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Methods of Land Capability, Capability Classes and Their Suitability in the Southwest Birbhum District, West Bengal

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Abstract

Land capability simply implies the measurement of capability of land for particular land uses. Land capability assessment for any particular bio-physical unit is very much essential to identify the scientific and appropriate landuse categories as well as landuse techniques which maintain the long term susceptibility of the land units. The study area is a rural backward area. The land-illiterate rural land users have practically no knowledge about the land capability of the area. Consequently, the haphazard, unscientific landuse practices irrespective of the susceptibility of the land results in either over utilization and consequent degradation of land or under utilization of existing resource base. The ultimate result is lowering of carrying capacity of land. Therefore, the need for land capability assessment in the study area is essential to put particular land units to suitable land uses which will not only increase the productivity of the land but also maintain the susceptibility of the land on a long term basis

In this context, the present study aims to analyse the methods of land capability assessment and to classify land into capability classes. The study also aims to analyse the uses and prospects of land in the Southwest Birbhum District. Based on physical and socio-economic land attributes the study area has been classified into 7 land capability classes.

Key Words: *Land capability, assessment, landuse, susceptibility.*

Objectives

The main objectives of the present paper are:

- To analyse the methods related to land capability assessment
- To classify land into different land capability classes
- To analyse the implication of land capability assessment in the context of Southwest Birbhum district

Study Area

The study area represents a small tract of Southwest Birbhum District (SWBD), comprising three C.D. blocks, Rajnagar, Khoyrasole and Dubrajpur. The study area is extends from $23^0$41'4'' N to $24^0$02'73''N latitudes and from 87^0 05'24''E to $87^0$31'26'' E longitudes. The area is bounded by the districts of Dumka and Jamtara of the State of Jharkhand on the west and north. The river Ajay forms the southern boundary of the study area. The eastern part is bounded by the two police stations of Birbhum district-Suri and Illambazar. It constitutes 18.40% of total area of the District (Fig. 1)

The study area is predominantly an agricultural area with 62.85% of its total population is engaged in agriculture and allied activities and 67.34% of its total area represents net sown area. The rural, illiterate land users of the study area have practically no knowledge about the capability or potentiality of the existing land resources.

