CHAPTER - V

LAND EVALUATION FOR ALTERNATIVE CROPS OF TOBACCO

5.0 Introduction

The present chapter deals with land suitability classification of Dinhata subdivision. The suitability classes are delineated for five important rabi crops and the suitable crops are suggested for replacement of tobacco cultivation in order to succeed WHO-FCTC treaty. The main objective of this chapter is to make land evaluation for best alternative crops of tobacco in Dinhata subdivision. Land suitability studies gives information on the choice of crops to be grown to replace tobacco cultivation on a specific site for maximizing crop production per unit land. In this study, Analytical Hierarchy Process (AHP) integrated with GIS was applied to establish a spatial model of the suitability of agricultural land of the study area for five alternative rabi crops of tobacco such as potato, maize, boro paddy, mustard and wheat.

The term 'Land Evaluation' was first used by Visser in his paper 'The trend of the development of land evaluation in the future' in 1950 (NBSS&LUP, 2006). Van Wambeke and Rossiter define land evaluation is the ranking of soil unit on the basis of its capabilities to provide optimum returns of an area besides conservation of environmental resources for future use (Wambeke and Rossiter, 1997). According to FAO (1976) land evaluation is "the process of assessment of land performance when used for specific purpose. It involves the execution and interpretation of surveys and the studies on landforms, soils, vegetation, climate and other related aspects of land for a compromising between the promising land use and specific land use". The principal objective of land evaluation is to select the optimum land use for each defined land unit taking into account both physical and socio-economic factors and the conservation of environmental resources for future use (FAO, 1983; Sys et. al. 1991). Suitability is measured by the land qualities with the specific crop requirements (FAO 1976a, b). In order to assess suitability of an area for a particular crop, several criteria need to be evaluated (Belka, 2005).

5.1 Land suitability classification

Food and agriculture organization's (FAO) guideline on the land evaluation system is widely acceptance. There are four categories or level of classification: land suitability orders, classes, sub-classes and units. The present study has not used the units, whereas land units are the basis for classification by grouping specific areas.

Table: 5.1 Definition of suitability orders

Suitability orders	Definition
Order S (suitable)	Land on which sustained use of the kind under consideration is expected to yield benefits that justify the inputs, without unacceptable risk of damage to land resources.
Order N (not suitable)	Land which has qualities that preclude sustained use of the kind under consideration.

Source: FAO, 1976

Table: 5.2 Structure of the suitability classification

Order	Class	Suitability	Rating scale (%)	Limitations
S	S1	Highly Suitable	85-100	Land having no significant limitations to sustained application of a given use, or only minor limitations that will not significantly reduce productivity or benefits and will not raise inputs above an acceptable level.
	S2	Moderately suitable	60-85	Land having limitations which an aggregate are moderately severe for sustained application of a given use; the limitations will reduce productivity or benefits and increase required inputs to the extent that the overall advantage to be gained from the use, although still

				attractive, will be appreciably inferior to that expected on Class S1 land.
	S3	Marginally suitable	40-60	Land having limitations which in aggregate are severe for sustained application of a given use and will so reduce productivity or benefits, or increase required inputs, that this expenditure will be only marginally justified.
N	N1	Currently not suitable	25-40	Land having limitations which may be surmountable in time but which cannot corrected with existing knowledge at currently acceptable cost, the limitations are so severe as to preclude successful sustained use of the land in the given manner.
	N2	Permanently not suitable	0-25	Land having limitations which appear as severe as to preclude any possibilities of successful sustained use of the land in the given manner.

Source: FAO, 1976; Juniarti et.al. 2013

5.1.1 Suitability order

Land suitability order indicate whether land is assessed as 'suitable' (S), or 'not suitable' (N) for the use under consideration (FAO, 1976) (Table 5.1). The focal reasons why land may be classified as not suitable are that the proposed use is technically impracticable, is environmentally undesirable or is economically unprofitable, the income from the estimated prediction being less than the cost of the required inputs.

5.1.2 Suitability classes

These indicate the degree of suitability. Within the order suitable, the three classes, highly, moderately, and marginally suitable, are defined in relative terms. The S1/S2 boundary, or lower limit of highly suitable land, should be set at the point where conditions have become clearly less than optimal. Crop yield or other forms of production are slightly but definitely lowered, or inputs to counter the effects of a limitation become needed. Highly suitable land is not the 'perfect' land for the use in question, but could be labelled as the best that might reasonably give hope. The S2/S3 boundary dividing the moderately from the marginally suitable land should separate land which, although it has some limitations, is quite clearly suited to the use but only by a small technical, economic or environmental protection margin.

Of the two classes within the order ‘not suitable, N1 indicating currently not suitable, refers to land on which the use under consideration is technically possible but not economic. N2 indicating permanently not suitable is widely applied to steep slopes, swamps, rock out crops and arid areas. The present study has not use not suitability classes, instead of only use N order.

5.1.3 Suitability sub-classes

Land Suitability Subclasses are reflecting kinds of limitations, or main kind of improvement measures required, within class. Subclasses are showed by lower-case letters with mnemonic significance, e.g. S2m, S2e, and S3me. The following subclasses have been identified:

c : climate limitations

t : topographic limitations

w: wetness limitations

s : physical soil limitations

f : soil fertility limitations

n : salinity and or alkalinity limitations

5.2 Climatic Suitability for alternative crops of tobacco

The agro-climatic condition of this subdivision is characterized as humid and damp throughout the year with high rainfall during pre-kharif (March to May) and Kharif season (June to September). Long term data of various climatic parameters such as minimum and maximum temperature, relative humidity, sunshine hours, rainfall and rainy days for 40 years (1972-2011) have been collected from meteorological station of Central Tobacco research Institute, regional research station, Dinhata, which is located at 26^0 20’ N latitude and 89^0 27’ E longitude and 41 metre above the mean sea level. Lack of various parameters of weather data for more locations in the study area is the main constraint for assessment of climate suitability for different crops among different locations. Therefore, the data of climate from a single station i.e., Dinhata town has been used to see overall climatic suitability of different crop in Dinhata subdivision. More the areas way from the climate station, Dinhata town the suitability results of the different crops will suffer from approximation due to the distance parameter. With this constraints in mind the climatic suitability of Dinhata has been done to see overall suitability of different crops in respect of climatic condition available over this area. The details of climate characteristics of the study area have been analysis in Chapter-II.

Climate suitability evaluation for five rabi crops under irrigated conditions are measured by parametric method. In this method a numeral rating is attributed to each characteristics (Sys et al., 1991b). The process of evaluation is based on the FAO qualitative land evaluation system (FAO 1976, 1984, 1985), which compares climatic conditions including insolation, temperature, rainfall and relative air humidity with each specific crop requirements developed by Sys et al. (1991a, b, 1993). The climatic indices are calculated from the individual rating. If the observed value is x and it falls into the interval [a, b] it needs to get a score y that falls into the interval [c, d]. The formula (Baghehzadeh and Gholizadeh, 2016) to calculate y is:

$$y = a + \frac{(b - a)(x - c)}{(d - c)}$$

Then, climate index has been calculated based on khiddir's square root method. The formula to calculate CI is:

Square root method (Khiddir, 1986)

$$\mathbf{CI = Rmin} \times \sqrt{\frac{\mathbf{A}}{\mathbf{100}} \times \frac{\mathbf{B}}{\mathbf{100}} \times \dots}$$

Where, CI= Climate Index

Rmin= minimum rating.

A, B … = other rating besides the minimum rating,

The climatic rating to be used in the total evaluation has to be calculated by (Sys et al., 1991b)

- If index between 25 and 92.5: climatic rating =16.67 + 0.9 index
- If index less than 25: Climatic rating = 1.6 × index

The suitability classes are defined according to the value of the index (table 5.3) as suggested by Sys et al.

Table: 5.3 Climate suitability classes according to climate index and climate rating based on Sys et al. (1991 b)

Climatic classes	Limitation level	Climate Index	Corresponding rating
S1	No to slight	100-75	100-85
S2	Moderate	75-50	85-60
S3	Severe	50-25	60-40
N	Very severe	25-12.5 12.5-0	40-20 20-0

The average day (td) and night (tn) temperature are calculated by following formula (Gommes, 1983; Sys et al., 1991a)

$$td = \frac{(tmax + tmin)}{2} + \frac{(tmax - tmin)}{4\pi}\frac{(46 - N)}{N}$$

$$tn = \frac{(tmax + tmin)}{2} - \frac{(tmax - tmin)}{4\pi}\frac{(46 - N)}{(24 - N)}$$

Where,

td= average daytime temperature °C

tn= average night time temperature °C

tmax= daily maximum temperature °C

tmin= daily minimum temperature °C

$\pi = 3.1416$

It is noted that, in the study area, rabi crops are grown under irrigation supply, hence rainfall parameter has not to be considered for climate index.

5.2.1 Potato

Potato is an important rabi crop in the study area. The temperature range for the optimal growth of potatoes between 16-20 °c. The growth of tuber virtually stops at temperature below 10 °c above 30 °c. A rainfall of 300-700 mm growing cycle is required. Potato grows well under long day conditions. Sunshine along with cooler nights is essential for reducing the spread of diseases.

Table: 5.4 Climatic requirements for potato (growing cycle 90-120 days) based on Sys et al. (1993)

Climatic characteristics	Class, degree of limitation and rating scale					
	S1		S2	S3	N1	N2
	0	1	2	3	4	
	100	85	60	40	25	0
Rainfall of 1st month (mm)	>60	60-45	45-30	30-20	-	<20
Rainfall of 2nd month (mm)	>100	100-80	80-65	65-50	-	<50
Rainfall of 3rd month (mm)	> 100	100-80	80-65	65-50	-	<50
Rainfall of 4th month (mm)	70-40 70-100	40-20 >100	<20 -	- -	- -	- -
Mean temperature of growing cycle °C	18-16 18-20	16-13 20-24	13-10 24-27	10-8 27-30	- -	< 8 > 30
Average absolute minimum temperature of first month °C	>2	2-0	0 to -1	-1 to -2	-	< -2
Average absolute minimum temperature of other three month °C	>0	0 to -1	0 to -1	-2 to -3	-	< -3
Average temperature difference between day and night °C	> 10	10-5	<5	-	-	-
Average day length of growing cycle (h)	15-16 15-13	>16 < 13	- -	- -	- -	- -

The climatic ratings under irrigation conditions for potato cultivation were determined by taking into account the inherent climatic condition and requirements of crop. The result of the crop suitability index and rating is provided in table 5.4 and 5.5 respectively. The result indicate that climate suitability class is S1 to indicate that climatic condition had to be satisfied. But irrigation is necessary during crop cycle.

Table: 5.5 The values of climate characteristics and the degree of limitation for Potato production in the study area

Climate characteristics	Value	Class	Degree of limitation
Rainfall of 1st month (mm)	15.4	N2	19.25
Rainfall of 2nd month (mm)	8.42	N2	4.21
Rainfall of 3rd month (mm)	10.46	N2	5.23
Rainfall of 4th month (mm)	14.07	S2	77.58
Mean temperature of growing cycle °C	17.84	S1	99.6
Average absolute minimum temperature of first month °C	9.34	S1	100
Average absolute minimum temperature of other three month °C	10.44	S1	100
Average temperature difference between day and night °C	7.89	S1	90.78
Average day length of growing cycle (h)	7.8	S1	91
Climate Index	86.43		
Climate rate	94.45		
Climate class	S1		

5.2.2 Maize

Maize is mainly cultivated in kharif season in all part of India, but in the study area maize is sown in rabi season. According to C, Singh (1983), the most favourable temperature for germination is 21°C and for growth 32 °C. Extremely low and high temperature and low humidity during flowering damage the foliage, exsiccate the pollen and delay with pollination, causing in poor grain formation. Maize grow in regions that have a total annual rainfall between 500-5000 mm (Sys et al., 1993). Maize is very sensitive to stagnant water, particularly during its early stages of growth. Details crop requirement as suggested by Sys et al. (1993) are furnished in table 5.6.

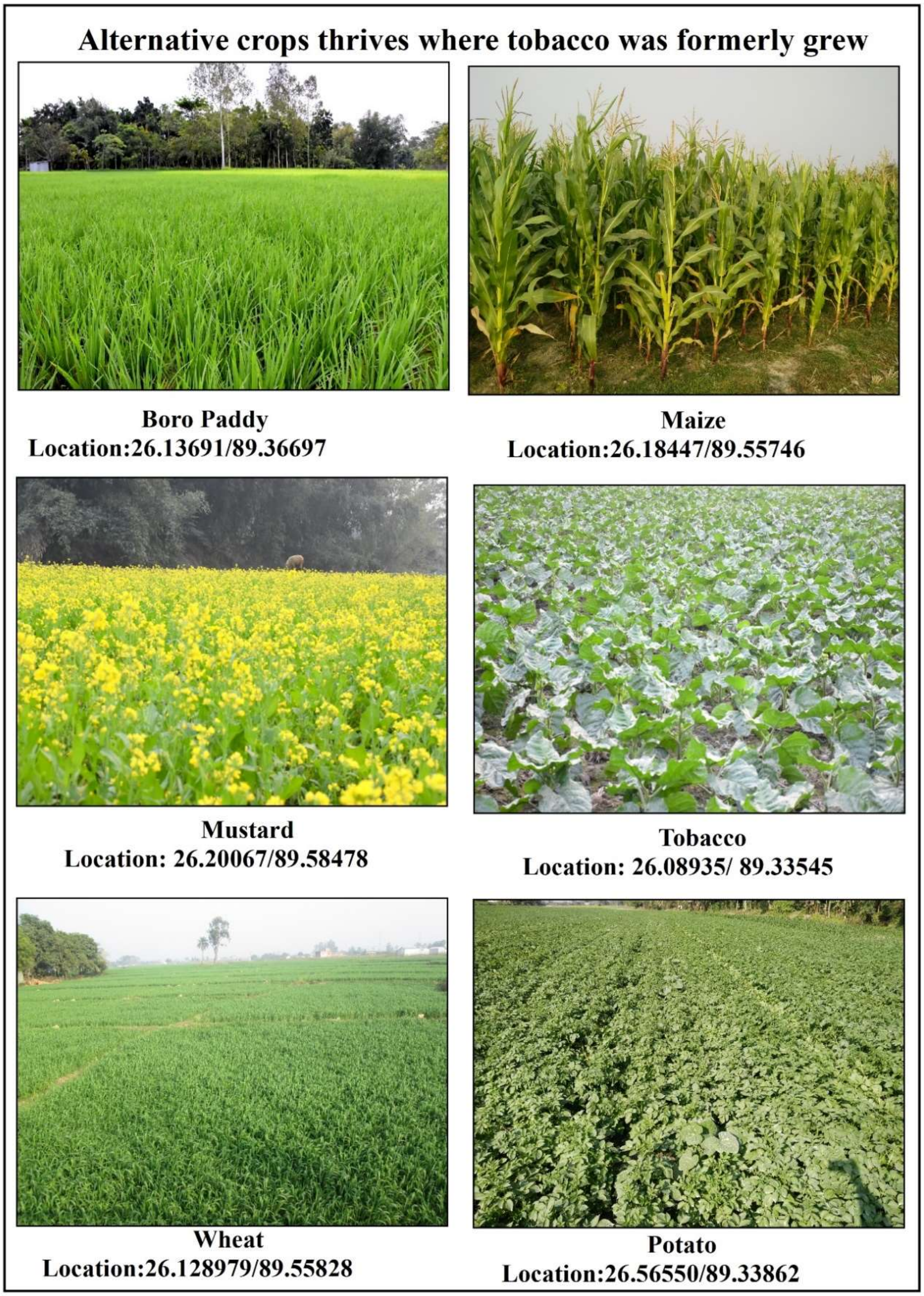


Plate 5.1 Alternative crops of tobacco of the study area

Table: 5.6 Climatic requirement for maize (growing cycle 90-130 days) based on Sys et al. (1993)

