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Resource appraisal of Damodar catchment (part) in Barddhaman district, West Bengal

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Abstract : Four soil series (Inceptisol) identified through detailed soil survey (1:4000 scale) have been evaluated for land capability and suitability for rice, potato, gram, sesame, mustard and vegetables. The study of different socio-economic parameters indicate that medium (2-10 ha) and marginal (<1 ha) group dominates the farming community sharing 38.74 and 35.21 per cent of total population respectively. Based on soil-site suitability of different crops and constraints perceived by different group of farmers, different crop sequence have been formulated. Rice-potato-sesame in Syamsundarpur I soil series have been suggested for large and medium farmers. *Citronella* plant may be introduced by them in culturable permanent fallow land. Rice-vegetable-blackgram is best suited crop rotation for small and marginal farmers in Naopara soil series.

Additional key words : *Soil-taxonomy, soil-site-suitability, suggested land use*

Introduction

Growing demand of food with outburst of huge population is posing threat to our ecosystem due to continuous mining of vital natural resources like soil and water. Despite remarkable achievement in agricultural production, unscientific conversion of the traditional land-use is creating unprecedented problems for the existing ecosystem. So it is essential to maintain a balance in potential use of natural resources in agro-ecosystem, selection of suitable crops and their effective management, judicial use of agricultural inputs and demand based production for developing an optimum land use plan (Chattopadhyay 1997). The present study aims to identify the existing resources in the catchment areas and to make their best utilization through optimum land use planning at village level.

Methodology

The study was carried out in three villages *viz.* Syamsundarpur, Naopara and Kantia lying in between 23°14'05" to 23°15' 30" N and 87°55'00" to 87°56' 20" E covering 365 ha in Barddhaman sadar block, Barddhaman, West Bengal. The area belongs to hot, moist, sub-humid agro-ecological region (Velayutham *et al.* 1999). Double to multicropping practices are followed by utilizing surface water (DVC canal) and subsurface water (through submersible and deep tubewell). Soil series have been identified on 1 : 4000 scale through detailed soil survey (IARI 1970) and classified as per Soil Survey Staff (1998). These have been described as surface, subsurface (upto 50 cm) and subsoil (up to 100 cm). Soils have been analyzed for physico-chemical properties (Jackson 1973) and fertility status (Page *et al.* 1982). Quality of irrigation water was estimated according to the procedure followed by Tandon (1999). Land evaluation was done according to Riquier (1970) and Storie (1954). Soils were evaluated for suitability of major crops using the methods suggested by FAO (1976) and Sys *et al* (1993).

Farmers selected through random sampling technique (Ray and Mondal 1999) were interviewed as per schedule (Sarker and Sinha 2003) for projecting their socio-economic conditions. Participatory rural appraisal technique (Ray 1996) was applied to evaluate constraints and opportunities towards cultivation of crops.

Results and Discussion

Land use planning of an area requires a minimum data set of natural resources in terms of soil, water and socio-economic issues. Integrating these components with scientific wisdom will facilitate the transfer of technology at farmers level and makes the land use plan easily adoptable and economically viable. The study area is a high potential zone of natural and biological resources. Natural resources mainly comprise of soil and water, where as biological resources deal with human population and stock of animals.