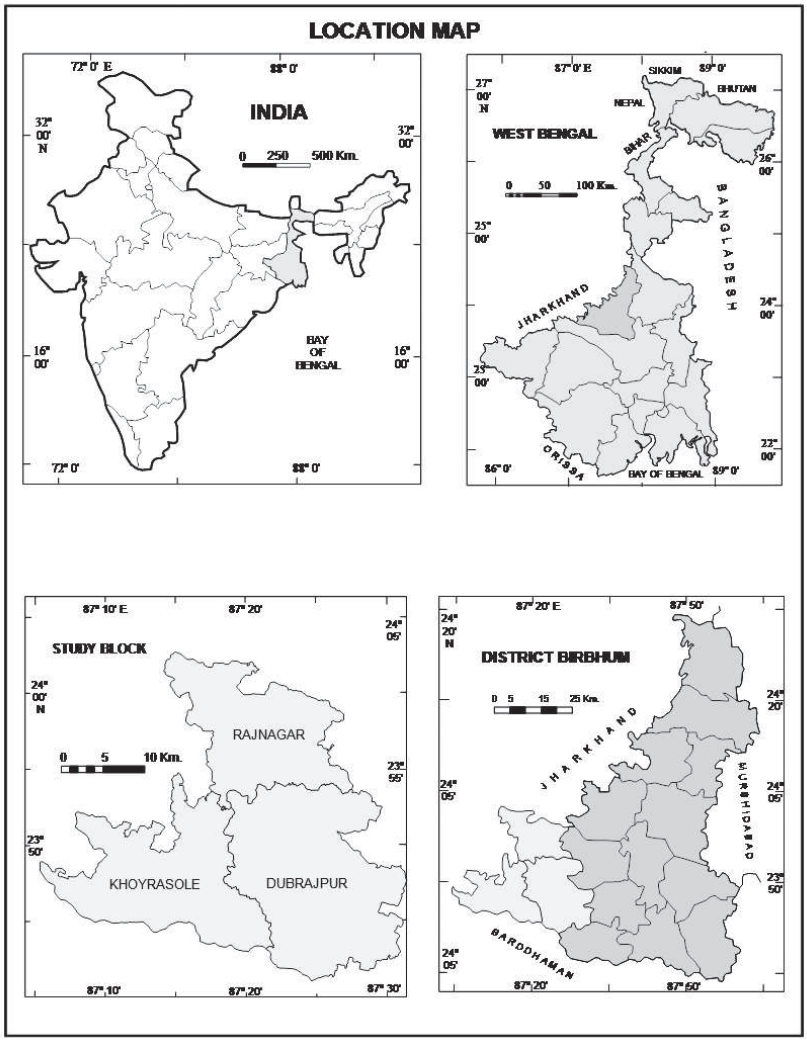

Fig. 1.

Methods of Land Capability Assessment

Land capability assessment of SWBD has been made by considering following steps:

1. Land capability assessment in the study area is based on seven intrinsic physical land attributes e.g. relative relief (R), dissection index (D), ruggedness index(Rn), surface elevation(SE), soil texture (T), soil depth (SD), soil available water capacity (A) and soil fertility (F). Besides these physical and permanent parameters, one anthropogenic or variable parameter has also been taken into consideration. This is the extent of irrigation, which has great potentiality to enhance the land capability to many folds. Thus, for land capability assessment altogether 9 parameters have been taken into consideration (Fig. 2).

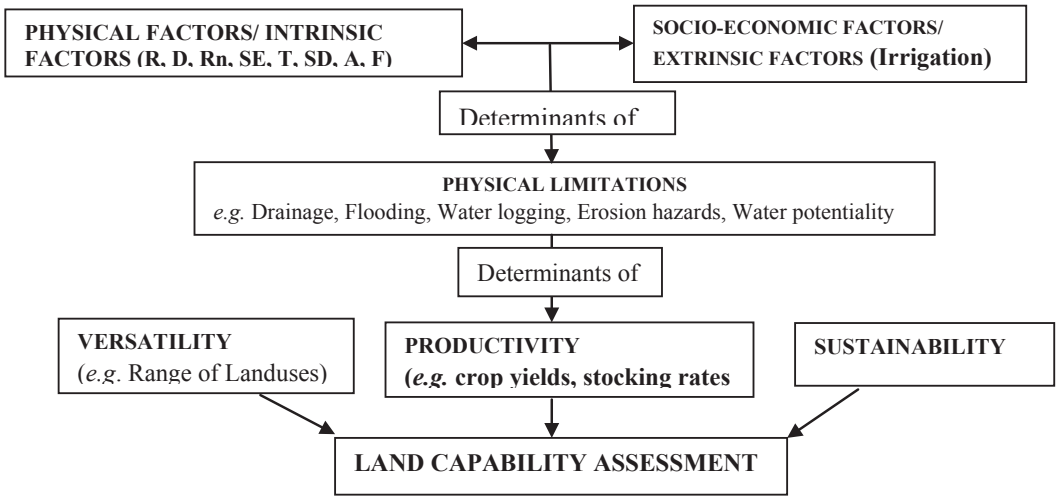

Fig. 2 : Factors in land capability assessment

2. Following the principle of Maull's griddle method, separate maps of all these parameters have been superimposed on a single map of land unit (Table 1) and the integrated characteristics of each land unit has been identified. Altogether 463 land units are demarcated.
3. Following the principle of Storie Index (Storie, 1954, p. 10), each of the above 9 land attributes has been awarded numerical scores to a maximum of 10. The score 10 is distributed proportionately among the sub classes of each of the land attributes. For example, soil fertility (F) scores a total of 10, and this has been distributed among the sub-classes (F1 to F3) proportionately (F1=1.67, F2=3.33, F3=5; total=10).
4. All the above land attributes are not equally important in determining land capability of the study area. Therefore, it is necessary to assign weightage against the above 9 parameters according to their importance in determining the land capability of SWBD.