Climatic characteristics	Class, degree of limitation and rating scale					
	S1		S2	S3	N1	N2
	0	1	2	3	4	
	100	85	60	40	25	0
Rainfall of growing cycle (mm)	750-900 750-600	900-1200 600-500	1200-1600 500-400	>1600 400-300	- -	- <300
Rainfall of 1st month (mm)	175-200 175-125	220-295 125-100	295-400 100-75	400-475 75-60	- -	>475 <60
Rainfall of 2nd month (mm)	200-235 200-175	235-310 175-150	310-400 150-120	400-475 120-70	- -	>475 <70
Rainfall of 3rd month (mm)	200-235 200-175	235-310 175-150	310-400 150-120	400-475 120-70	- -	>475 <70
Rainfall of 4th month (mm)	165-210 165-125	210-285 125-100	285-400 100-80	400-475 60-80	- -	>475 <60
Mean temperature of growing cycle °C	24-22 24-26	22-18 26-32	18-16 32-35	16-14 35-40	- -	<14 >40
Mean minimum temperature of growing cycle°C	17-16 17-18	16-12 18-24	12-9 24-28	9-7 28-30	- -	<7 >30
Relative humidity of development stage (%)	65-50 65-80	50-42 >80	42-36 _	36-30 -	- -	<30 -
Relative humidity of maturation stage (%)	40-30 40-50	30-24 50-75	24-20 75-90	<20 >90	- -	- -
n/N of development stage	0.55-0.5 0.55-0.6	0.5-0.35 0.6-0.75	<0.35 >0.75	- -	- -	- -

n/N of maturation stage	>0.7	0.7-0.5	<0.5	-	-	-

The degree of limitation of each climatic parameter and overall index and ratings for maize are illustrated in Table 5.7. The climate suitability rating is 77.92% and suitability class is S2, which indicate moderate suitability. The relative humidity and insolation are the main hindrances for maize cultivation in the study area.

Table: 5.7 The values of climate characteristics and the degree of limitation for maize production in the study area

Climate characteristics	Value	Class	Degree of limitation
Rainfall of growing cycle (mm)	549.94	S1	92.5
Rainfall of 1st month (mm)	14.07	N2	5.86
Rainfall of 2nd month (mm)	40.01	N2	14.28
Rainfall of 3rd month (mm)	152.05	S1	85.41
Rainfall of 4th month (mm)	343.81	S2	72.56
Mean temperature of growing cycle °C	22.47	S1	96.18
Mean minimum temperature of growing cycle °C	15.48	S1	94.29
Relative humidity of development stage (%)	67.8	S1	95.6
Relative humidity of maturation stage (%)	78.19	S2	79.68
n/N of development stage	0.63	S1	99
n/N of maturation stage	0.5	S1	85
Climate Index	68.05		
Climate rate	77.92		
Climate class	S2		

5.2.3 Boro paddy

Boro paddy is the cultivation of winter rice under fully controlled irrigation, hence rainfall has not to be considered, so availability of water supply is needed trough out the growing cycle**.** Moderate to high relative humidity (50-90 %) during the vegetative stage can result in reduced tillering. The average temperature required throughout the life period of the crop ranges from 10 to 36°C. The climate is considered unsuitable when the average temperature of this crop development stage is less than 10 °C and more than 45 °C (Sys et al. 1991 b). Taking into account different climatic requirements and the evaluation of the climate are presented in table 5.8 and 5.9 respectively.

Table: 5.8 Climatic requirement for boro paddy (growing cycle 90-150 days) based on Sys et al. (1993)

Climatic characteristics	Class, degree of limitation and rating scale					
	S1		S2	S3	N1	N2
	0	1	2	3	4	
	100	85	60	40	25	0
Rainfall of 1st month (mm)	200-300 200-75	300-400 75-50	400-550 -	550- 650 -	- -	> 650 < 50
Rainfall of 2nd month (mm)	200-300 200-125	300-400 125-100	400-550 100-75	550- 650 75-50	- -	> 650 < 50
Rainfall of 3rd month (mm)	200-300 200-125	300-400 125-100	400-550 100-75	550- 650 75-50	- -	> 650 < 50
Rainfall of 4th month (mm)	200-300 200-75	300-400 75-50	400-550 < 50	550- 650	- -	> 650
Mean temperature of growing cycle °C	31-30 31-32	30-24 32-36	24-18 >36	18-10 -	- -	<10 -
Mean maximum temperature of warmest month of growing cycle °C	35-36 35-33	36-40 33-30	40-45 30-26	45-50 26-21	- -	> 50 <21
Mean temperature of crop development stage °C	29-26 29-32	26-24 32-36	24-18 36-42	18-10 42-45	- -	<10 > 45
Mean minimum temperature of ripen stage °C	20-28 20-22	18-14 22-25	14-10 25-28	10-7 28-30	- -	< 7 >30

Relative humidity of tillage and vegetative stage (h)	65-60 65-75	60-50 75-90	50-40 90-100	40-30 -	- -	<30 -
Relative humidity of harvest stage (h)	50-37 50-65	37-33 65-80	33-30 >80	< 30	- -	- -
n/N of growing cycle	>0.75	0.75-0.65	0.65-0.45	< 0.45	-	-

The result of the overall climatic suitability evaluation showed that climate of the study area is moderately suitable for boro paddy production under irrigated conditions. The climate index is 56.63 and overall rating is 67.64, which fall in S2 climate suitability class. The main limiting factor is the lower mean daily temperature condition of the study area relative to the optimum condition in crop cycle and development stage which tends to delay maturity. Average sunshine hours of growing cycle is also lower than optimum condition for winter rice cultivation in the study area.

Table: 5.9 The values of climate characteristics and the degree of limitation for Boro paddy production in the study area

Climate characteristics	Value	Class	Degree of limitation
Rainfall of 1st month (mm)	14.07	N2	7.03
Rainfall of 2nd month (mm)	40.01	N2	20.01
Rainfall of 3rd month (mm)	152.05	S1	96.5
Rainfall of 4th month (mm)	343.81	S1	92.81
Mean temperature of growing cycle °C	22.47	S2	78.64
Mean maximum temperature of warmest month of growing cycle °C	31.55	S1	92.41
Mean temperature of crop development stage °C	21.8	S2	75.83
Mean minimum temperature of ripen stage °C	20.49	S1	98.77
Relative humidity of tillage and vegetative stage (%)	69.61	S1	97.69
Relative humidity of harvest stage (%)	75.07	S1	94.98
n/N of growing cycle	0.64	S2	83.75

Climate Index	56.63
Climate rate	67.64
Climate class	S2

5.2.4 Mustard

Mustard is one of the important oilseed crop in the study area. It is sown in rabi season under irrigated conditions. The optimum average temperature during mustard growing season ranges 15°C to 26°C but minimum goes down to 8°C. Details climatic requirement for mustard cultivation are furnished in Table 5.10.

Table: 5.10 Climatic requirements for mustard growing cycle (90-120 days) based on NBSS&LUP 2006; Shah 1984; Singh 1958; Weiss 1983

Climatic characteristics	**Class, degree of limitation and rating scale**					
	S1		**S2**	**S3**	**N1**	**N2**
	0	**1**	**2**	**3**	**4**	
	100	**85**	**60**	**40**	**25**	**0**
Rainfall of growing cycle (mm)	500-600	400-500	400-250	250-150	-	<150
		600-700	700-850	850-1650	-	>1650
Monthly rainfall of vegetative stage (mm)	65-45	45-30	30-15	15-8	-	< 8
	65-90	90-120	>120	-	-	-
Monthly rainfall of flowering stage (mm)	60-45	60-30	30-10		-	< 10
	60-75	75-90	90-120	>120	-	-
Mean temperature of growing cycle °C	21-24	24-26	26-32	32-34	-	> 34
	21-18	18-15	15-12	12-8	-	< 8
Mean temperature of vegetative stage °C	15-12	12-9	9-6	6-3	-	< 2
	15-18	18-21	21-26	26-32	-	> 32
Mean temperature of flowering stage °C	20-16	16-13	13-9	9-6	-	< 6
	22-25	25-28	28-32	32-36	-	> 36

n/N of vegetative stage	0.55-0.5	0.5-0.45	0.45-0.35	<0.35	-	-
	0.55-0.6	0.6-0.65	0.65 -0.75	>0.75	-	-
n/N of flowering stage	>0.75	0.75-0.65	0.65- 0.5	<0.5	-	-

The climatic characteristics of mustard growing season in the study area was favourable for crop growth with an average climate rate of 62.59 which made the region moderately suitable (S2 class) for irrigated wheat crop (Table 5. 11). Main hindrance is fog cover in vegetative stage.

Table: 5.11 The values of climate characteristics and the degree of limitation for mustard production in the study area

Climate characteristics	**Value**	**Class**	**Degree of limitation**
Rainfall of growing cycle (mm)	48.35	N2	8.06
Monthly rainfall of vegetative stage (mm)	18.2	S2	65.33
Monthly rainfall of flowering stage (mm)	9.1	N2	22.75
Mean temperature of growing cycle °C	17.84	S1	94.47
Mean temperature of vegetative stage °C	19.2	S1	91
Mean temperature of flowering stage °C	16.3	S1	95.38
n/N of vegetative stage	0.76	S3	59.73
n/N of flowering stage	0..69	S1	89
Climate Index	51.03		
Climate class	62.59		
Suitability class	S2		

5.2.5 Wheat

The temperature range for the optimal growth of wheat is 12- 23 ° C. Wheat growing areas need to receive a rainfall that exceeds 200mm in growing cycle (Sys et al. 1993). In irrigated rabi crop amble water supply is needed in vegetative stage. The value of climatic requirements for wheat production in the study area is presented in table.5.12.

Table: 5.12 Climatic requirements for wheat (growing cycle 100-130 days) based on Sys et al. (1993)

Climatic characteristics	Class, degree of limitation and rating scale					
	S1		S2	S3	N1	N2
	0	1	2	3	4	
	100	85	60	40	25	0
Rainfall of growing cycle (mm)	700-450 700-1000	450-350 1000-1250	350-250 1250-1500	250-200 1500-1750	- -	<200 >1750
Monthly rainfall of vegetative stage (mm)	65-45 65-90	45-20 90-120	20-12 >120	12-8 -	- -	< 8 -
Monthly rainfall of flowering stage (mm)	75-60 75-90	60-30 90-120	30-15 >120	15-10 -	- -	< 10 -
Monthly rainfall of ripening stage (mm)	60-50 60-70	50-30 70-100	30-10 100-200	< 10 > 120	- -	- -
Mean temperature of growing cycle °C	18-20 18-15	20-23 15-12	23-25 12-10	25-30 10-8	- -	> 30 < 8
Mean temperature of vegetative stage °C	10-8 10-12	8-6 12-18	6-4 18-24	4-2 24-28	- -	< 2 > 28
Mean temperature of flowering stage °C	18-14 18-22	14-12 22-26	12-10 26-32	10-8 32-36	- -	< 8 > 36
Mean temperature of ripen stage °C	20-26 20-24	16-14 24-30	14-12 30-36	12-10 36-42	- -	< 10 > 42
Average daily minimum temperature of coldest month °C	< 8 if	-	> 8	8-19 if	- -	- -
Average daily maximum temperature of coldest month °C	<21	-	>21	-	-	-

The parametric model reveals that, there was an optimal climatic condition in the study area with an average climate index of 75.98 and climate rate of 85.05 which made the region highly suitable (S1 class) for irrigated wheat crop (Table 5.13). However average daily maximum temperature of coldest month of the study area is 23.37 °C, which is higher than optimum condition (>21 °C).

Table: 5.13 The values of climate characteristics and the degree of limitation for wheat production in the study area

Climate characteristics	Value	Class	Degree of limitation
Rainfall of growing cycle (mm)	232.71	S3	53.08
Monthly rainfall of vegetative stage (mm)	15.73	S2	71.66
Monthly rainfall of flowering stage (mm)	8.17	N2	20.43
Monthly rainfall of ripening stage (mm)	48.02	S1	94.01
Mean temperature of growing cycle °C	18.63	S1	98.42
Mean temperature of vegetative stage °C	16.3	S1	91.42
Mean temperature of flowering stage °C	17.53	S1	99.41
Mean temperature of ripen stage °C	23.3	S1	95.88
Average daily minimum temperature of coldest month °C	7.49	S1	99.68
Average daily maximum temperature of coldest month °C	23.37	S2	82.18
Climate Index	75.98		
Climate rate	85.05		
Climate class	S1		

From the climatic point of view, if alternative has to be choosen it is better to consider potato and wheat in place of tobacco, which is presently dominant agricultural practice in Dinhata subdivision.

5.3 Soil characteristics of the study area

Data for this study has been based on secondary sources. By using Arc G.I.S software spatial analysis of texture of surface soil, soil pH, organic carbon and three primary soil nutrients such as nitrogen, phosphorous and potassium and five trace elements such as boron, copper, iron, manganese and zinc and one secondary soil nutrient such as sulphur have been done from the available data published by National Bureau of Soil Survey and Land Use Planning, Regional Centre (NBSS & LUP), Kolkata (2008). Besides this, MS office Excel has been used for data processing. The individual nutrient status has been categorized into three groups such as low, medium and high.

5.3.1 Spatial variability of soil properties

Soils are the most vital natural resources whose use greatly determines the life support system and the socio-economic development of any area. Knowledge on soil characteristics, their extent, distribution and potentiality is extremely important for optimum land use planning. Maintaining soils in a state of high Productivity is important for providing people with basic needs on sustainable basis (Surya et.al.2007). Soil survey helps to identity the extent of problems and potentials which in turn help to work out suitability of land for agricultural as well as non- agricultural uses (Aandahl 1958, Sehgal 1996). Soil fertility is one of the inherent capabilities of soil which determines the nutrient availability for plant growth. Soil fertility is an aspect of the soil-plant relationship, viz. plant growth with reference to plant nutrients available in soil (Biswas, T.D. and Mukherjee S.K., 1994).

Fertility of soil means the inherent capacity to supply nutrients (Das. P & S. Basu, 2004). Plants require at least 18 essential elements for normal growth and for completion of their life cycle. Those used in the largest amounts, carbon, hydrogen and oxygen, are non-mineral elements supplied by air and water. The other 15 elements are taken up by plants only in mineral form from the soil or must be added as fertilizers. Among different plant nutrients, nitrogen, phosphorous and potash are the three macro-nutrients or primary nutrients which are used in great quantities which actually set the fertility status of a soil. The three secondary elements, calcium, magnesium, and sulphur, are required in smaller amounts than the primary nutrients. The micronutrients consist of nine essential elements: boron, copper, chlorine, iron, manganese, molybdenum, zinc etc. These elements occur in very small amounts in both soils and plants, but their role is equally as important as the primary or secondary nutrients. A deficiency of one or more of the micronutrients can lead to severe retardation to growth, yield, and crop quality.