Soil resources

Four soil series have been identified in the study area through detailed soil survey on 1:4000 scale and mapped at phase level of soil series (Fig 1). Syamsundarpur I soil series (SM I) developed on highland are deep, well drained, slightly acidic (pH 6.3 to 6.7) with low CEC (10.2-14.0 cmol(p^+)kg^{-1}) and high base saturation (79-84%). Surface soils are characterized as low in available N (245 kg ha^{-1}), high in P_2O_5 (70 kg ha^{-1}) and medium in K_2O (162 kg ha^{-1}). Syamsundarpur II soil series (SM II) developed on medium land are deep, moderately well drained, slightly acidic to neutral (pH 6.0 to 7.0) with moderate CEC (18.5 – 19.6 cmol (p^+) kg^{-1}) and high base saturation (79-96%). Surface soils are characterized as medium in available N (272 kg ha^{-1}), high in P_2O_5 (80 kg ha^{-1}) and high in K_2O (340 kg ha^{-1}). Naopara soil series (NA) developed on midland are deep, imperfectly drained, moderately to slightly acidic (pH 5.3 to 6.6) with low to moderate CEC (14.6 – 19.5 cmol(p^+)kg^{-1}) and high base saturation (72–93%). Surface soils are characterized with medium available N (345 kg ha^{-1}), high P_2O_5 content (110 kg ha^{-1}) and high K_2O content (385 kg ha^{-1}). Kantia soil series (KA) developed on lowland are deep, poorly drained, slightly acidic to neutral (pH 6.0 to 7.2) with high CEC (22.4 – 28.7 cmol (p^-) kg^{-1}) and high base saturation (79–93%). Surface soils are characterized with low available N (275 kg ha^{-1}), high P_2O_5 (90 kg ha^{-1}) and medium K_2O (220 kg ha^{-1}).

Water resources

River and canal are main sources of surface irrigation and covers 62.35 per cent of the study area. The area also receives pond irrigation which covers only 4.86 per cent of the area (table 2). Ground water has been utilized for irrigation through deep-tubewell and shallow pump covering 26.44 per cent of the area. Cultivation of crops in *rabi* season in KA and SM I and SM II soil series is dependent on ground water resources.

Table 1. Physico-chemical properties and fertility status of soil series

	Physico-chemical properties				Fertility			
Depth (cm)	**pH (H_2O)**	**Org. C. (%)**	**Clay (%)**	**CEC cmol(p+) kg^{-1}**	**B.S. (%)**	**N (kg ha^{-1})**	**P_2O_5 (kg ha^{-1})**	**K_2O (kg ha^{-1})**
Syamsundarpur I (SM I) soil series :Fine loamy, mixed, hyperthermic Typic Haplustepts								
Surface (0-16)	6.4	0.44	18.5	10.2	79	245	70	162
Sub-surface (16-60)	6.7	0.21	24.3	12.0	84	182	48	97
Sub soil (60-180)	6.3	0.15	26.5	14.0	82	102	27	43
Syamsundarpur II (SM II) soil series : Fine, mixed, hyperthermic Aeric Endoaquepts								
Surface (0-14)	6.0	0.98	36.9	18.5	79	272	80	340
Sub-surface (14-67)	7.0	0.21	40.2	19.6	96	196	39	213
Sub soil (67-150)	6.4	0.17	41.8	18.5	89	98	21	134
Naopara (NA) soil series : Fine, mixed, hyperthermic Aeric Endoaquepts								
Surface (0-10)	5.3	0.98	34.9	14.6	72	345	110	385
Sub-surface (10-38)	6.5	0.31	41.8	17.9	89	248	57	274
Sub soil (38-150)	6.6	0.23	43.8	19.5	93	132	23	142
Kantia (KA) soil series : Fine, mixed, hyperthermic Typic Endoaquepts								
Surface (0-15)	6.0	0.73	57.4	22.4	79	275	90	220
Sub-surface (15-59)	6.7	0.25	45.3	24.6	85	178	59	129
Sub soil (59-150)	7.2	0.17	48.8	28.7	93	112	37	62