Lack of water is one of the most important agricultural constraints in the study area. Only the adequate and timely supply of water can convert the study area from mono to multi-cropped region. Irrigation is, therefore, ranked first. Among the physical land attributes, soil properties receive great priority. Soil texture has been considered to be the most important, because its character can hardly be changed. Soil depth is also equally important in determining the yield of crops in the study area. Therefore, soil texture and depth together ranks second. Agricultural productivity is also influenced by soil fertility and available water capacity. So, both of them have placed in third rank. Surface elevation is not a major limiting factor of agriculture in the study area. Therefore, surface elevation ranks fourth. Relative relief, dissection index and ruggedness index are very significant determinant of landuse in many areas. But

in SWBD more than 50% area are covered by low to very low categories of the above parameters. Therefore, the relatively monotonous distribution of these parameters in vast area has lessened their importance in delimiting the capability class of the study area. Therefore, all these three parameters collectively rank fifth.

With the above considerations, weightage has been given to each of the above 9 land attributes (Table 2). The overall score index for each component has been obtained by multiplying the original score by weighted score (Table 3).

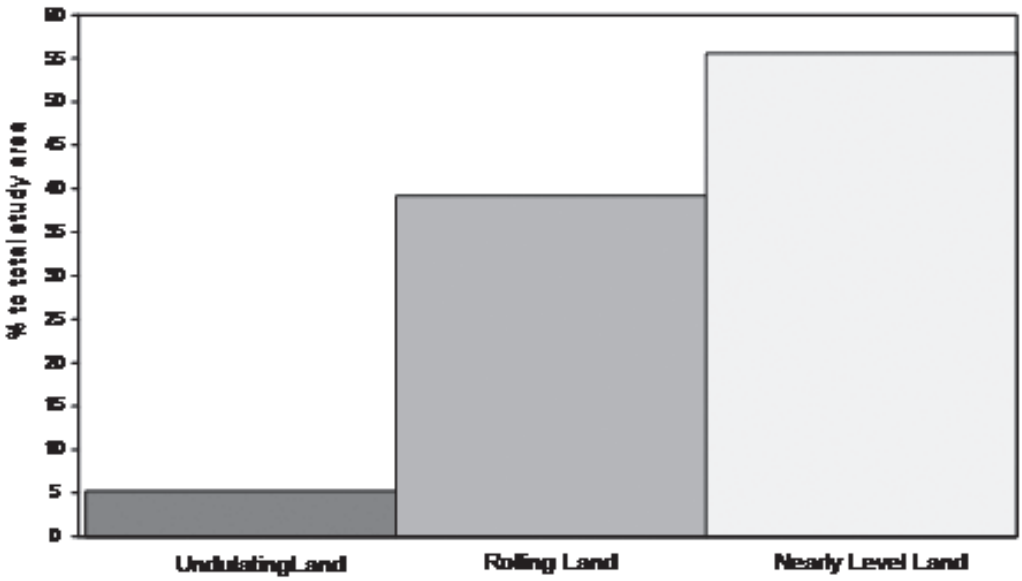

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Fig. 3b. (see page 73 for fig 3a.)

Table -1 : Land units

First order	Second order	Third order	Fourth order	Area (km^2)	% to total area
I Nearly Level Terrain	IA Nearly level terrain with surface elevation <80m.	IA1 Moderate physical property	IA1x Low fertility	2.28	0.27
		IA2 Good physical property	IA2x Low fertility	13.14	1.54
			IA2y Moderate fertility	3.10	0.36
			IA2z High fertility	0.21	0.02
		IA3 very good physical property	IA3x Low fertility	56.60	6.64
			IA3y Moderate fertility	131.37	15.42
			IA3z High fertility	12.58	1.48
	IB Nearly level terrain with surface elevation >80 m.	IB1 Moderate physical property	IB1x Low fertility	12.96	1.52
			IB1y Moderate fertility	3.62	0.42
			IB1z High fertility	1.46	0.17
		IB2 Good physical property	IB2x Low fertility	103.28	12.12
			IB2y Moderate fertility	29.12	3.42
			IB2z High fertility	0.88	0.10
		IB3 Very good physical property	IB3x Low fertility	67.19	7.89
			IB3y Moderate fertility	35.62	4.18
			IB3z High fertility	0.20	0.02
II Rolling Terrain	IIA Rolling terrain with surface elevation <80 m.	IIA1 Moderate physical property	IIA1x Low fertility	2.26	0.27
		IIA2 Good physical property	IIA2x Low fertility	20.37	2.39
			IIA2y Moderate fertility	8.35	0.98
			IIA2z Good fertility	2.54	0.30
		IIA3 Very good physical property	IIA3x Low fertility	20.80	2.44
			IIA3y Moderate fertility	5.03	0.59
			IIA3z Good fertility	2.15	0.25
	IIB Rolling terrain with surface elevation 80-120 m.	IIB1 Moderate physical property	IIB1x Low fertility	15.98	1.88
			IIB1y Moderate fertility	5.55	0.65
			IIB1z High fertility	3.15	0.37
		IIB2 Good physical property	IIB2x Low fertility	138.66	16.28
			IIB2y Moderate fertility	22.08	2.59
			IIB2z High fertility	0.45	0.05
		IIB3 Very good physical property	IIB3x Low fertility	54.40	6.39
			IIB3y Moderate fertility	6.59	0.77
	IIC Rolling terrain with surface elevation >120 m.	IIC1 Moderate physical property	IIC1x Low fertility	10.29	1.21
			IIC1y Moderate fertility	0.35	0.04
		IIC2 Good physical property	IIC2x Low fertility	13.58	1.59
			IIC2y Moderate fertility	0.14	0.02