Land suitability evaluation requires criterion mostly from the land and soil attributes. Several soil parameters used for generation of the thematic map layers which used in AHP for generating the final suitability map for each crop. Following important soil parameters are discussed.

5.3.1.1 Textural classification

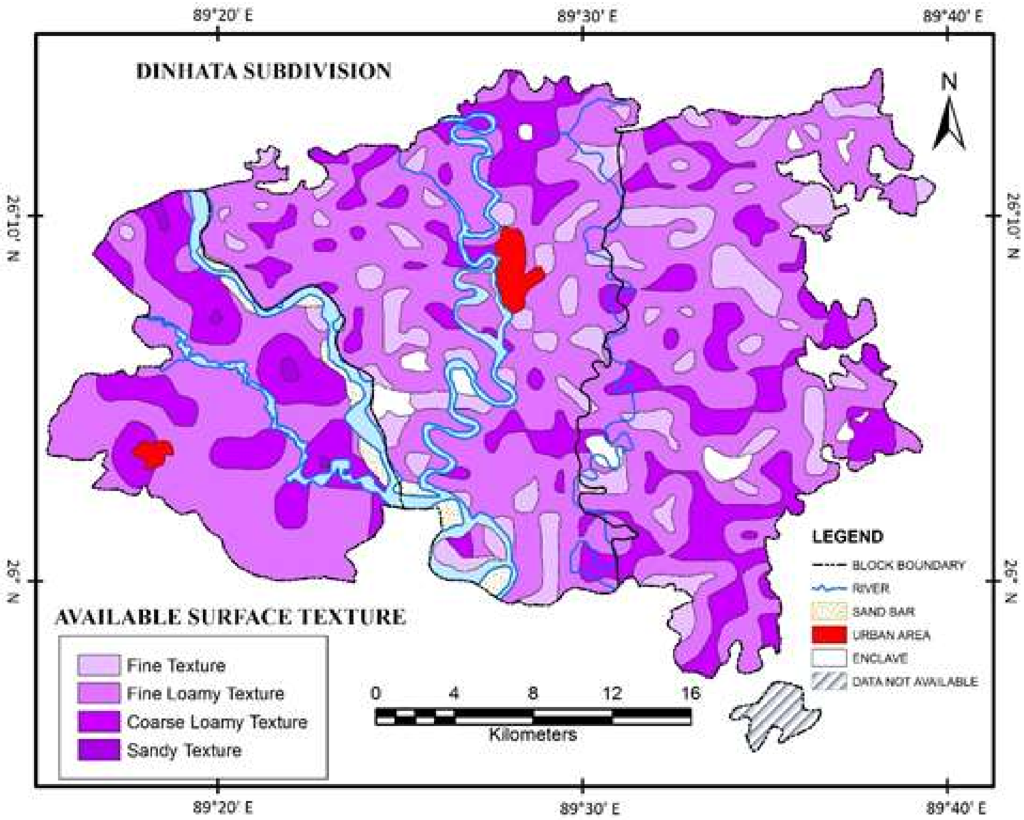
Texture is one of the important parameter of soil. Most of the physical and chemical characteristics of the soil depend upon texture class (Mustafa, et.al. 2011). Soil texture affects the retention and infiltration of water, aeration, absorption of nutrients, tillage, microbial activities and irrigation system (Foth 1990; Gupta, 2004). It is an inherent physical properties of soil which less affected by management. The rate of increase in gluiness or ability to mould as the moisture content increases be determined by the content of silt and clay, the degree to which the clay particles are bound together into stable pellets and the organic matter content of the soil (White, 1997). Over a long time, various pedogenic processes such as erosion, deposition, eluviation, illuviation and weathering can change the textures of various soil horizons (Forth, 1990; Brady and Weil, 2002).

Table: 5.14 Surface texture

Sl. No	Textural Class		Areas (sq km)	% of total area
1	Sandy	Ls	2.0492	0.27
2	Coarse loamy	sl, l and sil	157.0474	20.53
3	Fine loamy	scl, cl, sicl	444.1112	58.07
4	Fine	sc, sic, c	87.3527	11.42
5	Miscellaneous		74.2785	9.71
Total			764.839	100

Source: NBSS&LUP

The soils of the subdivision belonged to sandy, loamy and clayey textural groups. Sandy soils occupies as area of 2.0492 sq km constituting only 0.27 % area of the study area. Coarse loamy soil textural classes covered 20.53% area, while fine-loamy soils textural classes occupied 58.07% area. Clayey soils classified as fine soils constituted 11.42% area in the study area (Figure 5.1).

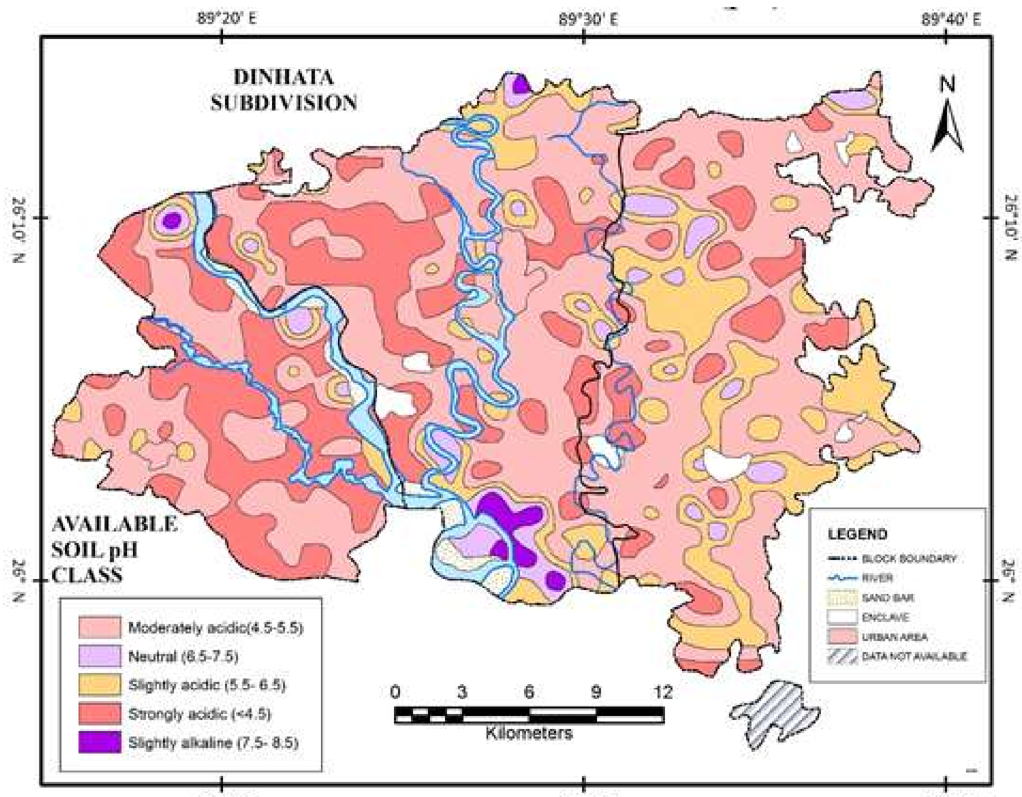


Data source: NBSS&LUP, 2008

Figure: 5. 1 Spatial distribution of surface texture in the study area

5.3.1.2 Soil reaction (pH)

Soil reaction is the degree of soil acidity or alkalinity, which is caused by particular chemical, mineralogical and biological environment (Tilahun, 2007).The supply of plant nutrients and thus the fertility of the soil are affected by pH. A number of natural and human activities such as leaching of exchangeable bases, acid rains, decomposition of organic materials, application of chemical fertilizers and different farming practices effect soil pH (Rowell, 1994; Tisdale et al., 1995; Brady and Weil, 2002). The solubility of most nutrients varies in response to pH. As acidity increases, the loss of these nutrients by leaching increases and their availability to plants decreases. The quantity of some nutrients may rise so greatly under acidic and alkaline conditions that they become toxic to plants (Briggs, 1977). Therefore, it is very essential to control soil pH between 6.5 to 7.5 regard most of the nutrients are available to plants for maintaining soil fertility (Daji, 1996).



Data Source: NBSS&LUP, 2008

Figure: 5.2 Spatial distribution of Soil reaction (pH) in the study area

Data on soil pH indicated that majority of the soils in the studied area were acidic. Strongly and moderately acidic soils together were mapped in 71.61 % area. Another 14.04% area was occupied by slightly acidic soils. Neutral and slightly alkaline soils occupied 3.77% and 0.87% area respectively (Figure 5.2). Due to high rainfall in the study area, most of the alkaline materials go through the lower horizon and most of the soil became acidic also due to agro-forestry and agricultural practice.

Table: 5.15 Soil Reaction (pH)

Sl. No	Soil reaction Class	Scale	Areas (sq km)	% of total area
1	Strongly acidic	<4.5	176.17217	23.03
2	Moderately acidic	4.5-5.5	371.5846	48.58
3	Slightly acidic	5.5-6.5	107.3597	14.04
4	Neutral	6.5-7.5	28.807	3.77
5	Slightly alkaline	7.5-8.5	6.637	0.87
6	Miscellaneous		74.2785	9.71

Total			764.839	100

Source: NBSS&LUP

5.3.1.3 Organic carbon

According to Dudal and Decaers (1993) Soil organic matter is defined as any living or dead plant and animal materials in the soil and it comprises a widespread of organic species includes humic substances, proteins, carbohydrates, and plant residues. The organic matter is a vital store of available nutrients. Sources of nutrients such as N, P, S and most micronutrients and growth promoting substances, that is, hormones or growth -promoting and regulating substances valuable to plants may be produced by organisms that decompose soil organic matter (Cook and Ellis, 1987 and Tisdale et al.1995). It helps to sustain soil fertility by improving soil structure, retention of mineral nutrients, increasing water holding capacity, water infiltration, drainage, aeration and root penetration. It also helps to increase the amount of soils flora (Havlin et. al. 2010). It comes in a soil from remains of plants and animals. However, in addition to this, it also includes grasses, trees, bacteria, fungi, protozoa, earthworm and animal manure.

The soils from the study area are classified on the basis of their organic carbon content into different categories such as low, medium and high. They are summarized in Table-5.17. The results on organic carbon content status indicated that soils in 39.08% area of the subdivision contained low organic carbon status. Medium and high organic carbon status soils were mapped on 31.11% and 20.10% area respectively (Figure 5.3). In general, majority of the soils in the area have low to medium carbon content. That is to say that these soils require adequate nitrogen fertilization through organic manure, farmyard manure, green manure etc.

Table: 5.16 Available organic carbon status

Sl. No	**Nutrient Class**	**Available organic carbon (%)**	**Areas (sq km)**	**% of total area**
1	Low	>0.50	298.8912	39.08
2	Medium	0.50-0.75	237.9661	31.11
3	High	>0.75	153.7032	20.10
4	Miscellaneous		74.2785	9.71
Total			764.839	100

Source: NBSS&LUP

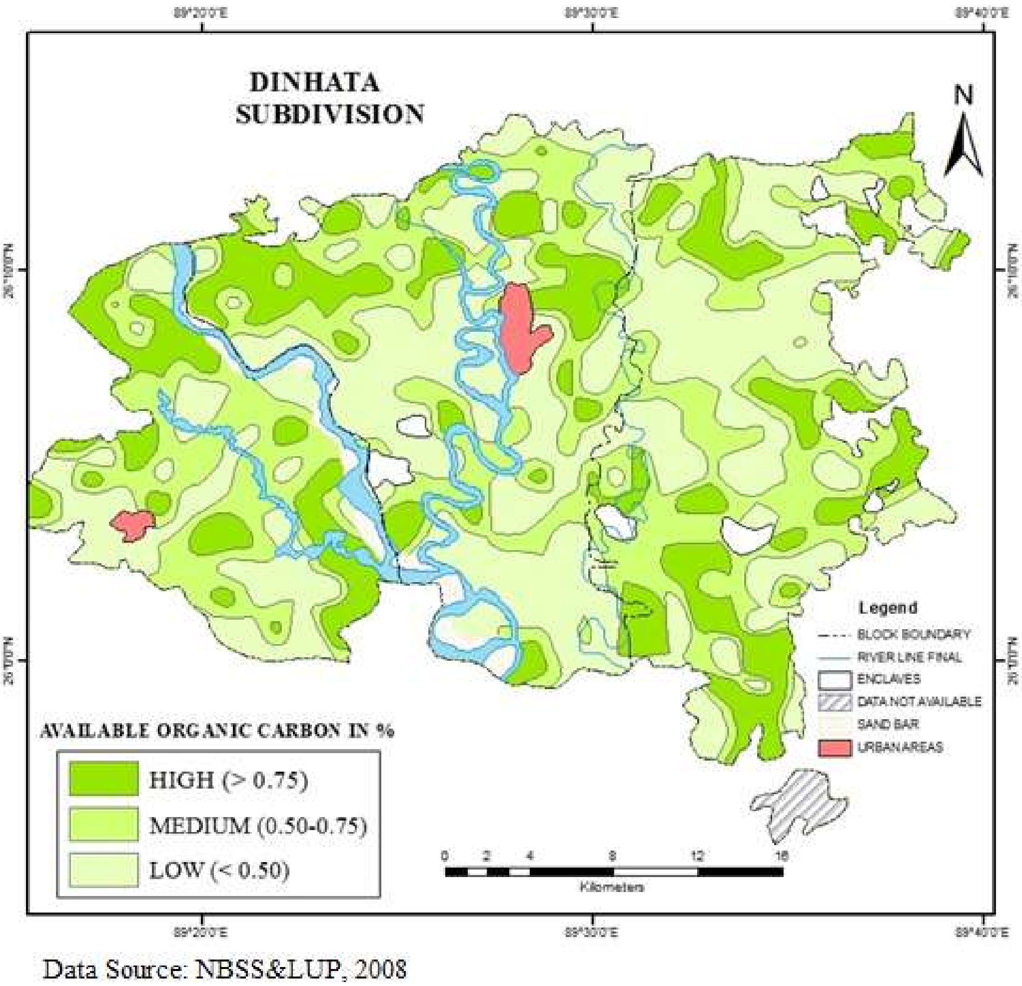


Figure: 5.3 Spatial distribution of Organic carbon in the study area

5.3.1.4 Available nitrogen (N)

Deficiency of nitrogen is almost universal in Indian soils. Therefore, nitrogen application is a must for canopy development and high yields. Nitrogen is the fourth plant nutrient taken up by plants in greatest quantity next to carbon, oxygen and hydrogen (Sanchez, 1976; Mengel and Kirkby, 1987), it should be present in the soil in appropriate proportion for the growth of plants. The plants absorb nitrogen either as ammonium or as nitrate ion. The occurrence of the nitrogen compounds in the soils involves the processes such as fixations of atmospheric nitrogen by free living and nodule forming bacteria, conversion of nitrogen containing compounds into humic acids, ammonification, nitrification, and then leaching loss of different nitrogen compounds by intra-soil and surface flows (Orlov, 1992).

The soils from the study area are classified on the basis of their nitrogen content into different categories such as low, medium and high. They are summarized in Table-5.17. Available nitrogen content in first 0-25 cm soils indicated that its availability was Low in the soils 42.89% area of the subdivision. Medium and High status soils with respect to available nitrogen were mapped in 27.35% and 20.05% area of the subdivision respectively (Figure-5.4).