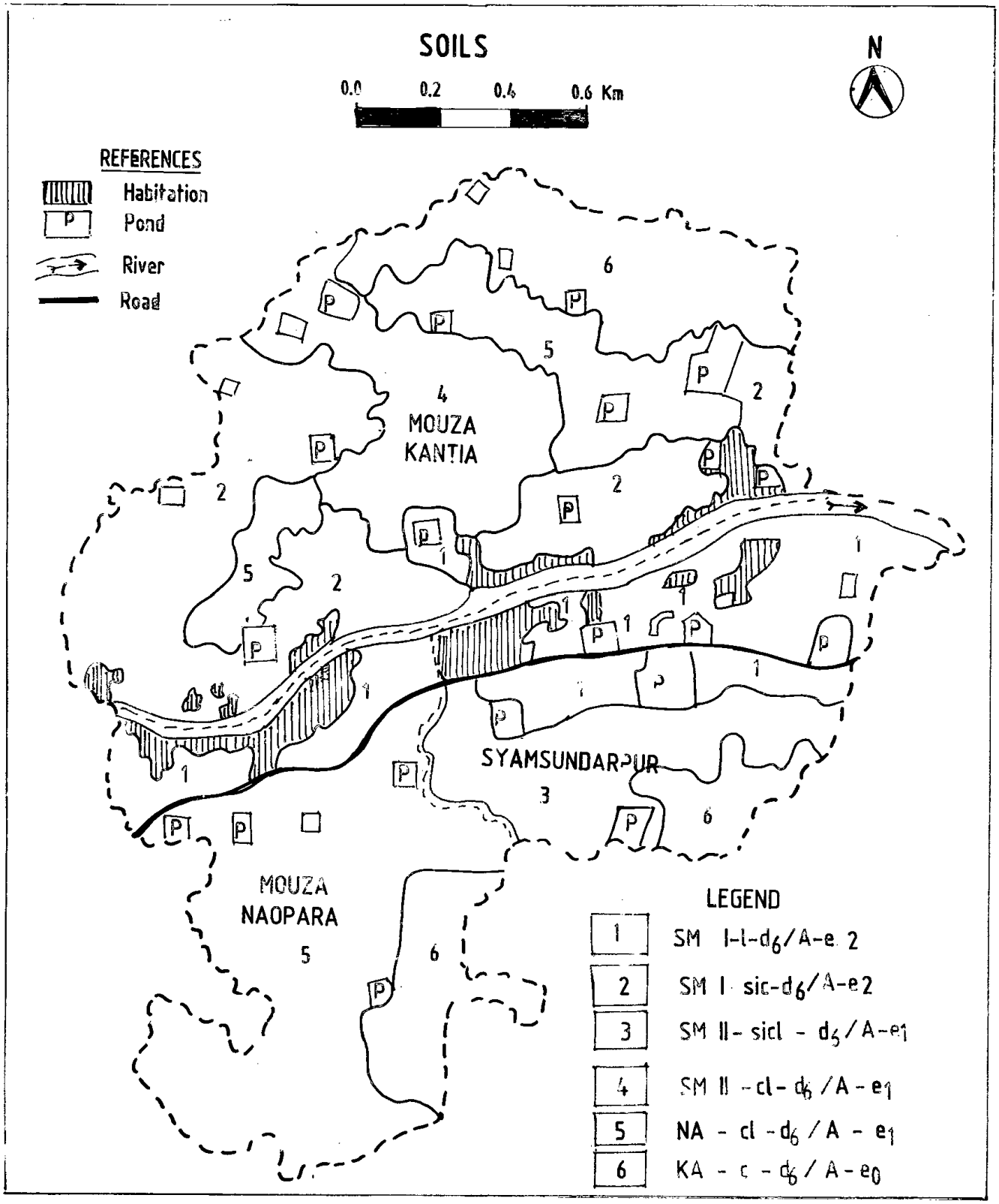

Fig 1. Soil map of Syamsundarpur, Naopara and Kantia village

Table 2. Quality of irrigation water of different sources and their command areas

Source of irrigation	Soils series under command area	Area covered in ha (%)	Properties of water						Constraints
			pH (H_2O)	EC1 (dsm^{-1})	Total ALK[2] (mgL^{-1})	Hardness (mgL^{-1})	DO[3] (mgL^{-1})	TSS[4] (mgL^{-1})	
River	SM I, SM II	62.60 (17.12)	7.6	0.76	82	96	4.6	56.2	Discharge varies according to monsoon
Canal	SM II, NA	165.12 (45.23)	7.2	0.42	76	78	4.2	21.4	Availability of water depending upon time & quantum of discharge of DVC reservoir
Deep-tubewell	SM II, NA, KA	54.14 (14.84)	7.0	0.53	65	94	3.9	16.1	Few in number as operational cost is high
Shallow pump	NA, KA, SM I	42.67 (11.60)	7.1	0.51	61	110	4.1	18.5	Pumps often fails in peak cropping season due to lowering of ground water table
Pond	SM I, NA	4.86 (1.33)	6.8	0.36	89	128	5.6	43.8	Numbers in limited, not properly maintained, lies nearer habitation