III Undulating terrain	IIIA Undulating terrain with surface elevation <80 m.	IIIA2 Good physical property	IIIA2x Low fertility	3.11	0.37
			IIIA2y Moderate fertility	0.99	0.12
			IIIA2z High fertility	0.70	0.08
		IIIA3 Very good physical property	IIIA3x Low fertility	3.50	0.41
			IIIA3y Moderate fertility	0.91	0.11
	IIIB Undulating terrain with surface elevation 80-120m.	IIIB1 Moderate physical property	IIIB1x Low fertility	5.69	0.67
			IIIB1y Moderate fertility	1.55	0.18
			IIIB1z High fertility	0.11	0.01
		IIIB2 Good physical property	IIIB2x Low fertility	18.21	2.14
			IIIB2y Moderate fertility	4.60	0.54
			IIIB2z High fertility	0.73	0.09
		IIIB3 Very good physical property	IIIB3x Low fertility	4.75	0.56
			IIIB3y Moderate fertility	0.68	0.09
Total				**851.86**	**100.00**

Table - 2: Ranking of Variables

Rank	Variable	Weightage
1	Irrigation	5
2	Soil texture & depth	4
3	AWC & soil fertility	3
4	Surface elevation	2
5	Relative relief, dissection index & ruggedness index	1

Table - 3: Variables and scores

A. Irrigation: Rank - First				
Variable (% of irrigated area to net sown area)	Symbol	Scores assigned on the basis of quality	Weightage assigned on the basis of rank	Total scores awarded
<10	I_1	1	5	5
10-20	I_2	2	5	10
20-30	I_3	3	5	15
>30	I_4	4	5	20
Total		10		50
B. Soil texture: Rank - Second				
Variable	Symbol	Scores assigned on the basis of quality	Weightage assigned on the basis of rank	Total scores awarded
Loamy skeletal	T_1	1.67	4	6.68

Fine loamy	T_2	3.33	4	13.32
Fine to very fine loamy	T_3	5.00	4	20.00
Total		10		40
C. Soil depth: Rank - Second				
Variable	Symbol	Scores assigned on the basis of quality	Weightage assigned on the basis of rank	Total scores awarded
Shallow	D_1	1.67	4	6.68
Moderate	D_2	3.33	4	13.32
Deep	D_3	5.00	4	20.00
Total		10		40
D. AWC: Rank - Third				
Variable	Symbol	Scores assigned on the basis of quality	Weightage assigned on the basis of rank	Total scores awarded
Very low-low	A_1	0.66	3	1.98
Low	A_2	1.33	3	3.99
Low-medium	A_3	2.00	3	6.00
Medium-high	A_4	2.67	3	8.01
High	A_5	3.34	3	10.02
Total		10		30
E. Soil fertility: Rank - Third				
Variable	Symbol	Scores assigned on the basis of quality	Weightage assigned on the basis of rank	Total scores awarded
Low	F_1	1.67	3	5.01
Moderate	F_2	3.33	3	9.99
High	F_3	5.00	3	15.00
Total		10		30
F. Surface elevation: Rank - Fourth				
Variable	Symbol	Scores assigned on the basis of quality	Weightage assigned on the basis of rank	Total scores awarded
<80m.	S_1	4	2	8
80-100m.	S_2	3	2	6
100-120m.	S_3	2	2	4
>120m.	S_4	1	2	2
Total		10		20
G. Relative relief: Rank - Fifth				
Variable	Symbol	Scores assigned on the basis of quality	Weightage assigned on the basis of rank	Total scores awarded