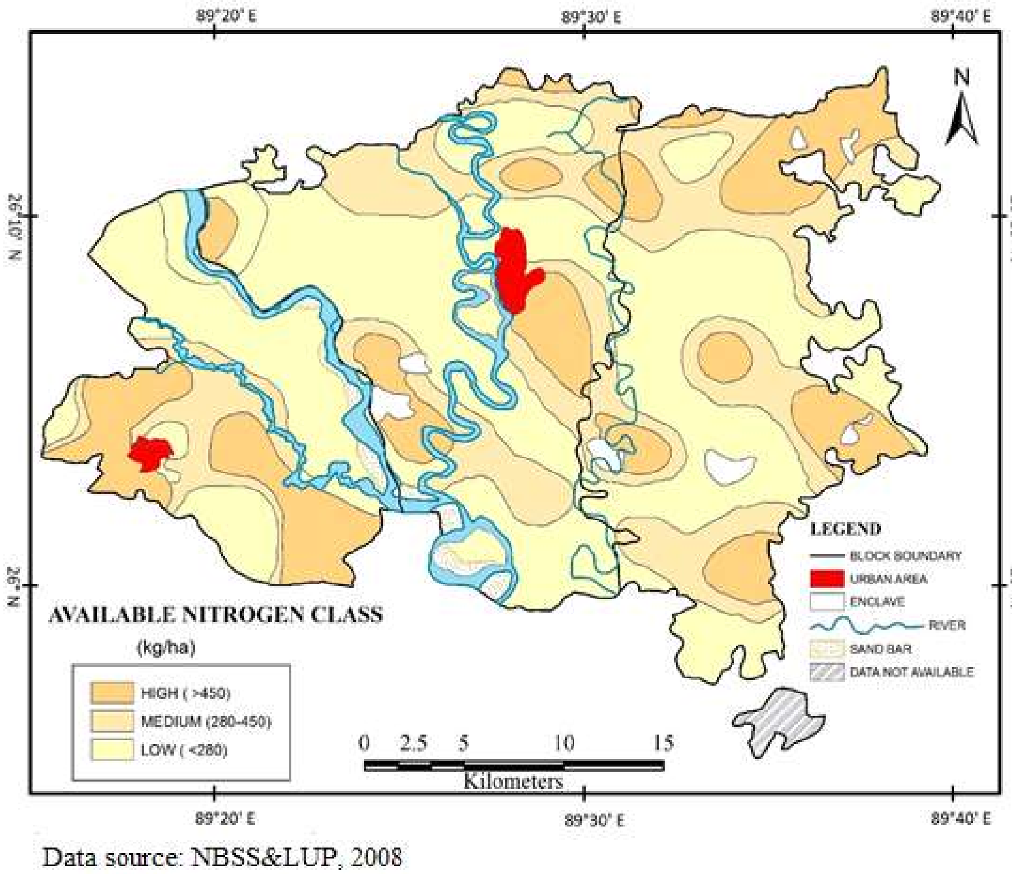


Figure: 5. 4 Spatial distribution of nitrogen in the study area

Table: 5.17 Available Nitrogen (N) status

Sl. No	**Nutrient Class**	**Available Nitrogen (kg/ha)**	**Areas (sq km)**	**% of total area**
1	Low	<280	328.0899	42.89
2	Medium	280-450	209.1544	27.35
3	High	>450	153.316	20.05
4	Miscellaneous		74.2785	9.71

Total			764.839	100

Source: NBSS&LUP

5.3.1.5 Available phosphorous (P)

Phosphorus has been called the "Master key to agriculture" (Foth and Ellis, 1997). Because low crop production more often due to lack of phosphorus than the deficiency of other elements except nitrogen. The importance of phosphorus in plant nutrient is many folds. It is essential for growth, cell division, root growth, fruit development and early ripening. It is also required for energy storage and transfer. It is a constituent of several organic compounds including oils and amino acids *(Tandon, 1997).* Phosphate ion enters the soil solution either as a result of mineralization of organophosphates or the application of fertilizers. The plants take available P mostly in the form of H_2PO_4 from soil solution. Chemisorption of P occur due to interaction of phosphate ions with the atoms like Al, Fe or Ca depending upon soil pH *(Orlov, 1992*).

In the present study the availability of phosphorous plant growth was low in 17.89%. Another 20.38% area was ranked medium, while larger part of the Dinhata subdivision covering 52.02% area was mapped with the high availability phosphorous (Figure-5.5).

Table: 5.18 Available Phosphorous (P) status

Sl. No	**Nutrient Class**	**Available Phosphorous(kg/ha)**	**Areas (sq km)**	**% of total area**
1	Low	<45	136.8418	17.89
2	Medium	45-90	155.8507	20.38
3	High	90-190	312.5615	40.87
4	Very High	>190	85.3063	11.15
5	Miscellaneous		74.2785	9.71
Total			764.839	100

Source: NBSS&LUP

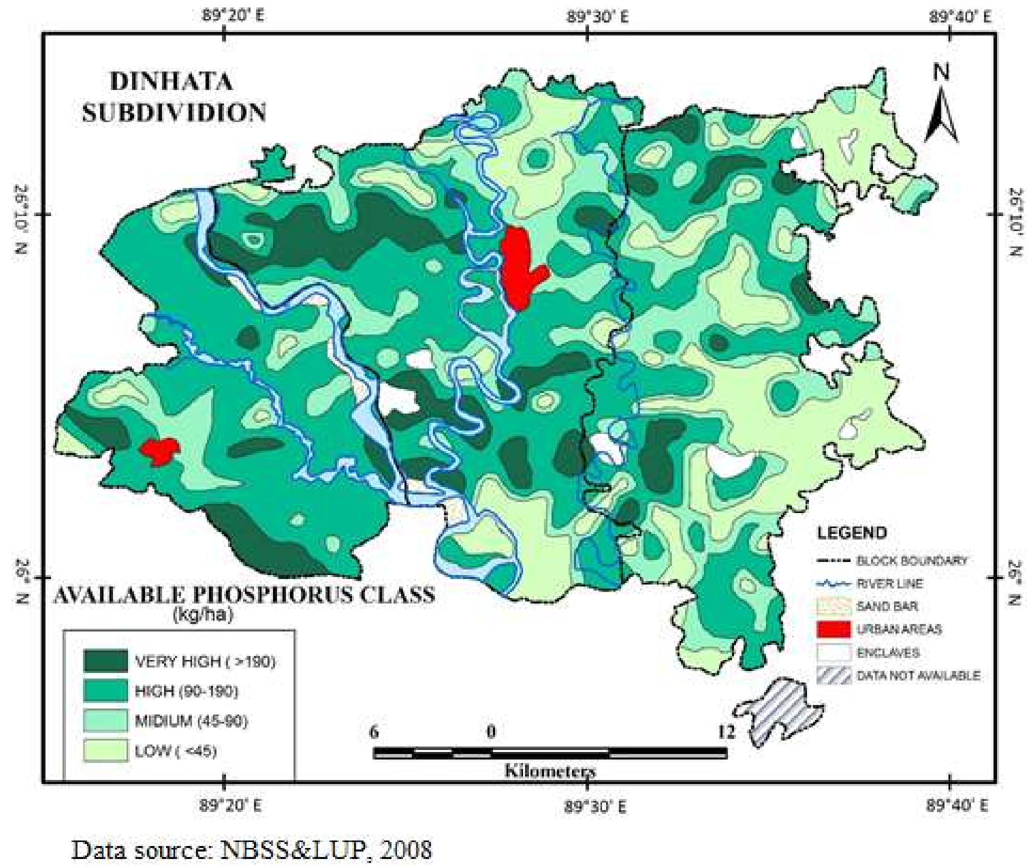


Figure: 5. 5 Spatial distribution of phosphorous in the study area

5.3.1.6 Available potassium (K)

Potassium is a master nutrient for the production of superior quality crop and it is the third most important essential element next to N and P that limit plant productivity (Brady and Weil, 2002). Soil parent materials contain potassium (K) mostly in feldspars and micas. Potassium exists in K ion form and it is released become either exchangeable or exist as adsorbed or as soluble in the solution (Foth and Ellis, 1997) and its function appears to be catalytic in nature. The potassium is important for plant because it participates in the activation of large number of enzymes which are involved in physiological process of plants. It controls the water economy and provides the resistance against a number of pests, diseases and environmental stresses *(Orlov, 1992*).

Availability of potassium for plant growth was found low (below 200kg/ha) in the larger part of the subdivision covering 41.46% area, while medium and high availability of potassium were observed in another 30.11% and 9.71% area respectively (Figure-5.6).

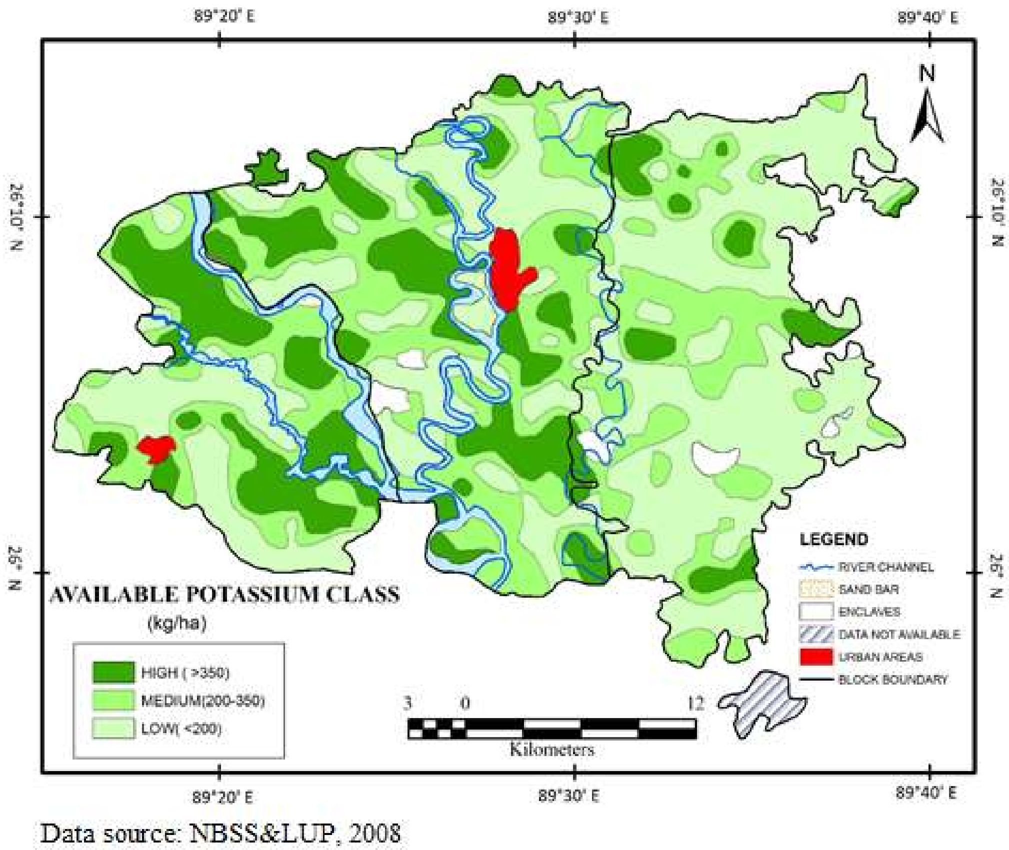


Figure: 5.6 Spatial distribution of potassium in the study area

Table: 5.19 Available Potassium (k) status

Sl. No	Nutrient Class	Available Potassium (kg/ha)	Areas (sq km)	% of total area
1	Low	<200	317.1215	41.46
2	Medium	200-350	230.3071	30.11
3	High	>350	143.1317	18.72
4	Miscellaneous		74.2785	9.71
Total			764.839	100

Source: NBSS&LUP

5.3.1.7 Available boron (B)

Boron is typical and important trace element. Orthoboric acid (H3BO3) and its salts are the main forms of boron present in the soil. Several factors including soil pH, calcium, soil texture, organic matter, light and moisture are known to influence the availability level of boron in soil *(Orlov, 1992)*. However, boron greatly influences the metabolism and transport of carbohydrates in plants. It is also involved in membrane integrity and cell wall development, which affect permeability, cell division and cell extension. Boron deficiency like calcium affects the growing points of roots, shoots and young leaves30. Boron deficiencies retard the uptake of calcium. The excess lime might reduce the uptake of calcium because of boron deficiency *(Tandon, 1997).*

In the present study the available boron status in the first 0-25 cms soils ranged from 0.36 mg/kg to 0.75 mg/kg. The data reveals that soils on 68.47% area in the Dinhata subdivision are deficient, while 21.82% areas were sufficient in respect of Boron (Figure-5.7).

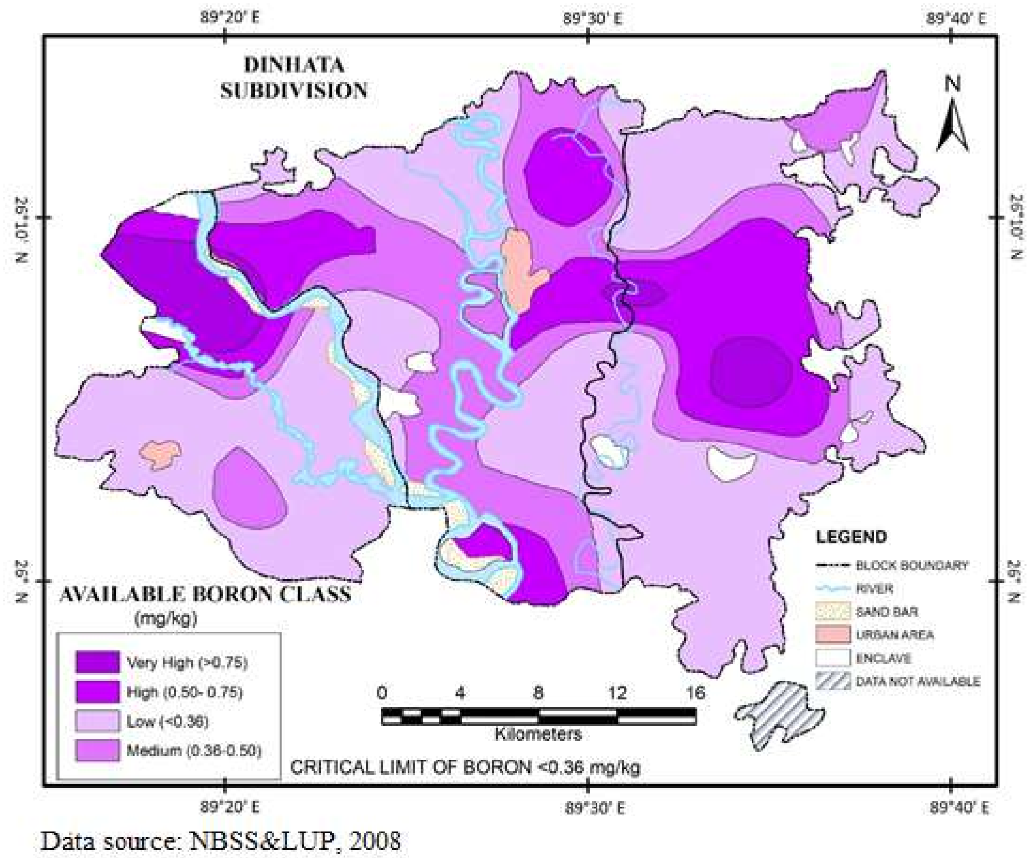


Figure: 5. 7 Spatial distribution of boron in the study area

Table: 5.20 Available Boron (B) status

Sl. No	Nutrient Class	Available Boron(mg/kg)	Areas (sq km)	% of total area
1	Low	<0.36	358.5945	46.89