* Note: EC[1]: Electrical conductivity, ALK[2] : Alkalinity, DO[3] : Dissolved oxygen, TSS[4]: Total soluble salt

The quality of irrigation water indicates that pH lies in neutral range (6.8 to 7.6) where as EC was recorded low (0.36 to 0.76 dsm^{-1}). Total alkalinity, hardness, dissolved oxygen and total soluble salts were far below the critical limits. But inadequate and untimely supply of canal water and increasing operational cost of lifting under groundwater are major concerns in cultivation.

Socio-economic conditions

Farmers have been grouped under four classes on the basis of their operational land holdings *viz.* marginal (< 1 ha), small (1-2 ha), medium (2-10 ha) and large (>10 ha). There are 125 families in marginal category whereas medium, small and large categories have 96, 49 and 13 families respectively (Table 3). Total population is 1613 and characterized with male-female ratio greater than one. Medium category shares 38.74 per cent of total population followed by marginal with 35.21 per cent, small with 18.16 per cent and large category with 7.87 per cent. The average family size figures as 6 in number. However, it has been recorded that large farmers has biggest family size of 10 followed by medium (7), small

Table 3. Demographic features of different classes of farmers

Farmers class	Characteristics of population			Type of population				Population
(Operational land holdings in ha)	No of house	Family size holds	Male : Female ratio	No of literate	SC	ST	Others	(%)
Large(> 10 ha)	13	10	1.09	125 (7.75)	0	0	127	127 (7.87)
Medium (2 – 10 ha)	96	7	1.03	540 (33.48)	156	51	418	625 (38.74)
Small (1 – 2 ha)	49	6	1.02	230 (14.26)	67	89	137	293 (18.16)
Marginal (< 1 ha)	125	5	1.02	289 (17.92)	198	293	77	568 (35.21)
Total	283	6	1.03	1184 (73.41)	421	433	759	1613 (100)

* Figures in the parentheses are the percentage over total population

(6) and marginal (5). It was also observed that joint family possesses large land holding (>10 ha) while most of the nuclear family is under marginal land holding (1-2 ha) group since division in the family have also caused fragmentation in land holdings.

Schedule cast and schedule tribe contribute 26.10 per cent and 26.84 per cent of total population, respectively. Marginal category is dominated by them contributing 86 per cent of their population.

The average literacy rate has been recorded as 73.41 per cent. It increases with the increasing of land holding status which figures as highest (98.43 per cent) in large category.

Present land use

Rice based cropping system is dominant land use pattern in this area. Rice-rice crop sequence is followed with vegetables and oilseeds in some pockets of upland and medium land. Large and medium farmers mainly cultivate rice in both *kharif* (monsoon) and *rabi* (winter). Cabbage, cauliflower, tomato, chilli, brinjal are grown in kitchen garden. Part of upland areas around the ponds and homestead garden have been kept as fallow land under SM I and SM II soil series.

Land holdings and food production

Medium farmers possess largest area of land (40.94 per cent) followed by large (35.24 per cent), small (13.30 per cent) and marginal (10.52 per cent) farmers (Table 4). The study indicates that comparatively more people depend on SM I soil series whereas the number of people depending upon NA soil series was lowest since 55.12 per cent of the NA soil series was owned by medium class of farmers. Marginal farmers had also a good share of land in upland (14.3 per cent) which are utilized by them for vegetable cultivation.

Table 4. Land owned by different farmer class *vis-à-vis* their food production.