Very low (<10m.)	R_1	5.00	1	5.00
Low (10-20m.)	R_2	3.33	1	3.33
Moderate (>20m.)	R_3	1.67	1	1.67
Total		10		10
H. Dissection index: Rank - Fifth				
Variable	Symbol	Scores assigned on the basis of quality	Weightage assigned on the basis of rank	Total scores awarded
Very low(<0.10)	D_1	5.00	1	5.00
Low (0.10-0.20)	D_2	3.33	1	3.33
Moderate (>0.20)	D_3	1.67	1	1.67
Total		10		10
I. Ruggedness index: Rank - Fifth				
Variable	Symbol	Scores assigned on the basis of quality	Weightage assigned on the basis of rank	Total scores awarded
Very low (<0.010)	Rn_1	5.00	1	5.00
Low (0.010-0.020)	Rn_2	3.33	1	3.33
Moderate (>0.020)	Rn_3	1.67	1	1.67
Total		10		10

5. Finally the cumulative scores for all the 463 land units have been obtained (e.g., for IIC2x, R2, D2, (Rn1+Rn2), S3, T1, SD2, F1, (I0+I2) =3.33+3.33+4.17+4+ 6.68+3.32+5.01+3.99+5= 48.83). All the 463 land units have been statistically grouped to find out the land capability classes. For this purpose, the mean and standard deviation of the scores are calculated and the land units are put under various categories.

The mean and standard deviation are obtained as 68.53 and 12.91 respectively. Now based on these two Fig.s 7 land capability classes have been identified (Table 4, Fig. 5) (see page 73 for fig 5). For this purpose, 0.25 S.D. has been taken which came as 3.23. Now this Fig. (3.23) has been added with the value of mean (68.53+3.23) which stood as 71.76 and after that the same Fig. (3.23) has been deducted from the mean (68.53-3.23) which came as 65.30. In this way the range of 6.46 has been obtained and the class boundary of the middle class has been decided as 65.30 to 71.76. This capability class has been named as 'fair'. Now, 0.75 SD has been taken, which came as 9.69. Now, this particular value is added and subtracted from mean (68.53), which came as 8.22 and 58.84 respectively. Thus, two capability classes namely moderately good and moderately fair have been obtained. Now, 1.25 SD has been taken, which came as 16.15. Now, this particular value is added and subtracted from mean (68.53), which came as 84.68 and 52.38 respectively.

These two values represent the upper and lower boundary of good and poor capability classes. Now the land units which score more than 84.68 represent the very good capability class and the land units which score less than 52.38 represent the very poor capability class.

6. The above method of land capability assessment (Fig. 4) is very much appropriate, because the assessment has been verified through ground checking by the researcher.

Table - 4 : Land capability class

Class	**Scores**	**Character**	**Area (sq.km.)**	**% to total study area**
I	>84.68	Very good	196.76	23.10
II	78.22-84.68	Good	105.51	12.39
III	71.76-78.22	Moderately good	112.66	13.23
IV	65.30-71.76	Fair	101.87	11.95
V	58.84-65.30	Moderately fair	181.76	21.34
VI	52.38-58.84	Poor	113.31	13.30
VII	<52.38	Very poor	39.99	4.69
Total			**851.86**	**100.00**

Table - 5 : Block-wise distribution of land capability class

Land capability class	Name of blocks								
	Rajnagar			Khoyrasole			Dubrajpur		
	Area (km.^{2})	% to total block area	% to individual capability class	Area (km.^{2})	% to total block area	% to individual capability class	Area (km.^{2})	% to total block area	% to individual capability class
Very good	0.23	0.10	0.12	32.20	11.88	16.37	164.33	45.71	83.52
Good	4.45	2.01	4.22	46.82	17.27	44.37	54.24	15.09	51.41
Moderately good	10.05	4.54	8.92	41.87	15.44	37.16	60.74	16.89	53.91
Fair	32.65	14.76	32.05	30.43	11.22	29.87	38.79	10.78	38.08
Moderately fair	107.71	48.69	59.26	55.50	20.47	30.53	18.55	5.16	10.21
Poor 42.38 19.16			37.40	48.04	17.72	42.40	22.89	6.37	20.20
Very poor	23.73	10.74	59.34	16.26	6.00	40.66	----	---	---
Total	221.20	100		271.12	100		359.54	100	

