rabi crops**	
X_1	Soybean	R_1	Wheat (HYV)
X_2	Groundnut	R_2	Wheat (local)
X_3	Maize	R_3	Gram
X_4	Red gram	R_4	Barley
X_5	Black gram	R_5	Pea
X_6	Green gram	R_6	Lentil
X_7	Paddy (rice)	R_7	Mustard
X_8	Sorghum	R_8	Linseed
X_9	Vegetable	R_9	Safflower
X_{10}	Cotton	R_{10}	Berseem
X_{11}	Sugarcane	R_{11}	Potato
		R_{12}	Tomato
		R_{13}	Cauliflower

Constraints

(i) Water availability constraints

The monthwise gross irrigation requirement for each crop and as a whole gross irrigation requirements for each crop is taken from crop water requirement tables for different run. The gross irrigation requirement in any month by all the crops grown in that month is considered to be not more than the water available for utilisation in that month.

The water constraints are as follows :

$0.125\ X_1 + 0.156\ X_2 + 0.125\ X_3 + 0.349\ X_4 + 0.473\ X_5$
$+ 0.435\ X_6 + 0.628\ X_7 + 0.142\ X_8 + 0.125\ X_9 + 0.359\ X_{10}$
$+ 1.185\ X_{11} \leq 4800$ (water available in Kharif in ha-m)

Similarly,

$0.811\ R_1 + 0.700\ R_2 + 0.629\ R_3 + 0.629\ R_4 + 0.423\ R_5 + 0.556\ R_6$
$+ 0.624\ R_7 + 0.624\ R_8 + 0.624\ R_9 + 1.071\ R_{10} + 0.667\ R_{11} + 0.560\ R_{12}$
$+ 0.321\ R_{13} \leq 17600$ (water available in Rabi in ha-m)

(ii) Land availability constraints

In these constraints, the cropping intensity is considered and fixed to a limit of 146% (56% kharif and 90% Rabi). Also keep in mind that sowing area of kharif or Rabi crop may not exceed the designed C.C.A. of Left bank and Right Bank Canal. The constraints equations under this run VI are as follows :

Kharif Area

$$X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 + X_8 + X_9 + X_{10} + \leq 15750$$

$$R_1 + R_2 + R_3 + R_4 + R_5 + R_6 + R_7 + R_8 + R_9 + R_{10} + R_{11} + R_{12} + R_{13} \leq 25200$$

(iii) Minimum Area Constraints

Minimum area for each crops taken in proposed cropping pattern has been fixed as per the food habits, cultivation practices and marketing facilities of that area. The constraints equations for cropwise minimum area are formulated as :

Kharif Crops :