Farmers class	Area (ha) in soil series owned by different classes				Distribution of land (series wise)	Average per capita production (ton)*
	SM I (%)	SM II (%)	NA (%)	KA (%)		
Large	67.28 (19.22)**	16.40 (4.68)	25.50 (7.28)	14.20 (4.06)	4.74:1.15:1.80:1	5.64
Medium	28.41 (8.11)	32.47 (9.28)	51.95 (14.84)	30.50 (8.71)	1:1.14:1.83:1.07	2.32
Small	25.57 (7.30)	6.10 (1.74)	9.40 (2.69)	5.50 (1.57)	4.65:1.11:1.71:1	0.85
Marginal	20.24 (5.78)	4.80 (1.37)	7.40 (2.11)	4.40 (1.26)	4.6:1.09:1.68:1	0.41

* Production was calculated on rice equivalent basis
** Figures in the parentheses are the percentage over total

Live stock status

Livestock, which serves as a backbone of rural agriculture includes animals and poultry. Large farmer possess average number of 6 cattle (table 5) but marginal farmers have a good number of goats representing 49.84 per cent of total goat population. On the contrary, large farmers have less number of goats (1.79 per cent). Social custom plays a factor here against keeping of goats in rural areas by large farmers. Land area under fodder production is very little except 4.67 ha owned by large farmers. Availability of fodder for the domestic animals is not sufficient for medium, small and marginal group of farmers. Shortfall of fodder requirement has been recorded as 47.60 per cent for marginal farmers followed by 27.20 per cent and 15.8 per cent for small and medium farmers respectively.

Table 5. Livestock of the study area.

Farmer class	No. of animals (%)			Poultry birds (hens & ducks)	Area (ha) under fodder	Annual fodder production* (ton)	Actual requirement (ton)
	Cattle	Goat	Total				
Large	71 (6.44)	11 (1.00)	82 (7.44)	548 (22.57)	4.67	681.6	330.1
Medium	196 (17.79)	168 (15.24)	364 (33.03)	879 (36.20)	0.90	836.4	993.4
Small	175 (15.88)	130 (11.80)	305 (27.68)	420 (17.30)	0.09	636.6	874.5
Marginal	44 (3.99)	307 (27.86)	351 (31.85)	581 (23.93)	-	202.2	385.9
Total	486 (44.10)	616 (55.90)	1102 (100)	2428 (100)	0.71	2356.8	2583.9

* Fodder production calculation include total straw production

Relationship between social factors with food production

Productivity and land use efficiency of an area reflect the extent and degree of utilization of natural resources in agriculture (Mukhopadhyay *et al* 2004). Pearson chi square test have been used to know the extent of association between productivity and land use efficiency with socio economic factors *viz.* land holdings, family size, literacy, caste and average livestock number (table 6). Utilization of natural resources has been greatly influenced by socio-economic status of the farming community of the area. The similar finding has been reported by Ramesh Kumar *et al* (1997). Now effective land use plan needs a better integration between existing natural resources, available technology and socio-economic status of farmers.

Constraints perceived by the farmers

Farmers come across different types of problems in agriculture. Ten problems (I – X) have been identified and rated different by different class of farmers according to their degree of severity (table 7). Winter rice cultivation in some parts of the area under SM II and KA soil series suffers severely due to non-availability of canal water of Damodar. Non-availability of agricultural labour and family labour (person) have been identified as major constraints which demotivate large and medium farmers to go beyond traditional rice-rice cropping system to cultivate other crops/ vegetables. Increasing cost of irrigation and inadequate storage facility force them to keep a part of their land fallow in winter season. Poor financial conditions, fluctuation of market price and high price of irrigation water are the main constraints for small and marginal farming community. Limited knowledge of soils and lack of suitable crop calendar restrict them to switch over to alternate cropping pattern.

Interpretation of soils

The four soil series belong to land capability class II with varying degree of limitations of erosion (e) and soil (s) (table 8). SM II and NA soil series have been

Table 6. Relationship between socio-economic factors and crop production.