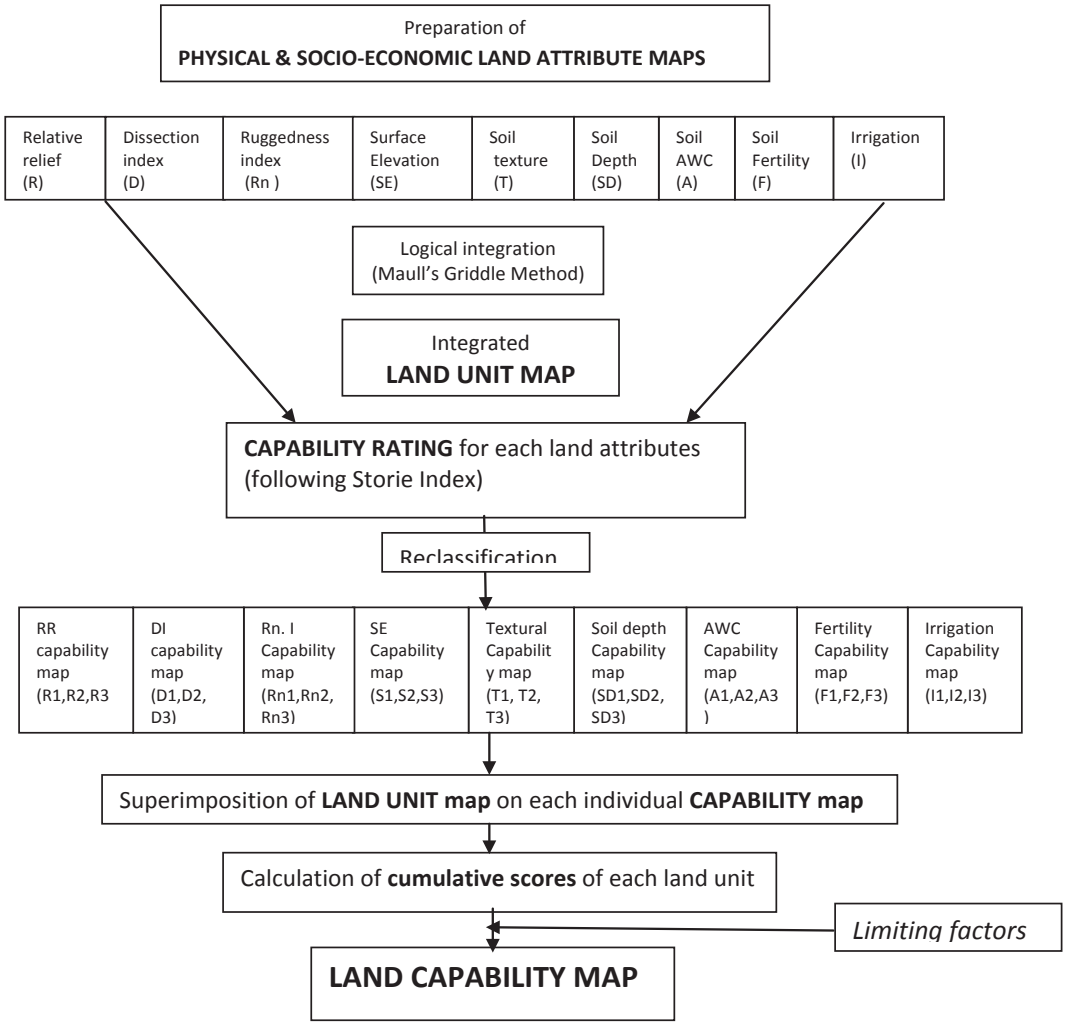

Fig. 4. Methods of land capability assessment

Spatial Distribution of Land Capability Class

1. Very good

This land unit of very good capability class covers an area of 196.76 sq.km., which accounts for 23.10% of the total study area and is distributed mainly in the southern and southeastern parts (covering Dubrajpur and Khoyrasole block) of the study area. About 84% of this land unit is distributed in Dubrajpur block (Table 4& 5). Land units like IA3y, IA3z, IA2y, IIA3x, IIA3y, IIA3z, IB3y and IIB3y are included in this land capability class.