(i) Minimum area for soybean in ha
$X_1 \geq 6000$

(ii) Minimum area for groundnut in ha
$X_2 \geq 1000$

(iii) Minimum area for maize in ha
$X_3 \geq 500$

(iv) Minimum area for red gram in ha
$X_4 \geq 500$

(v) Minimum area for black gram in ha
$X_5 \geq 500$

(vi) Minimum area for green gram in ha
$X_6 \geq 1500$

(vii) Minimum area for paddy (rice) in ha
$X_7 \geq 1500$

(viii) Minimum area for sorghum in ha
$X_8 \geq 1000$

(ix) Minimum area for vegetables in ha
$X_9 \geq 500$

(x) Minimum area for cotton in ha
$X_{10} \geq 1000$

(xi) Minimum area for sugarcane in ha
$X_{11} \geq 1000$

Rabi crops

(xii) Minimum area for wheat (HYV) in ha
$R_1 \geq 7500$

(xiii) Minimum area for wheat (local) in ha
$R_2 \geq 7500$

(xiv) Minimum area for gram in ha
$R_3 \geq 2000$

(xv) Minimum area for barley in ha
$R_4 \geq 1000$

(xvi) Minimum area for pea in ha
$R_5 \geq 1000$

(xvii) Minimum area for lentil in ha

$R_6 \geq 500$

(xviii) Minimum area for mustard in ha

$R_7 \geq 1000$

(xix) Minimum area for linseed in ha

$R_8 \geq 500$

(xx) Minimum area for safflower in ha

$R_9 \geq 500$

(xxi) Minimum area for berseem in ha

$R_{10} \geq 500$

(xxii) Minimum area for potato in ha

$R_{11} \geq 1000$

(xxiii) Minimum area for tomato in ha

$R_{12} \geq 500$

(xxiv) Minimum area for cauliflower in ha

$R_{13} \geq 500$

Using the above model, various linear programming optimal plans have been prepared considering different combinations of constraints in order to arrive at an optimal one. An abstract of various optimal plans studied under linear programming model are enlisted in Table 7.1 & Fig. 7.1.

The run number six was found to utilise the allocated water resources of the project. The crop pattern decided in the output satisfied the food, fibre, sugar, pulse, oil etc. requirements and fetched a net benefit of Rs.29.34 crores which is the highest out of all the alternate crop plan tried. Thus the crop plan calculated through run 6 soybean (16.22%), groundnut (2.45%), maize (2.45%), red gram (1.22%), blackgram (1.22%), green gram (3.67%), paddy (3.67%), sorghum (2.45%), vegetable (1.22%), cotton (2.45%), sugarcane (2.45%), wheat (HYV) (18.35%), wheat (local) (18.3%), gram (4.90%), barley (2.45%), pea (2.45%), lentil (1.22%), mustard (2.45%), linseed (1.22%), safflower (1.22%), berseem (1.22%), potato (5.31%), tomato (1.22%) and cauliflower (1.31%).

VIII. DISCUSSION

In most of the irrigated areas, specially in the canal command, cropping pattern has become monotonous. This has caused many adverse effects on soil fertility and crop productivity particularly by exhausting the rootzone soil nutrients and allowing soil borne pathogens to establish in it. Soil nutrients can somehow be replenished using industrial products but the pathogenicity built once in the soil will not be easily curable even by using costly pesticides.

The exiting cropping pattern of Samrat Ashok Sagar Project command is predominantly soybean based. Since this is a low water requiring crop it is causing a direct annual loss of irrigation revenue to the Government of M.P. In order to avert such an aggravating situation the cropping pattern in run 6 is found to be optimum and diversified in nature to fetch the annual net return of Rs. 29.34 crores annually and satisfying the agricultural food needs of the command people.

Table 7.1: Comparative Statement of Optimal Crop plan optained thorogh different Runs

Crops	Optimal Cropped Area in different Runs (ha)						
	Run I	**Run II**	**Run III**	**Run IV**	**Run V**	**Run VI**	**Run VI**
Kharif							
Soyabean	13000.00	6183.00	6750.00	2500.00	6000.00	6620.00	12500.00
Groundnut	0.00	1396.00	1396.00	0.00	1000.00	1000.00	0.00
Maize	0.00	2792.00	2792.00	0.00	500.00	500.00	250.00
Red Gram	0.00	1116.00	1116.00	0.00	500.00	500.00	250.00
Black Gram	0.00	238.00	238.00	0.00	500.00	500.00	0.00
Green Gram	0.00	838.00	1256.00	0.00	1500.00	1500.00	0.00
Paddy	0.00	1396.00	1396.00	0.00	1500.00	1500.00	0.00
Sorghum	0.00	838.00	838.00	0.00	1000.00	1000.00	0.00
Vegitable	0.00	558.00	558.00	0.00	500.00	500.00	0.00
Cotton	0.00	0.00	0.00	12500.00	1000.00	1000.00	0.00
Sugercane	0.00	0.00	0.00	0.00	1000.00	1000.00	0.00
Rabi							
Wheat (Hyv)	10000.00	11170.00	11170.00	0.00	7500.00	7500.00	8750.00
Wheat (Local)	8000.00	6981.00	6981.00	0.00	7500.00	7500.00	6250.00
Gram	8000.00	1396.00	1395.00	0.00	2000.00	2000.00	7500.00
Barley	0.00	0.00	0.00	0.00	1000.00	1000.00	0.00
Pea	0.00	558.00	558.00	0.00	1000.00	1000.00	500.00
Lentil	0.00	558.00	558.00	0.00	500.00	500.00	2000.00
Musturd	0.00	838.00	838.00	0.00	1000.00	1000.00	0.00
Linseed	0.00	698.00	698.00	0.00	500.00	500.00	0.00
Safeflower	0.00	0.00	0.00	0.00	500.00	500.00	0.00
Berseem	0.00	672.50	798.00	0.00	500.00	500.00	0.00
Patato	0.00	306.50	280.00	24000.00	1000.00	2165.60	0.00
Tomato	0.00	280.00	280.00	0.00	500.00	500.00	0.00
Cauliflower	0.00	280.00	280.00	0.00	500.00	535.40	0.00
G.C.A. (ha)	**39000.00**	**39093.00**	**40176.00**	**39000.00**	**39000.00**	**40821.00**	**38000.00**
C.C.A. (ha)	**27924.00**	**27924.00**	**27924.00**	**27924.00**	**27924.00**	**27924.00**	**27924.00**
C.I. (%)	**139.66**	**140.00**	**143.88**	**139.66**	**139.66**	**146.19**	**136.08**
Net Benefit (Rs. Crores)	**25.08**	**23.49**	**24.34**	**55.66**	**26.95**	**29.33**	**24.35**