	Parameters	x^2 test value		Parameters	x^2 test value
Productivity vs	Land holding	13.1*	Land use efficiency vs	Land holding	19.4**
	Family size	14.4*		Family size	21.3**
	Cast	12.7*		Cast	18.6**
	Literacy	9.5 NS		Literacy	12.6*
	Avg. livestock no.	18.1**		Avg. livestock no.	15.9 *

*** Significant at 1% level; *Significant at 5% level; NS : Not significant*

Table 7. Constraints perceived by the farmers of the study area

Sl.No	Parameters	Large	Medium	Small	Marginal
1.	Non-availability of agriculture labour	I	II	X	IX
2.	Fluctuation of market price	IV	III	III	II
3.	Lack of storage facility	III	IV	VI	VIII
4.	Lack of machinery for irrigation in time	VIII	VII	II	III
5.	Lack of own farm machinery	IX	X	IV	IV
6.	Lack of family labour	II	I	IX	X
7.	Need of transfer of technology	VI	V	VII	VI
8.	Lack of soil test facility	V	VI	VIII	VII
9.	Lack of monetary investment	X	IX	I	I
10.	Lack of communication & transport facility	VII	VIII	V	V

Table 8. Interpretative groupings of the different soil series.

Soil series	Land capability class	Soil irrigability class	Land irrigability class	Productivity class (P)		Storie index rating
				P (actual)	P' (potential)	
SM I	IIe	A	1	3 (Average)	2 (Good)	III (Fair)
SM II	IIw	A	2	2 (Good)	1 (Excellent)	I (Excellent)
NA	IIw	A	2s	2 (Good)	1 (Excellent)	I (Excellent)
KA	IIws	C	3sd	4 (poor)	3 (Average)	IV (Poor)

rated as good where as KA soil series belongs to poor irrigability class due to poor drainage and basin shape micro-landform. Potential productivity and Storie index rating indicate their high inherent capacity towards maximum crop production. KA soil series have been rated average to poor due to excessive clay content and poor drainage leading to adverse micro pedo-environment in root zone except for rice crop.

Soil site suitability of different crops

Soil resource informations have been utilized to evaluate soil-site suitability of major crops by limitation approach (Sys *et al* 1993). It has been carried out by comparing existing soil characteristics and actual requirement of that by specific crop. Suitability classes are marked as highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and temporarily unsuitable (N1) for

Table 9. Soil-site suitability of dominant crops.

Soil series	Crops								Suggestion
	Rice	Mustard	Sesame	Potato	Gram	Tomato	Cabbage	Cauli-flower	
SM I	S3	S2	S1	S1	S1	S1	S1	S1	Cultivation of rice is limited due to poor water holding capacity at high land situation
SM II	S2	S1	S1	S2	S2	S1	S1	S1	*Rabi* crops and vegetables are highly suitable
NA	S1	S1	S1	S2	S2	S2	S2	S2	Due to high water retention characteristics *rabi* crop may be raised
KA	S1	S3	S3	N1	N1	N1	N1	N1	Due to heavy texture, poor drainage and low land situation vegetable cultivation may be avoided.

S1 : Highly suitable; S2 : Moderately suitable; S3 : Marginally suitable; N1 : Temporarily suitable

a particular crop. Rice is highly suitable in NA and KA soil series (table 9) where as potato is highly suitable in SM I. Sesame is highly suitable in SM I, SM II and NA soil series. Vegetables are moderate to highly suitable in SM I, SM II, NA soil series. Vegetable cultivation is not suitable in KA soil series due to poor drainage.

Land use planning

Land use planning at village level indicates the use of agriculture lands to best suited crops and permanent fallow land to other economic uses. Based on characteristics of land features, soil resources, irrigation facility, land holding size, economic status of farmers, social acceptability and local market demand, crop planning in agricultural land have been formulated for successful agriculture.

Availability of resource component of farming system varies with farmers class (table 10). Irrigation facility, power machine, storage facility, capacity for investment in inputs and other agricultural operations are well balanced by large farmers. Marginal and small farmers are not able to provide required inputs in agriculture as they depend on agriculture for their total livelihood. Irrigation facility have been identified as one of the main constraints followed by their poor financial condition.