This capability class is characterized by very gentle slope (<0.500) with very low relative relief (0-10m.), dissection index (0.01-0.15) and ruggedness index. Surface elevation in this part ranges between less than 60m. and 80m. Geologically this portion is underlain by Quaternary Sediments with high ground water potentiality. This capability class is also characterized by very deep soil with none to slight soil erosion. Fine to very fine loamy soil texture increases the available water capacity in this part of the study area. Nearly level land coupled with fine textured soil inhibits the free drainage of excess water. Thus this land unit is characterized by imperfectly to poorly drained soil. Most of the mouzas located in this capability class have more than 30% irrigated area to total net sown area. This land unit is very much suitable for agriculture with very minor or no physical limitations.

2. **Good**

The good land capability class covers an area of 105.51sq.km. (12.39%) and is distributed in a more or less continuous patches in the southern and southeastern parts and very isolated patches in the middle and middle-eastern parts of the study area (Table 4& 5). Land units like IA3x, IA3y, IA2x, IB2x, IB3x, IIA2y, IB2y, IB3x and IB3y are included in this category. There are altogether 42 patches of this class has been identified. Out of 42 patches, 39 patches of this land unit are distributed in the middle, southern and southeastern parts of the study area.

This capability class is characterized by very gentle slope (<0.500) with very low relative relief (5-10m.), dissection index (0.05-0.10) and ruggedness index. Surface elevation in this part ranges between 60m. and 80m. About 90% of this capability class is underlain by Quaternary Sediments. Only few small isolated patches in the middle and northern parts are underlain by hard granite-gneissic landscape. Soils are deep to very deep with none to slight soil erosion. 92% of this class is characterized by fine to very fine loamy soil texture. The rest of the area is characterized by fine loamy soil texture. Consequently the available water capacity in this part of the study area is high. This capability class is characterized by various categories of soil drainage i.e. well drained (55%), poorly drained (40%) and well to imperfectly drained (5%). Except part of three mouzas (no irrigation), the rest of the mouzas located in this capability class have >30% irrigated area to total net sown area.

Therefore, it can be said that this capability class, located in nearly level land unit, is very much suitable for agricultural landuse. This land unit can be used for intensive cultivation.

3. **Moderately good**

This capability class covers an area of 112.66 sq.km., which accounts for 13.23% of total study area. This capability class is mainly distributed in the middle, southeastern and southern parts, covering Dubrajpur and Khoyrasole block of the study area. 14 small patches (covering 10.05 sq.km. area) of this land unit is also distributed in the northern part (Rajnagar block)

of the study area (Table 4& 5). Terrain units like IA3x, IB3x, IB3y, IIA2x, IIA2y, IIA3x, IIB3x are included in this capability class.

This capability class is moderately productive and is suitable for agricultural landuse. It has very minor physical limitations. 99% of this land unit is distributed on nearly level land with slope less than 0.5o. Soil capability is more or less same as that of the above two classes. In some patches in the middle-eastern part, relative relief is relatively higher, ranging between 10-15 m. In rest of the area of this land unit, relative relief ranges between <5 and 10 m. However, the only factor which creates lowering of total cumulative score is the availability of irrigation. If adequate irrigation facility can be arranged, most of the land unit of this capability class will be upgraded into the good to very good capability class.

4. Fair

Covering an area of 101.87 sq.km. (11.95%), this capability class is sporadically distributed all over the study area. More or less equal distribution of this land unit is observed in all the three blocks of the study area, ranging from more than 30% to less than 40% (Table 4& 5). Land units like IB2x, IB2y, IIA3x, IIB3x, IIB2y are included in this category.