Note: C.I. : Cropping Pattern
Run I : NWMP proposal
Run II : Cropping pattern (22 crops) without cotton and sugarcane (140% CI)
Run II : Cropping pattern (22 crops) without cotton and sugarcane (145% CI)
Run IV : Cropping pattern (24 crops) with cotton and sugarcane (140% CI)
Run V : Utility based Crop pattern (140% CI)
Run VI : Utility based Crop pattern (146% CI)
Run VII : Existing Cropping pattern

IX. CONCLUSION

Imposing a cropping pattern on farmers in the existing geopolitical condition of India is very difficult. The gross deviation in the cropping pattern of Samrat Ashok Sagar Project from the proposed one is a living example. Since the lob sided development in cropping pattern in a given area may cause many social (imbalancing supply and demand of agricultural produce) and technical (under utilisation of reservoir water or soil fertility imbalance) problems, a diversified cropping pattern is essential. The present study with a crop plan of 24 crops and 146% cropping intensity and the net benefit of Rs. 29.34 crores in the command is suggested. The adoption of this cropping pattern may help overcoming the problem of under utilisation of water, normalising the dominance of soybean crop and improving the socio-economic status of the farmers. The Government(s) concerned may attempt adopting extension techniques to popularise the diversified cropping pattern proposed.

REFERENCES

1. Anonymous (1978), Halali Project (Samrat Ashok Sagar) Irrigation cum flood protection scheme Vidisha and Raisen Distt. Of Madhya pradesh. A Project Report published by Chief Engg., Chambal Betwa Basin, Irrigation Department, Bhopal.

2. Annonymous (1999), Estimateion of crop water requirement and irrigation water requirement, Design series technical circular No.25, Published by M.P. Irrigation Department.

3. Anonymous (1999), Samrat Ashok Sagar Project (Halili) Vidisha and Raisen Distt. A Project Report published by Chief Engg., Operation & Maintenance WRD Bhopal

4. Doorenbos, J. and Pruitt, W.O. (1977), Guidelines for Predicting crop water requirement, FAO Irrigation & Drainage Paper No.24, Published by FAO Rome (Italy).

5. Gupta, A.K. (2000), Impact Evaluation of water users society in the command of Samrat Ashok Sagar Project, M.E.(IWM) Dissertation submitted to University of Roorkee in partial fulfilment of the requirement.