Suggested land use for large and medium farmers

Rice is grown mostly in piece of land as rainfed crop in rainy season. In winter season, boro rice is cultivated as traditional crop in NA, SM II and KA soil series. This crop is cultivated under assured irrigation. Erratic supply of canal water, lowering of ground water depth and huge investment of capital in cultivation has warranted to replace boro rice with suitable alternate crop. In winter season, SM I soils on upland and SM II soils on midland may be brought under potato cultivation which generally gives high economic return (Gupta *et al* 1999). Some part of NA soils under the midland may also be brought under mustard and vegetables. Lands are generally left vacant in pre-monsoon. With residual moisture and nutrient reserve, sesame can be grown in this period. Low water requirement and less incidence of insect and pest attack favours this crop (Vyas *et al.* 1987). A part of the fallow land on upland and midland may be brought under fodder cultivation in pre-monsoon (Singh *et al.* 1997). Fodder cultivation should be initiated by large and medium farmers which will fill the gap between fodder production and it's consumption in the village. Permanent fallow land belonging to SMI and SM II soil series can be utilized for plantation of different fruit trees like mango, guava, coconut at small scale. Plantation of segun, mehagini etc. under social forestry may be encouraged. *Citronella* cultivation have been introduced on permanent fallow land that gives a good economic return. Oil extracted from *citronella* leaves are effectively used for mosquito as repellents and other uses. Considering all factors, different crop sequence have been worked out in different soil series (table 11). Rice-potato-fodder crop, rice-potato-sesame, rice-potato-greengram are the important crop sequence which can increase the operational land holdings upto 28.6 per cent and per capita production up to 39.2 per cent in case of large and medium class of farmers.

Suggested land use for small and marginal farmers

Suggested land use for small and marginal farmers aims at maximum utilization of land and water resources without deteriorating soil health and creating maximum man days of employment in agriculture. Rice is cultivated in *kharif* season without choice to fulfill the family consumption. In the *rabi* season, land with marginal farmers may be brought under oilseeds and vegetables. Sesame is highly suitable (S1) in all soil series except Kantia and requires less capital investment. Potato and other vegetables may be grown in SM I, SM II and NA soil series which will create additional months of employment and give good economic return due to easy market accessibility and demand. Tomato which have low cost of cultivation, can be cultivated in SM II and NA soil series. In pre-monsoon, blackgram, a short duration crop may be included in crop rotation with low irrigation requirement. It indicates that 20.7 per cent increase in operational landholding with an increase of 41.6 per cent for per capita production may be achieved for small farmers in SM I soil series (table 12).

Table 10. Different resource component of farming system.

Farmers class	Land type		Population pressure (ha/100 person)	Nature of irrigation	Soil potential	Factors influencing land use planning	
	Cultivated	Fallow				Existing	To be improved
Large	108.72 (31.05)	14.66 (4.19)	73	High 84.4 % by FOF[1] 15.6 % by FPID[2]	67.78 ha well drained, light textured soils on upland and 41.9 ha moderately well drained, medium textured soils on midland	Low crop intensity, use of more machine power, low family labour input, availability of storage facility	Crops with minimum nurturing, high market price, insurance covers crop failure, loan available in national bank for farm machinery and crop husbandry
Medium	134.76 (38.49)	8.57 (2.45)	31	Moderate 62.7 % by FOF 30.4 % by FPID 6.9 % by FARB[3]	84.42 ha moderately well drained, medium textured soils with slight problem of acidity in some part on midland and 30.50 ha poorly drained, heavy textured soil on lowland	Crops with minimum supervision, rice based cropping, high input	Stable market price due to demand, storage facility, agriculture loan and insurance cover
Small	46.57 (13.30)	-	12	Poor 9.8 % by FOF 30.4 % by FARB 43.9 % by FPID	25.57 ha well drained, light textured soils on upland and 15.50 ha moderately well drained, medium textured soils on midland	High cropping intensity, high family labour input, less involvement of machine power, low monetary involvement	Crops under periodic supervision, low irrigation water requirement, short time investment, storage facility
Marginal	36.84 (10.52)	-	5	Very poor 53.3 % by FARB 46.7 % by FPID	20.24 ha well drained, light textured soils on upland and 12.2 ha moderately well drained, medium textured soils on midland	Production for family consumption, low monetary input, cooperative bank for short time loans	Low irrigation water requirement, high family labour input, short time investment, assistance of panchayat for getting seeds, fertilizer in subsidized rate

[1]FOF : Facility owned by farmers; [2] FPID : Facility provided by irrigation department (Govt.); [3]FARB: Facility available on rent basis.