This capability class has some inherent physical limitations. This land unit is composed of rolling surface forms, slight to moderate soil erosion, moderate soil depth and moderate available water capacity. Natural productivity of land is moderate to low in this part of the study area. However, with some management practices agriculture is also suitable in this part of the study area. Most of the land under this capability class is mono cropped with rainfed paddy cultivation. The rest of the time, the lands under this category remain as fallow.

5. Moderately fair

This capability class occupies an area of 181.76 sq.km., which accounts for 21.34% of total study area. Overall 88 patches of this land unit are distributed all over the study area. Large number (30) of relatively small patches of this capability class is distributed in Dubrajpur block, which accounts for 10.21% of this land unit. Small number (22) of relatively large patches of this capability class is distributed in northern and middle part, covering Rajnagar block, of the study area, which accounts for 59.26% of this land unit. 30% of this land unit is distributed in 35 very small patches in Khoyrasole block of the study area (Table 4& 5). Land units like IB1x, IB2x, IIA2x, IIB2x, IIB2y, IIC2x, IIIA3x, IIIB2x, IIIB3x, and IIIB3y are included in this category.

This capability class has moderate physical limitations with rolling and undulating land, shallow to moderate soil depth, moderate to severe soil erosion, moderate soil texture and moderate to low available water capacity. Some of the mouzas located in this land unit have no irrigation facility. Productive potential of this land unit is low. If adequate irrigation water can be provided, low to moderate agriculture is possible in this land unit with sound management practices.

6. **Poor**

This capability class occupies 13.30% (113.31 sq.km.) area of the study area. About 42.4% of this capability class is distributed in Khoyrasole block, followed by Rajnagar (37.40%) and Dubrajpur (20.20%) block (Table 4& 5). Land units like IIB2x, IIC2x and IIIB2x are included in this capability class.

This capability class is characterized by severe physical limitations with rolling to undulating land surface, sloping land and severe soil erosion. Productive potential of this land unit is very low. This land unit is marginally suitable for agriculture.

7. **Very Poor**

Only 4.69% (39.99 sq.km.) of total study area fall under this category (Table 4& 5). This capability class is mainly concentrated in the northwestern and southwestern parts, covering Rajnagar (59.34%) and Khoyrasole (40.66%) block of the study area. Land units like IIC1x, IIC2x, IIIC1x, and IIIB1x are included in this category.

This land unit is characterized by very severe physical obstacles. This land unit is hardly suitable for agricultural landuse.

Concluding Remarks

In conclusion it can be said that, the land capability class obtained by considering the above 9 parameters are not permanent features. The 9 parameters can be grouped into two broad categories: permanent limiting factors (relative relief, dissection index, ruggedness index, surface elevation, soil texture, soil depth and available water capacity) and non-permanent or removable limiting factors (soil fertility and irrigation). The suitability of removal of limitations largely depends on the severity of limitations and the existing socio-economic conditions. Therefore, it can be said that, though the present land capability classes are the outcome of direct or active influence of the 9 parameters, but their permanency are largely determined by the indirect influence of the existing socio-economic conditions of the study area. Increasing technological knowhow with rising economic conditions can improve the status of non-permanent limiting factors by lessening the degree of limitations. In such cases, the land can be reclassified into higher capability classes.

Land capability assessment for whole of the southwest Birbhum district represents a wide range of landuse potentiality, depending on diversified land units. Nearly 60% of the land unit has characteristics favourable for crop production e.g. a) Sufficiently deep soil with moderate to high moisture retentive capacity, b) Nearly level land with low to moderate external drainage causing none to slight soil erosion, c) Relatively high ground water potential of alluvium parent material and d) Nearly level land allowing the use of labour saving machinery etc. The rest of the study area has also the potential for crop production provided adequate irrigation facility can be supplied.

As landuse potential for landuses other than agriculture, are more influenced by extrinsic land attributes (communication, educational status, availability of raw material, labour supply, water supply etc.) than the intrinsic physical land attributes, then any land not suitable for agricultural landuse must be suitable for urban/industrial landuse, provided the supporting socio-cultural and economic land attributes are favourable. In southwest Birbhum district,

low level of literacy, poor communication system and lack of adequate water harvesting structure provide hindrance to industrial use of land. However, the southwestern and southern parts of the study area contain mineral resources like coal, fireclay etc. Therefore, improvement in communication system may provide scope for industrial use of land.

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