2	Medium	0.36-0.50	165.093	21.58
3	High	0.50-0.75	128.148	16.76
4	Very High	>0.75	38.725	5.06
5	Miscellaneous		74.2785	9.71
Total			764.839	100

Source: NBSS&LUP

5.3.1.8 Available copper (Cu)

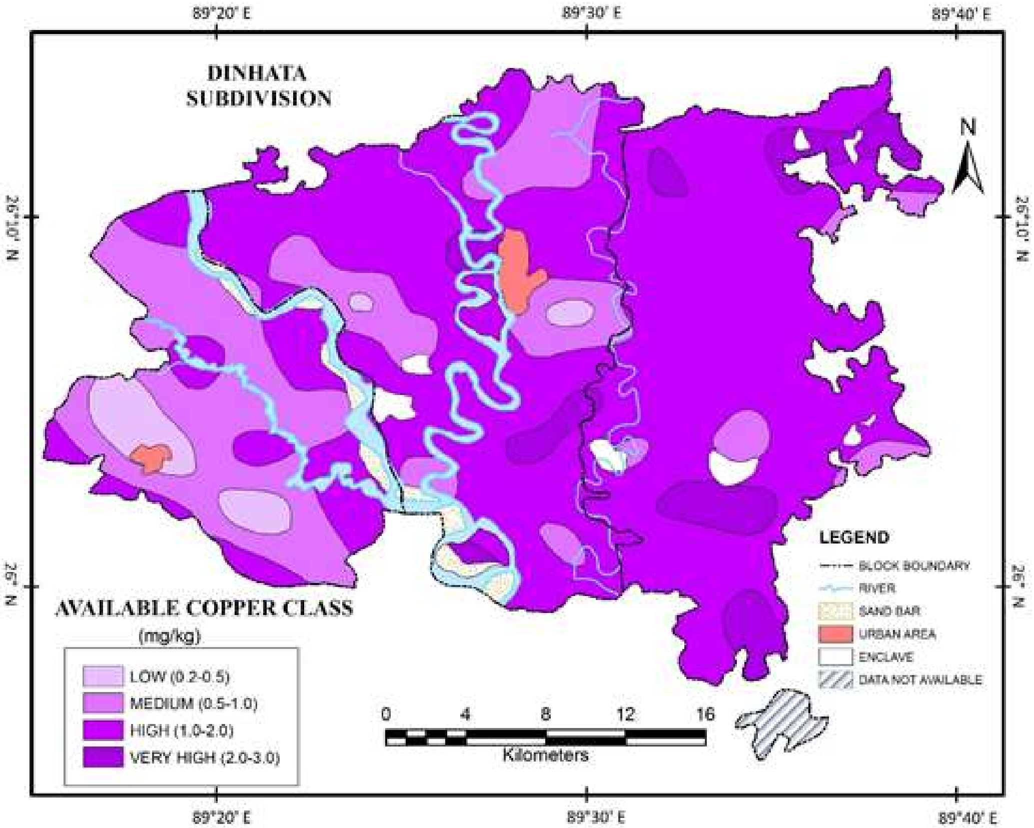
Copper (cu) is absorbed by plants as cupric ion (cu^{2+}). It is a constituent part of several enzymes participating in the cellular oxidation-reduction. It is also involved in carbon assimilation. Copper deficient plants are known to accumulate amino nitrogen. The crops most susceptible to Cu deficiency are alfalfa, wheat, barley and oats. The younger leaves of maize become yellow and pale while the older leaves die back.

The available copper status in the first 0-25 cms soils of the Dinhata subdivision reveals that soils are mostly sufficient (>0.2 mg/kg) in respect of available copper (Figure-5.8). Due to sufficient nature, this criterion have been excluded from the model.

Table: 5.21 Available copper (Cu) status

Sl. No	**Nutrient Class**	**Available copper (mg/kg)**	**Areas (sq km)**	**% of total area**
1	Low	0.2-0.5	22.238	2.91
2	Medium	0.5-1.0	160.9667	21.05
3	High	1.0-2.0	463.1772	60.56
4	Very High	2.0-3.0	44.1786	5.77
5	Miscellaneous		74.2785	9.71
Total			764.839	100

Source: NBSS&LUP



Data source: NBSS&LUP, 2008

Figure: 5.8 Spatial distribution of copper in the study area

5.3.1.9 Available iron (Fe)

Iron (fe) is absorbed by plants as Fe^{2+} or Fe^{3+} and also organically complexed or chelated Fe. Fe^2 iron is the active form, used in plant metabolism. Iron plays a direct role in the primary process of photosynthesis. Though iron is not a constituent in chlorophyll, it is involved in the synthesis of chlorophyll. Iron has an important catalytic role in enzyme activity. It is directly or indirectly in all the metabolic processes of plants such as synthesis of carbohydrates, organic acids and vitamins. Being a constituent of ferroxidine, iron is involved in N fixation. The leg haemoglobin of root nodules contains iron as an essential constituent.

Iron deficiency has been shown to result in decreased level of photosynthesis due to reduction of chlorophyll production. The deficiency results of iron in chlorosis in which the inter veinal area of leaves turns yellow. The leaves may turn into almost pale white with severe deficiency. Crops such as maize, sorghum, groundnut and soya bean are considered sensitive to Fe deficiency.

Table: 5.22 Available Iron (Fe) status

Sl. No	Available Iron (mg/kg)	Areas (sq km)	% of total area
1	4.5-10	39.278	5.13
2	10-25	83.901	10.97
3	25-50	77.924	10.19
4	50-100	151.6653	19.83
5	100-200	329.8565	43.13
6	>200	7.9357	1.04
7	Miscellaneous	74.2785	9.71
Total		764.839	100

Source: NBSS&LUP

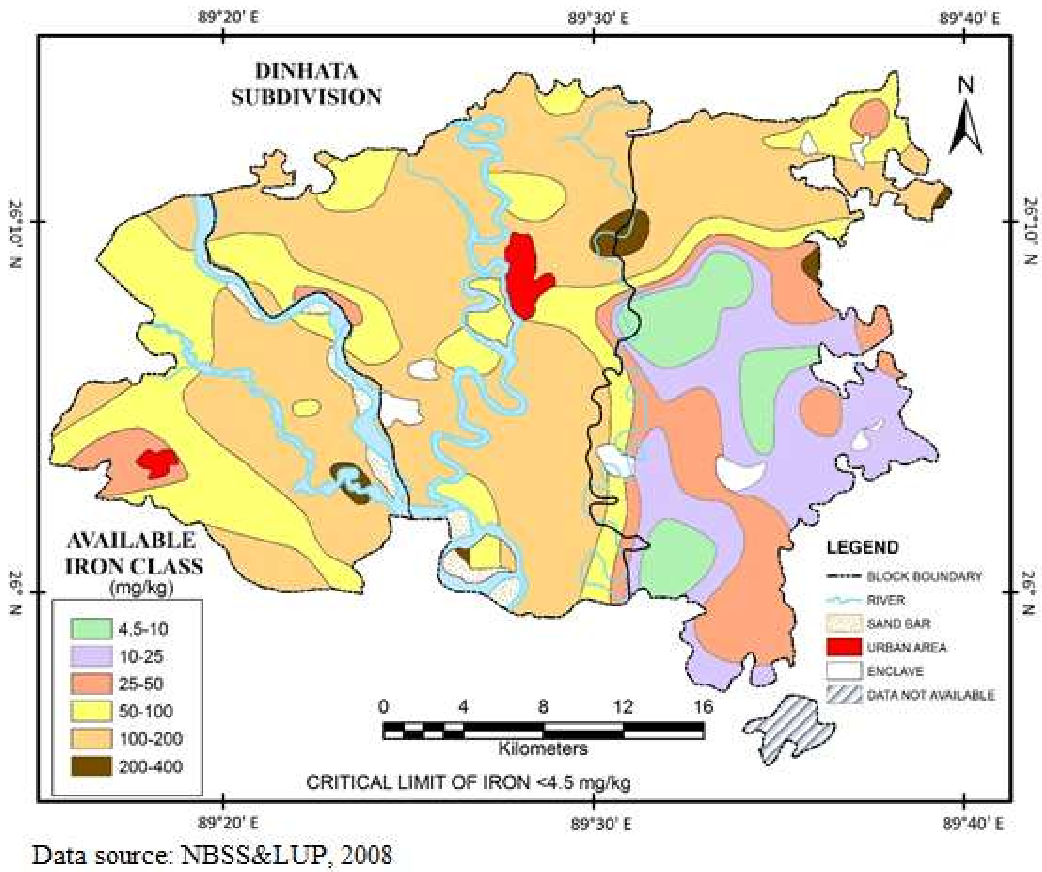


Figure: 5.9 Spatial distribution of iron in the study area

The availability iron in first 0-25 cm on soils was observed sufficient in the entire study area (Figure-5.9). Hence iron content was not taken into accounts for land suitability evaluation.

5.3.1.10 Available manganese (Mn)

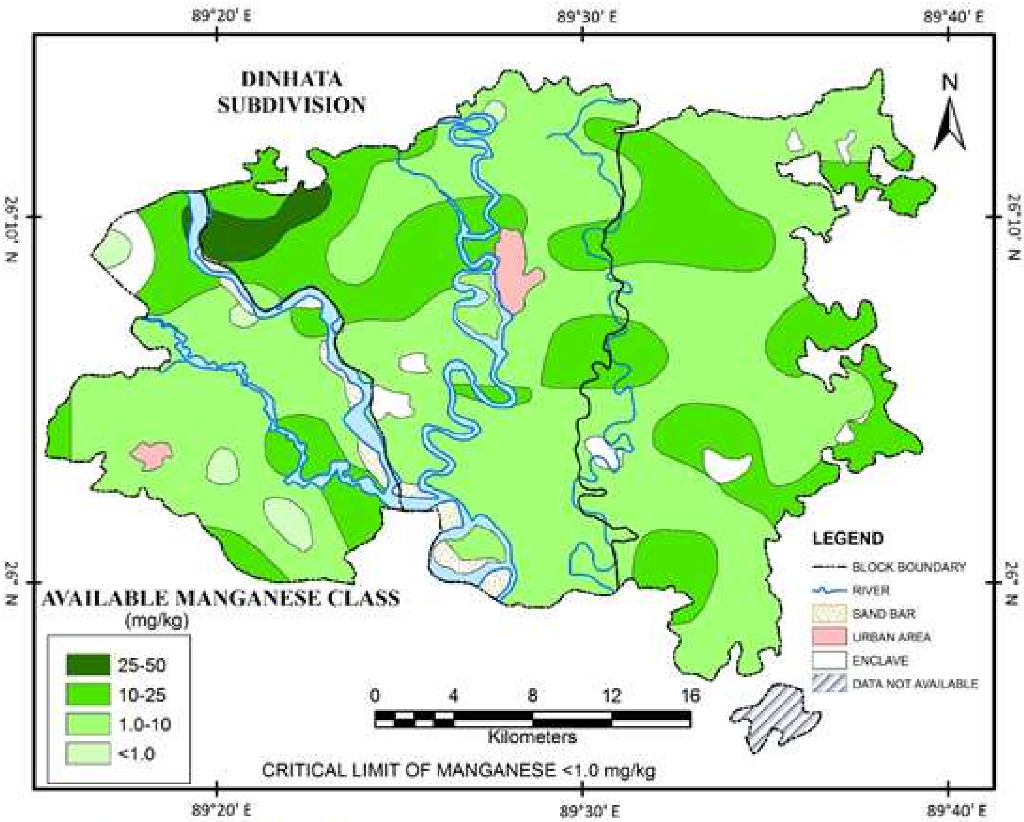
The concentration of Manganese content in soil is a particularly wide range, the lower values are distinctive of severely leached acid soils, whereas excess or toxicities often occur in unleached acid soils and waterlogged conditions. Soil pH are the main controlling factor for manganese availability in soils. A pH value below 6.0 favours reduction of manganese and the formation of the more available bivalent form (Mn^{+2}); higher pH values favour oxidation to the Mn^{+4} ion, forming the insoluble oxides (MnO_2 , Mn_2O_3 and Mn_3O_4) (Harmsen and Vlek, 1985).

Manganese status in the first 0-25 cms of the soils of the study area reveals that about 680.4885 sq km area (88.97 % area) in the subdivision sufficient (>1 mg/kg) in manganese status (Figure-5.10). Only 1.32% area in the study area deficient in Mn status needs special care for manganese nutrition.

Table: 5.23 Available Manganese (Mn) status

Sl. No	**Nutrient Class**	**Available Manganese(mg/kg)**	**Areas (sq km)**	**% of total area**
1	Low	<1.0	10.072	1.32
2	Medium	1.0-10	457.8605	59.86
3	High	10-25	211.123	27.60
4	Very High	25-50	11.505	1.51
5	Miscellaneous		74.2785	9.71
Total			764.839	100

Source: NBSS&LUP



Data source: NBSS&LUP, 2008

Figure: 5.10 Spatial distribution of manganese in the study area

5.3.1.11 Available sulphur(S)

Sulphur (s) is absorbed by plants as sulphate iron (SO_4). Concentration S in plants ranges from 0.1 to 0.4%. Sulphur requirement is high for the crops of families of Gramineae, leguminosae and Cruciferae. Sulphur is involved as a ligand in a number of enzymes metallo-proteins, most conspicuously in the iron-sulpher proteins and copper proteins (Adinarayana, 1992). It is an integral part of some of the essential amino acid viz, cysteine, cystine and methionine. It is also constituent of glutathione, a compound that plays a part in the plant resoiration and synthesis of essential oils. The biologically active sulphate-3 phosphoadenosine-5 phospho-sulphate is an important sulphate donor involved in carbohydrate metabolism of the crop plants. The characteristic taste and smell of plant in the mustard and onion families is due volatile compound containing S (De Kok et.al. 1993).

The deficiency of S results in increase in nitrate, soluble organic nitrogenous compounds, amides and ammonia and a decrease in insoluble (protein) nitrogen. Sulphur deficiency symptoms mostly resemble that of N deficiency. Leaves become pale yellow or light green and the symptoms will persist even after N application. Plants become small and spindly with short and slender stalks and crop growth is retarded. In sulphur deficient plants, the stem becomes hard and woody.

Available sulphur status in the study area was observed high on 438.4127 sq km area (57.32% area), medium 139.7528 sq km (18.27% area) and low in 112.395 sq km (14.70% area) area (Figure-5.11).