Table 11. Suggested land use of the study area for large and medium farmers

Soil series	Large farmer				Medium farmer			
	Suggested land use	Total area (ha)	LUE[1]	% increase OLH[2]	% increase PCP[3]	Suggested land use	Total area (ha)	LUE[1]	% increase OLH[2]	% increase PCP[3]
Syamsun-darpur I	(i) Rice– potato-fodder crop	57.78	80 78	28.6	39.2	(ii) Rice- potato-sesame (ii) Rice-mustard-green gram	24.31	78 73 80	28.6	31.3
	(ii) Rice-potato-sesame (i) Mango, guava, bel etc (ii) Citronella/ Social forestry	9.5	-	-	-	(iii) Rice-mustard-fodder crop (i) Mango, guava, bel etc (ii) Citronella/ Social forestry	4.1	-	-	-
Syamsun-derpurII	(i) Rice-potato-rice (ii) Rice-potato-fodder crop	13.6	80 80 73	11.1	19.4	(i) Rice-potato-rice (ii) Rice-potato-green gram	27.17	80 73	10.7	21.4
	(iii) Rice-cabbage/ cauliflower-green gram (i) Mango, guava, bel etc (ii) Citronella/ Social forestry	2.8	-	-	-	(i) Banana (ii) Citronella	5.3	-	-	-
Naopara	(i) Rice-potato-rice (ii) Rice-mustard-rice	25.5	80 80	21.4	37.3	(i) Rice-potato-green gram (ii) Rice-cabbage/ cauliflower-green gram	51.95	73 73	17.2	28.4
	(iii) Rice-cauli-flower/cabbage-green gram		73							
Kantia	(i) Rice-rice (ii) Rice-sesame	14.2	55 53	21.1	26.3	(i) Rice-rice (ii) Rice-sesame	30.5	55 53	15.8	22.7

Note: LUE[1] : Land use efficiency ; OLH[2] : Operational landholdings ; PCP[3] : Per capita production

Table 12. Suggested land use of the study area for large and medium farmers

Soil series	Large farmer					Medium farmer				
	Suggested land use	Total area (ha)	LUE[1]	% increase OLH[2]	% increase PCP[3]	Suggested land use	Total area (ha)	LUE[1]	% increase OLH[2]	% increase PCP[3]
Syamsun -darpur I	(i) Rice– potato-black gram (ii) Rice-sesame-black gram (iii) Rice-sesame-chilli	25.57	78 77 81	20.7	41.6	(i) Rice-sesame-black gram (ii) Rice-sesame-chilli	20.24	78 81	15.0	27.4
Syamsun -derpurII	(i) Rice-potato-black gram (ii) Rice-cabbage / cauliflower-black gram (iii) Rice-mustard-black gram	6.10	78 78 78	10.3	19.7	(i) Rice-potato-black gram (ii) Rice-tomato-black gram (iii) Rice-tomato-chilli	4.8	78 86 90	10.0	17.6
Naopara	(i) Rice-potato-sesame (ii) Rice-mustard-black gram (iii) Rice-cauli-flower/cabbage-black gram	9.4	78 78 78	11.9	24.3	(i) Rice-potato-black gram (ii) Rice-tomato-sesame (iii) Rice-tomato-black gram	7.4	86 86 78	10.0	16.4
Kantia	(i) Rice-rice (ii) Rice-sesame	5.5	55 53	5.1	8.2	(i) Rice-rice	4.4	53	-	-

Note: LUE[1] : Land use efficiency ; OLH[2] : Operational landholdings ; PCP[3] : Per capita production

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