6. Shrivastava, P.K. (2002), Cropping pattern analysis in command of Samrat Ashok Sagar Project in Madhya Pradesh.

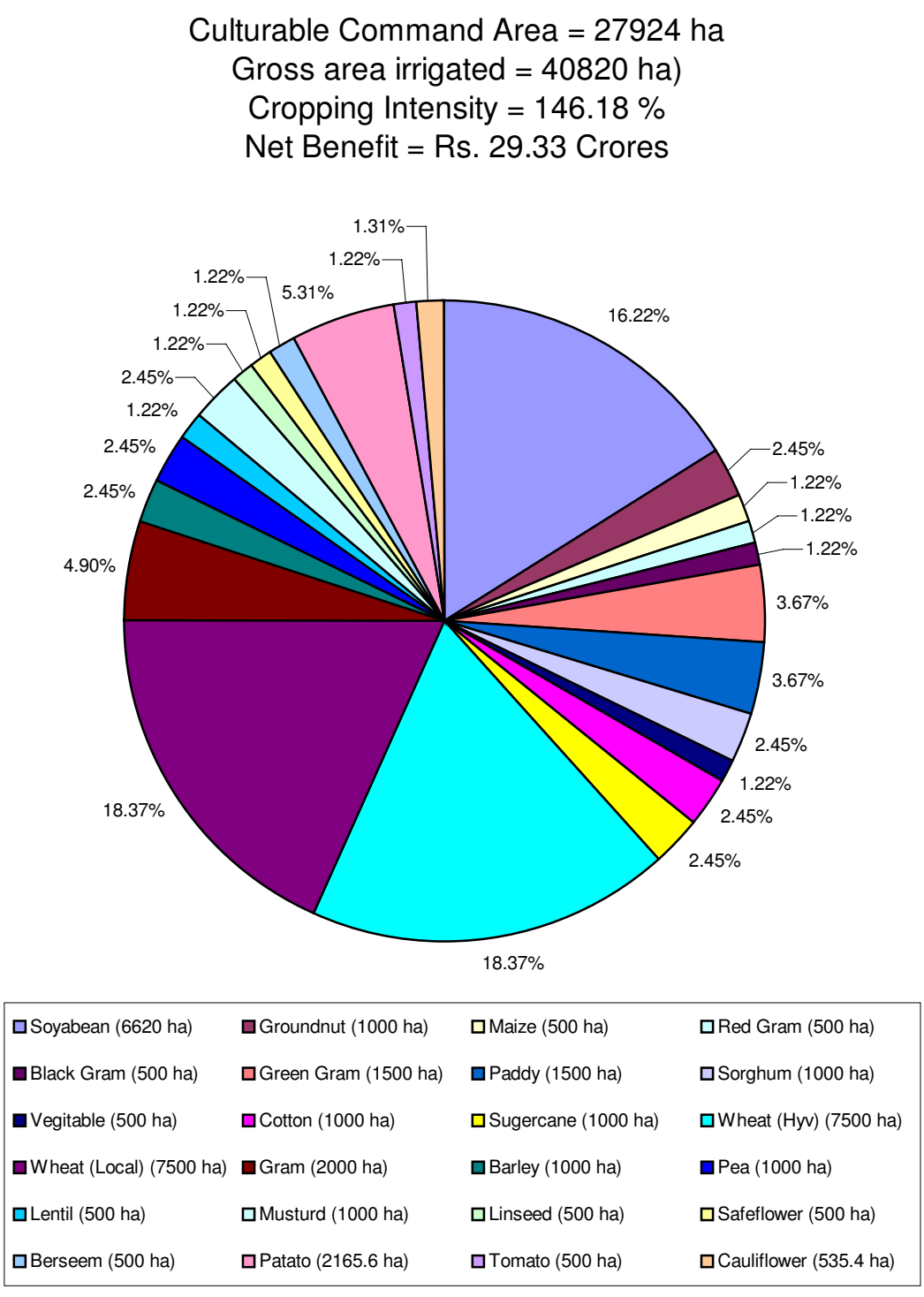

Fig. 2: Optimal Cropping Patter for Samrat Ashok Sagar Project (M.P.)