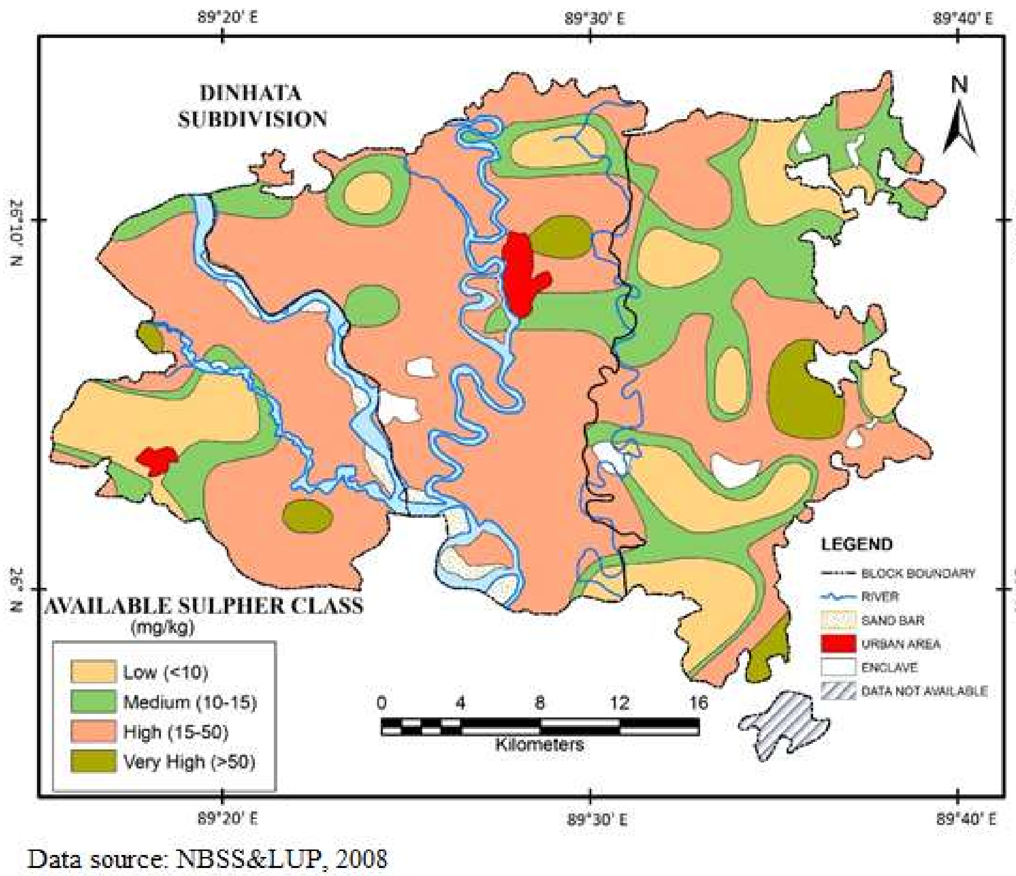


Figure: 5.11 Spatial distribution of sulphur in the study area

Table: 5.24 Available Sulphur (S) status

Sl. No	**Nutrient Class**	**Available Sulphur (mg/kg)**	**Areas (sq km)**	**% of total area**
1	Low	<10	112.395	14.70
2	Medium	10-15	139.7528	18.27

3	High	15-50	413.7167	54.09
4	Very High	>50	24.696	3.23
5	Miscellaneous		74.2785	9.71
Total			764.839	100

Source: NBSS&LUP

5.3.1.12 Available zinc (Zn)

Plants absorb zinc as Zn^{2+} and it is a constituent of several dehydrogenase, proteinase and peptidase enzymes. Zinc is believed to promote RNA synthesis which, in turn, is needed for protein synthesis (FAO, 2006). It plays an important role in the formation of some growth hormones and starch formulation. It also promotes seed maturation and production. Crops such as rice, soya bean, maize and linseed are classified as very sensitive to Zn deficiency.

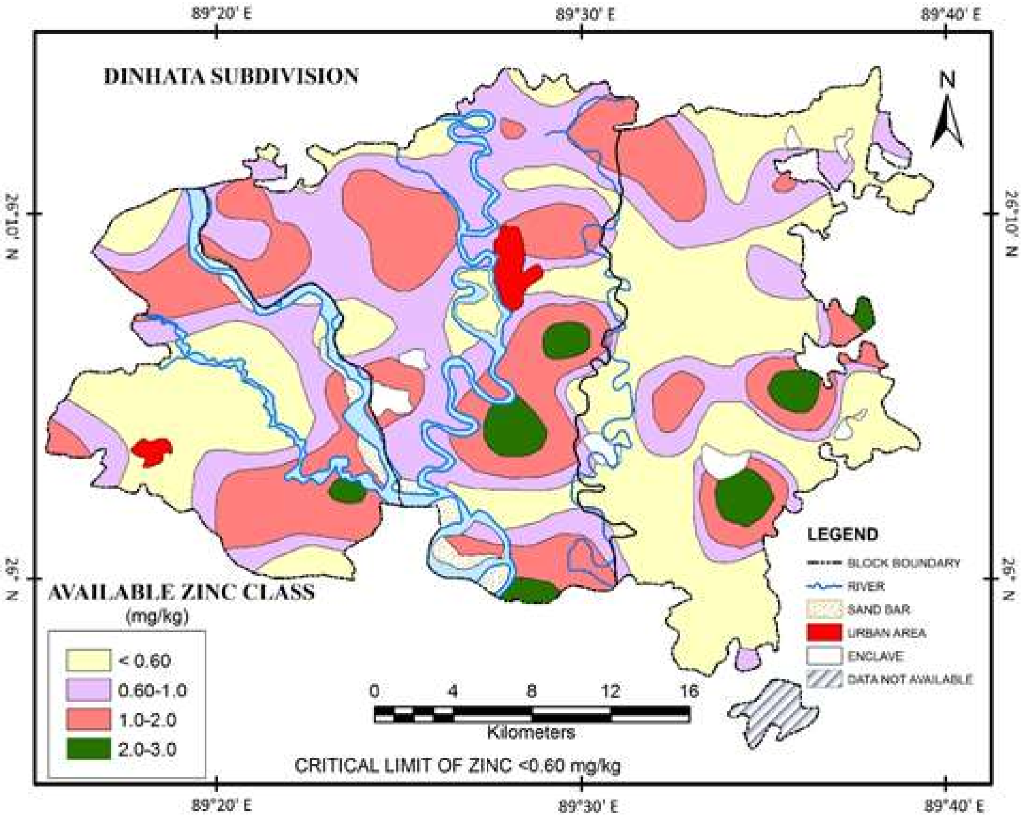
Zn deficiency causes decrease in the level of photosynthesis. Flower and fruit setting are considerably reduced and delayed. Plant growth is stunted and tillering is poor. Characteristic brown rusty spots occur on rice leaves. In maize and sorghum the deficiency is known as 'white bud' and in cotton it is called 'little leaf' (Harmsen and Vlek, 1985).

The available Zinc status in first 0-25 cms soils indicated that about 489.326 sq km (63.98% area of the subdivision) is deficient in Zinc (Figure-5.12). The area having sufficient status of Zinc was marked on 201.2345 sq km area that constitutes another 26.31% area of Dinhata subdivision.

Table: 5.25 Available Zinc (Zn) status

Sl. No	**Nutrient Class**	**Available Zinc(mg/kg)**	**Areas (sq km)**	**% of total area**
1	Very Low	<0.60	275.08	35.97
2	Low	0.60-1.0	214.246	28.01
3	Medium	1.0-2.0	176.0885	23.02
4	High	2.0-3.0	25.146	3.29
5	Miscellaneous		74.2785	9.71
Total			764.839	100

Source: NBSS&LUP



Data source: NBSS&LUP, 2008

Figure: 5.12 Spatial distribution of zinc in the study area

5.3.1.13 Soil fertility

The fertility rating have been prepared by Maull's Griddle method. Followed by Maull's Griddle method (Mitchel, 1977) separate maps of each of three primary nutrient maps (NPK) have been superimposed on a single map. The line where more than a given number of boundaries approximately coincide has been selected or the mean boundary has been taken. The basic theme of this method is represented in the Table 5.26.

Table: 5.26: Fertility rating after Maull's Griddle

Fertility status	Fertility rating (NPK)
Low fertility	LLL, LML, MLL, LLM
Medium fertility	LMM, MLM, MML, HMM, MMM, MHM, MMH
High fertility	HHH, HLM,HHL,HHL, HHM

L= Low, M= Medium, H= High

Following the method, the study area has been divided into three soil fertility zones viz, low, moderate and high fertility.

Table: 5.27 Soil Fertility status

Sl. No	Fertility status	Fertility rating (NPK)	Areas (sq km)	% of total area
1	Low fertility	LLL, LML, MLL, LLM	390.9861	51.12
2	Medium fertility	LMM, MLM, MML, HMM, MMM, MHM, MMH	95.3958	12.47
3	High fertility	HHH, HLM,HHL,HHL, HHM	204.1786	26.70
4	Miscellaneous		74.2785	9.71
Total			764.839	100

Source: NBSS&LUP

Low fertility: This fertility group occupies maximum percentage of area (51.12%) in the study area (Figure-5.13) and spreads over nearly level land, rolling land as well as undulating land. In the western and midlle parts (greater part of Dinhata-II and parts of Dinhata-I), the continuity of this zone is broken by some small isolated patches of moderate fertility zones. More than 70% of this soil group is characterized by moderately acidic soil (pH 4.5 to 5.5) and nearly 10 % are characterized by strongly acidic soil (pH less than 4.5). About half of the soil group suffers from well to imperfectly drained soil with moderate soil erosion.

Moderate fertility: This fertility group occupies only 12.47% (95.3985 sq km) area of the study area (Figure-5.13). Very small isolated patches of this zone are distributed over the study area. More than 80% of this soil group is characterized by moderately acidic soil (pH 4.5 to 5.5) and nearly 10 are characterized by slightly acidic soil (pH 5.5 to 6.5).

High fertility: This fertility zone covers 26.70% (204.1786 sq km) area of the study area (Figure-5.13). This zone is distributed within the moderate fertility zone. The middle, western and southern parts of Dinhata-II block is totally devoid of this fertility zone. Most of mouzas (J.L.4,5,7,8,9,10,11,12,14,16,17,20,30,31,32,34,36,39,40,41,42,45,46, 47,48,49,51,52,53) of Sitai block located in this parts. This zone contain medium (280-

450kg/ha) to high (more than450 kg/ha) available nitrogen, high (90-190 kg/ha) to very high (more than190 kg/ha) available phosphorous and medium (200-350 kg/ha) to high (more than350 kg/ha) available potassium.

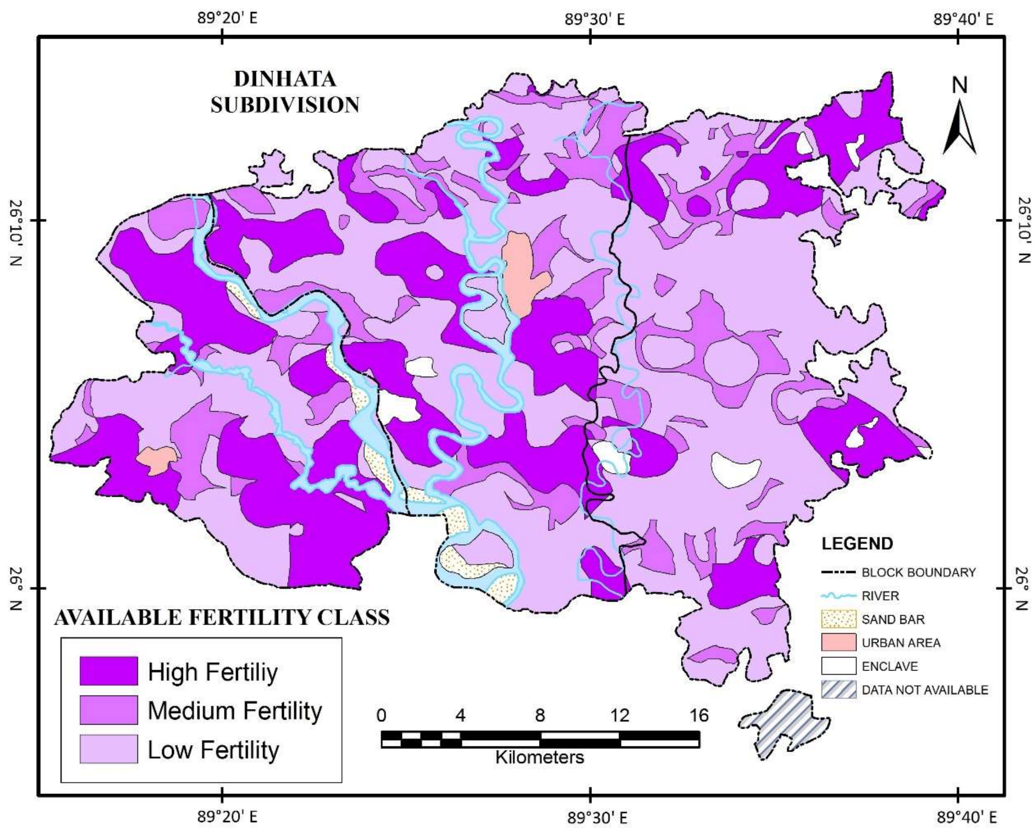


Figure: 5.13 Fertility status (NPK) in the study area

5.3.1.14 Soil Erosion

Soil erosion is the dominant limiting factor for crop production. The figure 5.14 showed that largest part of the subdivision (70.29%) faced moderate (10-15t/ha/yr) soil erosion due to water and wind action. Remaining area 16.62% and 3.5% falls under moderately slight (5-10t/ha/yr) and moderately severe (15-20t/ha/yr) soil erosion class.

Table: 5.28 Soil Erosion status

Sl. No	Soil Erosion Class	Soil erosion rate (t/ha/Yr)	Areas (sq km)	% of total area
1	Moderately Slight	5-10	127.16	16.62
2	Moderate	10-15	537.52	70.29

3	Moderately Severe	15-20	26.859	3.51
4	Miscellaneous		73.3	9.58
Total			764.839	100

Source: Raw data obtained from NBSS&LUP AND SOIL & WATER CONSERVATION RESEARCH & TRAINING INSTITUTE and complied by the researcher.

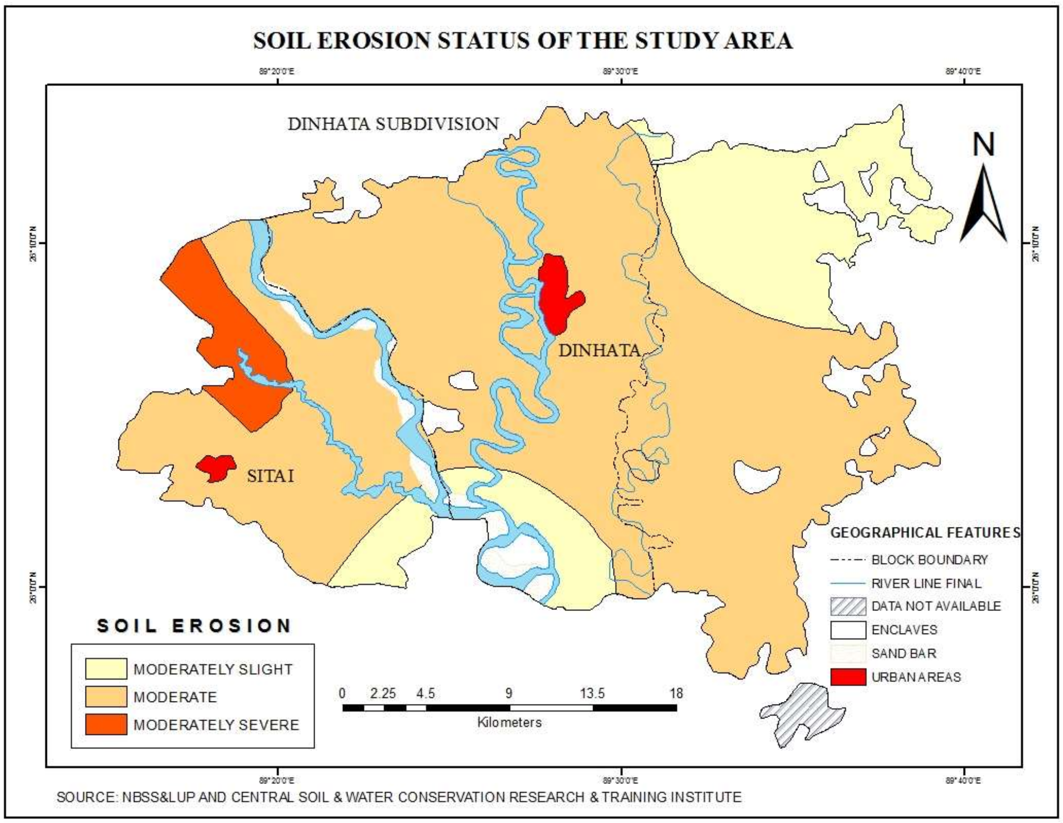


Figure: 5.14 Soil erosion status of the study area

5.3.1.15 Slope

Slope is very important factor for land suitability analysis. Places with high slope is not suitable for cultivation due to being impenetrable. On the other hand the very sharp slopes as result of low soil depth and lack of evolved soils have not appropriate condition for growth plants. Meanwhile the elevation criteria because of effect on soil are considered as important factor in land suitability analysis.

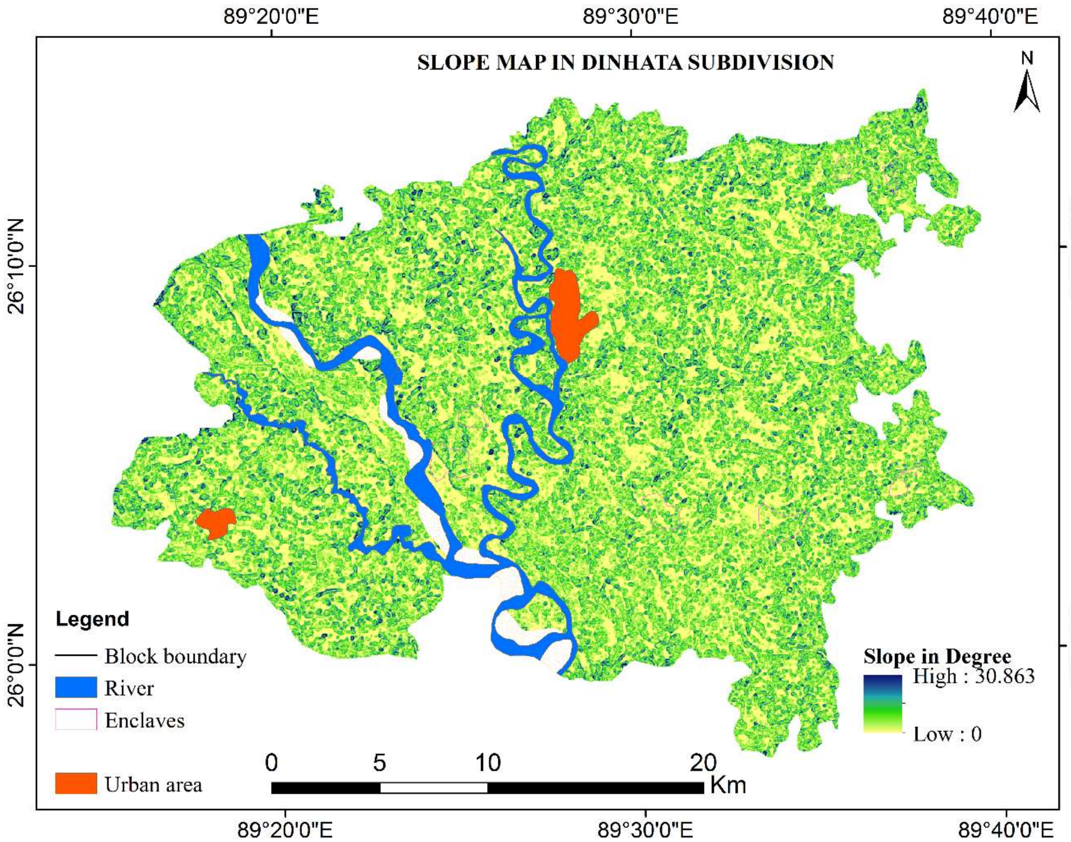


Figure: 5.15 Slope map of the study area

5.3.2 Soil-site suitability for alternative crops of tobacco

Soil site suitability for alternative crops of tobacco were determine by AHP model. The analytical hierarchy process is firstly introduced by Saaty in 1980. It is a multi-objective, multi-criteria decision making approach, which enables the user to arrive at a scale of preference drown from a set of alternatives (Saaty, 1980). This method is very important for suitability analysis, regional planning, decision making. In the construction of a pair wise comparison matrix, each factor is rated against every other factor by assigning a relative dominant value between 1 and 9 to the intersecting cell (Table. 5.29).

Table: 5.29 Fundamental scale of absolute number between two parameters in AHP (Saaty, 2000)

Intensity of Importance	Degree of Preference	Explanation
1	Equally	Two activities contribute equally to the objective

3	Moderately	Experience and judgment slightly to moderately favour one activity over another
5	Strongly	Experience and judgement strongly or essentially favour one activity over another
7	Very strongly	An activity is strongly favoured over another and its dominance is showed in practice
9	Extremely	The evidence of favouring one activity over another is of the highest degree possible of an affirmation
2,4,6,8	Intermediate values	Used to represent compromises between the preferences in weights 1,3,5,7 and 9
Reciprocals	Opposites	Used for inverse comparison

For the AHP model, the final result includes the weights of the derived factors, class weights and a calculated consistency ratio (CR), as seen in Table 5.31. In the AHP method, an index of consistence, known as the consistency ratio (CR), is used to indicate the probability that the matrix judgments were randomly generated (Saaty, 1980).

$$CR = CI/RI$$

Where RI is the average of the resulting consistency index depending on the order of the matrix given by Saaty in 1980 and CI is the consistency index and can be expressed as:

$$CI = (\lambda max - n)/(n - 1)$$

Where λmax is the largest or principle eigenvalue of the matrix and can be easily computed from the matrix and 'n' is the order of the matrix. The consistency ratio is a ratio between the matrix consistency index and random index, and in general ranges from 0 to 1. A CR of 0.1 or less is a reasonable level of consistency (Malczewski, 1999). A CR above 0.1 requires revision of the judgment in the matrix due to an inconsistent treatment for particular factor ratings.

In this study, the consistency ratio is less than 0.06; the ratio indicates a logical level of consistency in the pair-wise comparison that is good enough for recognize factor weights. For all cases of the gained class weights, the CRs are less than 0.1, the ratio indicates a reasonable level of consistency in the pair-wise comparison that is good enough to recognize the class weights. Regard alternative crop suitability mapping (ACSM) by AHP, is used based on following equation:

$$\sum_{i=1}^{n}(Ri \times Wi)$$

Where Ri is the rating classes each layer and Wi is the weights for each of the crops conditioning factors. For the estimation of alternative crops suitability value (ACSV) the each crops conditioning factors values is summed by weighted linear sum model on a GIS environment (Lee and Talib, 2005). Finally ACSV is classified into four classes (S1, S2, S3 and N) based on natural break to determine the class interval in the ACSM.

Table: 5.30 Pair-wise priority rating of different data layers

Factor	Class	Rating (Ri) for all crops				
		Boro paddy	Mustard	Maize	Wheat	Potato
Surface Texture	Fine soil	0.473	0.138	0.168	0.272	0.189
	Fine loamy soil	0.284	0.478	0.383	0.157	0.109
	Coarse loamy soil	0.170	0.256	0.342	0.483	0.351
	Sandy soil	0.073	0.128	0.107	0.088	0.351
Soil pH	<4.5	0.039	0.039	0.050	0.039	0.064
	4.5-5.5	0.192	0.107	0.151	0.107	0.207
	5.5-6.5	0.368	0.243	0.354	0.243	0.388
	6.5-7.5	0.296	0.383	0.295	0.383	0.219
	7.5-8.5	0.105	0.227	0.151	0.227	0.122
Organic carbon	High	0.540	0.540	0.540	0.540	0.540
	Medium	0.297	0.297	0.297	0.297	0.297
	Low	0.163	0.163	0.163	0.163	0.163
Nitrogen	High	0.570	0.550	0.550	0.550	0.558
	Medium	0.333	0.240	0.240	0.240	0.320
	Low	0.097	0.210	0.210	0.210	0.122
Phosphorus	Very high	0.469	0.487	0.402	0.402	0.469

	High	0.297	0.273	0.337	0.337	0.297
	Medium	0.166	0.134	0.164	0.164	0.166
	Low	0.068	0.106	0.097	0.097	0.068
Potassium	High	0.540	0.540	0.540	0.400	0.540
	Medium	0.297	0.297	0.297	0.400	0.297
	Low	0.163	0.163	0.163	0.200	0.163
Boron	Very high	0.473	0.473	0.473	0.473	0.473
	High	0.284	0.284	0.284	0.284	0.284
	Medium	0.170	0.170	0.170	0.170	0.170
	Low	0.073	0.073	0.073	0.073	0.073
Manganese	Very high	0.473	0.473	0.473	0.473	0.473
	High	0.284	0.284	0.284	0.284	0.284
	Medium	0.170	0.170	0.170	0.170	0.170
	Low	0.073	0.073	0.073	0.073	0.073
Sulpher	Very high	0.326	0.449	0.449	0.449	0.351
	High	0.363	0.288	0.288	0.288	0.351
	Medium	0.163	0.138	0.138	0.138	0.189
	Low	0.148	0.126	0.126	0.126	0.109
Zinc	Very high	0.476	0.476	0.476	0.476	0.476
	High	0.289	0.289	0.289	0.289	0.289
	Medium	0.176	0.176	0.176	0.176	0.176
	Low	0.059	0.059	0.059	0.059	0.059
Soil erosion	Moderately slight	0.582	0.582	0.582	0.582	0.582
	Moderate	0.309	0.309	0.309	0.309	0.309
	Moderately severe	0.109	0.109	0.109	0.109	0.109
Slope	0-1	0.483	0.168	0.168	0.168	0.168
	1-3	0.272	0.461	0.461	0.461	0.461
	3-5	0.157	0.236	0.236	0.236	0.236
	>5	0.088	0.135	0.135	0.135	0.135

Table: 5.31 The priority weights of each cops conditioning factor by analytical hierarchical process (AHP)

Factors	Weights of each factors (Wi)				
	Boro paddy	**Mustard**	**Maize**	**Wheat**	**Potato**
Surface Texture	0.200	0.188	0.188	0.196	0.066
Soil pH	0.053	0.075	0.045	0.177	0.060
Organic carbon	0.067	0.033	0.060	0.037	0.024
Nitrogen	0.171	0.145	0.165	0.113	0.165
Phosphorus	0.154	0.173	0.140	0.143	0.140
Potassium	0.137	0.124	0.125	0.043	0.125
Boron	0.020	0.018	0.021	0.017	0.021
Manganese	0.017	0.022	0.018	0.078	0.020
Sulpher	0.034	0.028	0.076	0.094	0.030
Zinc	0.041	0.094	0.098	0.049	0.128
Soil erosion	0.026	0.044	0.035	0.022	0.045
Slope	0.080	0.057	0.028	0.031	0.038
Consistency ratio (CR)	0.039	0.054	0.052	0.040	0.036

5.3.2.1 Potato

Potato is one of the important food crop in India. It is considered as a crop of the poor man's food. For vegetable purpose it has become one of the most popular crops in the country. It is a cash crop in the study area.

Soil and Site Requirements: Potatoes can be grown on soils that have a fine sandy to clay texture. Its require high to medium soil fertility with high manganese content. This crop is well suited to pH range of 5.6 - 7.0 (Sys et al., 1993). The soil-site suitability criteria for potato are shown in Table 5.32.

Table: 5.32: Soil-site suitability criteria for Potato

Land characteristics		Class and Degree of limitation			
		Highly Suitable	**Moderately suitable**	**Marginally Suitable**	**Unsuitable**
		S1	**S2**	**S3**	**N**
Topography	Slope	<10	10-18	18-28	>28
	Erosion Hazard	Moderately slight	Moderate	Moderately severe	-
Soil	Texture	Coarse loamy & sandy texture	Fine texture	Fine loamy texture	-
	pH	Slightly acidic	moderately acidic	slightly alkaline	-
			Neutral	strongly acidic	
	Organic Carbon	High	Medium	Low	-
	Nitrogen	High	Medium	Medium	Low
	Phosphorous	Very high	High	Medium	Low
	Potassium	High	Medium	Low	-
	Boron	Very high	High	Medium	Low
	Sulpher	Very high & high	Medium	Low	-
	Manganese	Very high	High	Medium	Low
	Zinc	Very high	High	Medium	Low

Source: Compiled from, NBSS&LUP, 2006; Reddy and Shivprasad, 1999; Dent and Young, 1981; FAO, 1983; FAO/UNDP, 1984ab; IIASA/FAO, 2002; IIASA/FAO, 2012; Jones, 2003; Sanchez et al., 2003; Sys and Riquier, 1980; Sys et al., 1991ab; Sys et al., 1993; Van Diepen et al., 1991

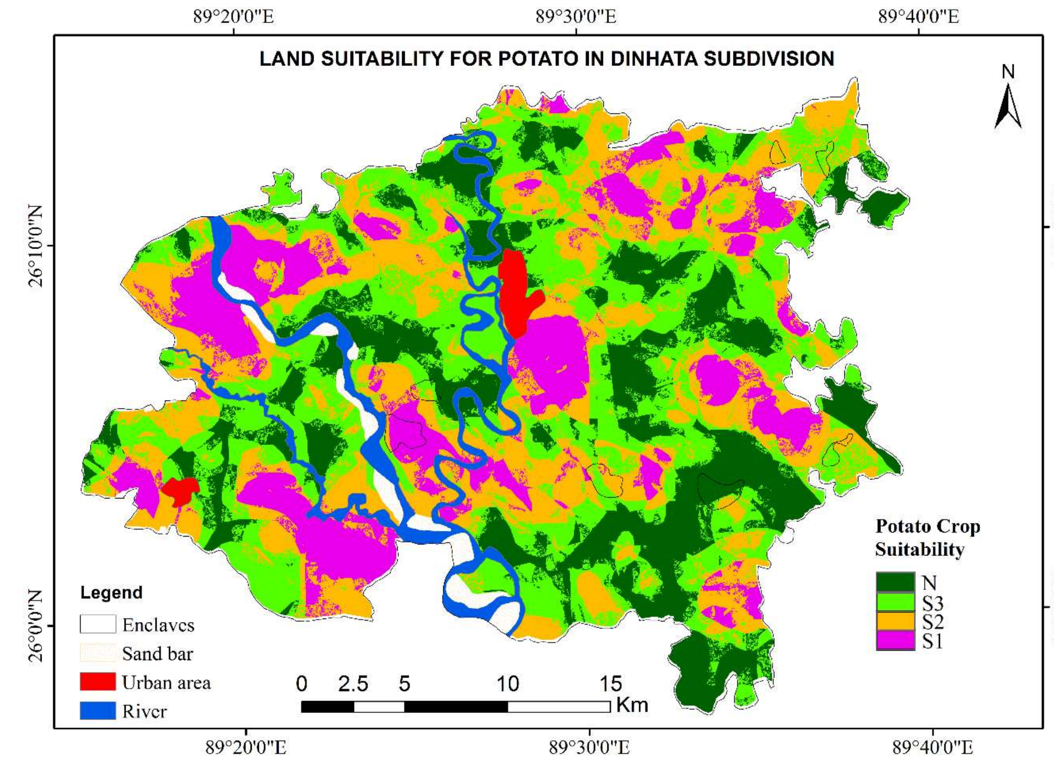


Figure: 5.16 Land suitability for potato in the study area

Suitability analysis revealed that about 540.57 sq km area is suitable for potato cultivation, which accounted 78.27% of total area of Dinhata subdivision and out of which 15.88%, 29.01% and 33.38% are highly (S1), moderately (S2) and marginally suitable (S3). The rest of area (21.73%) is having severe limitations that impede the cultivating of potato. High pH and low NPK rating, organic carbon are the major limitations of this area which can be improved by specific management (Fig. 5.16).

5.3.2.2 Maize

Maize is the fastest growing cereal in India today, but scientist believe its true potential is yet to be realised. Physiologically maize is one of the most efficient crop species farm by man with high yield potential. Maize has become the queen of cereals, courted by state government, seed companies, farmers and the feedstock and starch industries as the crop of the future. The golden promise of hybrid maize with its high productivity and high returns is luring farmer across the country (Jishnu and Sood, 2011).

In India, about 35 per cent of the maize produced is used for human consumption, whereas 25 per cent for poultry and cattle feed and 15 per cent for food processing and other industries. India may possibly have to produce 20 million tonnes of maize to meet its requirement for human consumption, piggery, pharma industry and fodder by 2020 (Singhal, 1999).

Soil and site requirement: Maize is best adapted to well drain sandy loam to silt loam soils. Maize will not thrive on heavy clays, especially in low lands (Singh, C. 1983; Giri et.al. 1994). Optimum soil pH for maize cultivation ranges from 5.8 to 7.8 (Van Diepen et al., 1991). The land suitability criteria for different suitability classes for maize are shown in Table 5.32.

Table: 5.33: Soil-site suitability criteria for Maize

Land characteristics		**Class and Degree of limitation**			
		Highly Suitable	**Moderately suitable**	**Marginally Suitable**	**Unsuitable**
		S1	**S2**	**S3**	**N**
Topography	Slope	<10	10-18	18-28	>28
	Erosion Hazard	Moderately slight	Moderate	Moderately severe	-
Soil	Texture	Fine loamy & Coarse loamy texture	Fine texture	Sandy texture	-
	pH	slightly acidic & neutral	slightly alkaline & moderately acidic	strongly acidic	-
	Organic Carbon	High	Medium	Low	-
	Nitrogen	High	Medium	Low	-
	Phosphorous	very high & High	Medium	Low	-
	Potassium	High	Medium	Low	-
	Manganese	Very High	High	Medium	Low
	Sulpher	Very high	High	medium & low	-

	Boron	Very High	High	Medium	Low
	Zinc	very high	High	medium	Low

Source: Compiled from, NBSS&LUP, 2006; Dent and Young, 1981; FAO, 1983; FAO/UNDP, 1984ab; IIASA/FAO, 2002; IIASA/FAO, 2012; Jones, 2003; Sanchez et al., 2003; Sys and Riquier, 1980; Sys et al., 1991ab; Sys et al., 1993; Van Diepen et al., 1991

The key limitations faced by maize cultivation in some parts in the study area due to low potassium, low organic carbon and subsequently low available nitrogen. The data in Table 5.35 and Fig. 5.17 clearly showed that about 108.45 sq km (15.29 %), 219.78 sq km (30.99 %) and 228.00 sq km (32.14 %) area of Dinhata subdivision are falls under S1, S2 and S3 classes respectively, whereas 21.58% area falls under N class.

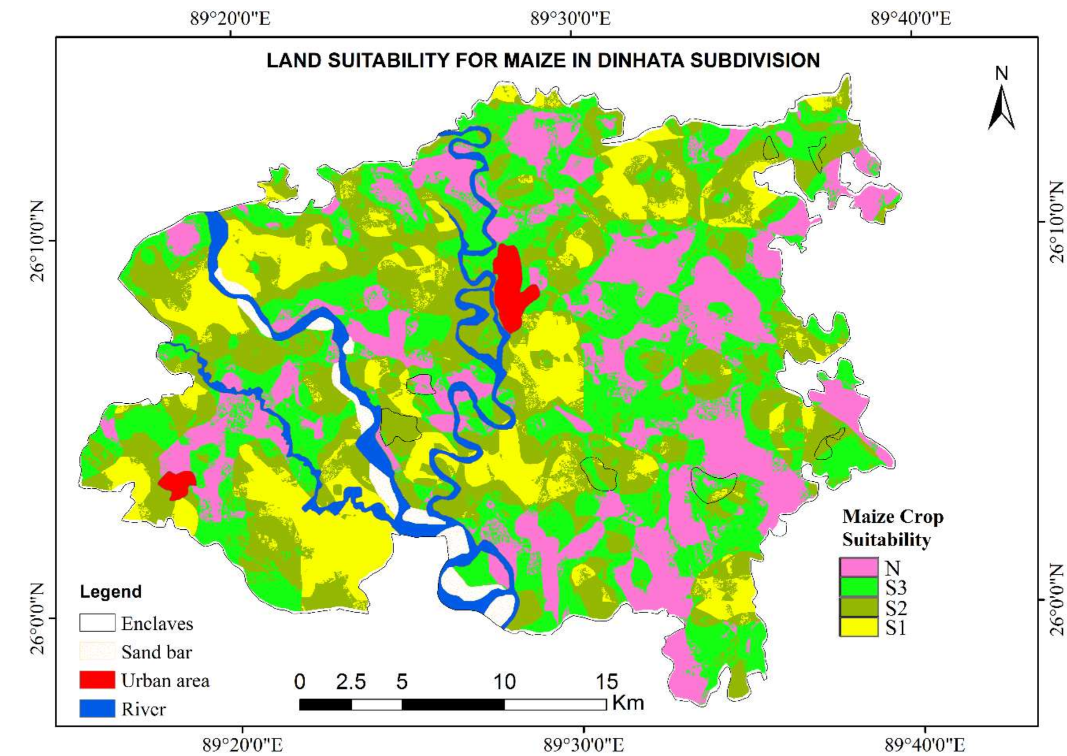


Figure: 5.17 Land suitability for maize in the study area

5.3.2.3 Boro paddy

Rice belongs to genus Oryza family Graminae and is an annual crop. Rice grows in the state in three different types, Aus, Aman and Boro. Boro paddy cultivation is the cultivation of rice under fully control irrigation. Irrigated boro paddy is the most popular variety of agriculture produce in the study area. The reason for its gaining ascendancy has essentially been the availability of copious ground water, favourable economic return, a compelling need to boost agricultural production.

Soil and Site Requirements: Rice is grown under diverse soil conditions and over a wide range of soil reaction (pH 4.5 to 8.0), optimum range of pH 5.5 to 7.5. Soils on Alluvial deposits with heavy texture are better suited for irrigated rice cultivation. Rice require a high nitrogen content and moderate to high soil fertility. The soil- site suitability criteria and ratings developed for irrigated boro paddy are presented in Table 5.34

Table: 5.34: Soil-site suitability criteria for Boro Paddy

Land characteristics		**Class and Degree of limitation**			
		Highly Suitable	**Moderately suitable**	**Marginally Suitable**	**Unsuitable**
		S1	**S2**	**S3**	**N**
Topography	Slope in Degree	0 to 3	3 to 10	10 to 15	>15
	Erosion Hazard	Moderately slight	Moderate	Moderately severe	-
Soil	Texture	Fine texture	Fine loamy texture	Coarse loamy texture	sandy texture
	Ph	slighlty acidic & neutral	moderately acidic & neutral	slightly alkaline	strongly acidic
	Organic Carbon	High	Medium	Low	-
	Nitrogen	high	Medium	-	Low
	Phosphorous	very high	High	Medium	Low
	Potassium	high	Medium	Low	
	Sulpher	Very High & high	Medium & Low	-	-
	Boron	Very High	High	Medium	Low
	Manganese	Very High	High	Medium	Low
	Zinc	Very High	High	Medium	Low

Source: Compiled from, NBSS&LUP, 2006; Dent and Young, 1981; FAO, 1983; FAO/UNDP, 1984ab; IIASA/FAO, 2002; IIASA/FAO, 2012; Jones, 2003; Sanchez et al., 2003; Sys and Riquier, 1980; Sys et al., 1991ab; Sys et al., 1993; Van Diepen et al., 1991

The figure 5.18 indicated that only 14.52% of the area is highly suitable (S1) for boro paddy cultivation and about 29.06% and 34.69% of the area are fall under S2 and S3 suitability classes. High pH and low nitrogen, phosphorous and zinc are the major limiting factors which may be discouraged farmers from growing boro paddy in about 21.73 % that belongs to N suitability order.

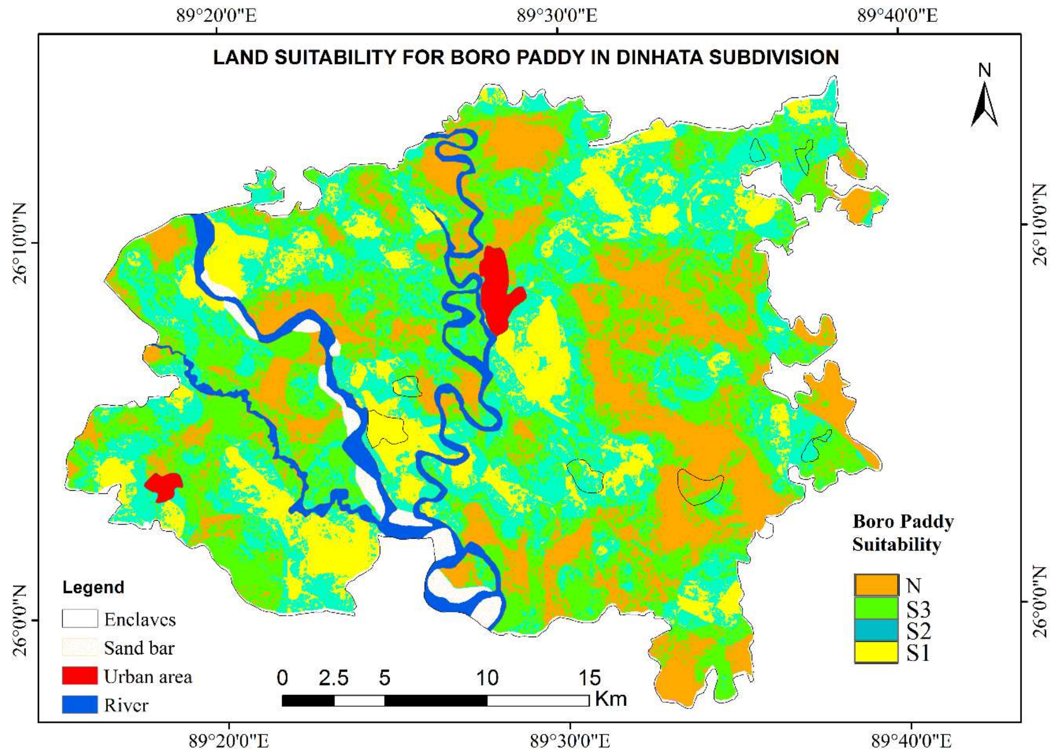


Figure: 5.18 Land suitability for boro paddy in the study area

Table: 5.35: Area (sq km) under different categories of suitability and their percentage distribution

Crops	Suitability classes				
	Highly Suitable	Moderately Suitable	Marginally suitable	Currently not Suitable	Total
	S1	S2	S3	N	
Maize	108.45 (15.29)	219.78 (30.99)	228 (32.14)	153.06 (21.58)	709.29 (100)

Potato	112.66 (15.88)	205.73 (29.01)	236.74 (33.38)	154.16 (21.73)	709.29 (100)
Boro Paddy	102.99 (14.52)	206.13 (29.06)	246.03 (34.69)	154.14 (21.73)	709.29 (100)
Mustard	95.45 (13.46)	210.07 (29.62)	245.56 (34.62)	158.21 (22.31)	709.29 (100)
Wheat	119.89 (16.90)	177.39 (25.01)	251.27 (35.43)	160.74 (22.66)	709.29 (100)
Mean	107.89 (15.21)	203.82 (28.74)	241.52 (34.05)	156.06 (22.00)	709.29 (100)

Note: Figure in the parenthesis indicate percentage of suitability

5.3.2.4 Mustard

In India, oil seeds crops are the second most important determinant of agricultural economy, next only to cereals. Rapeseed mustard is an important crop next to groundnut, among nine annual oilseed crops. In the study area indigenous variety, mainly brown sarson (Brassica rapa L. var. brown sarson) and yellow sarson (Brassica rapa L, var. yellow sarson) are traditionally grown. Mustard is also a cash crop in the study area.

Soil and Site Requirements: Mustard is best grown in fine loamy texture soils. Sandy loam soils are considered most suitable for brown seeded varieties. Heavy soils are considered if drainage is good (NBSS &LUP). They prefer neutral pH reaction but cultivars can be grown on soils with pH range 5.5 to 8.0. Excellent performance was observed by Das (1997) in the pH range of 6.0 to 7.5. The soil-site suitability criteria for mustard are presented in Table 5.36.

Table: 5.36: Soil-site suitability criteria for Mustard

Land characteristics		**Class and Degree of limitation**			
		Highly Suitable	**Moderately suitable**	**Marginally Suitable**	**Unsuitable**
		S1	**S2**	**S3**	**N**
	Slope	<10	10-18	18-28	>28

Topography	Erosion Hazard	Moderately slight	Moderate	Moderately severe	-
Soil	Texture	Fine loamy texture	Coarse loamy texture	Fine and sandy texture	-
	pH	Neutral	slightly acidic & slightly alkaline	moderately acidic	strongly acidic
	Organic Carbon	Medium	High	Low	-
	Nitrogen	High	Medium	Low	-
	Phosphorous	very high	high	medium & low	-
	Potassium	High	medium	low	-
	Boron	very high	high	medium & low	-
	Manganese	very high	high	medium & low	-
	Zinc	high	high	medium & low	-
	Sulpher	very high	high	medium & low	-

Source: Compiled from, NBSS&LUP, 2006; Das, 1997; FAO, 1983; FAO/UNDP, 1984ab; IIASA/FAO, 2002; IIASA/FAO, 2012; Jones, 2003; Shah 1984; Singh 1958; Weiss 1983

Mustard is extensively cultivated in moderate to high fertile soils, yet about 22.31 % of area is not suitable (Fig. 5.19). This may be due to the fine and sandy texture that occur in area in addition to the strongly acidic in nature. Suitability analysis showed that about 89.86% of agricultural area is suitable for this crop and out of which 95.45 sq km (13.46 %), 210.07 sq km (29.62 %) and 245.56 sq km (34.62 %) are highly (S1), moderately (S2) and marginally suitable (S3) respectively.

5.2.2.5 Wheat

Wheat is the second most important staple food crop after rice in India. It is cultivated as rabi crops in the study area, belonging to family Graminae and genus Triticum aestivum. It accounts for 26 percent of the total area and 36.5 percent of the total production of cereals in the country (Tiwari, 2008). It contains more proteins than any other cereals cultivated in the study area. It has high content of niacin and thiamine amino acids.

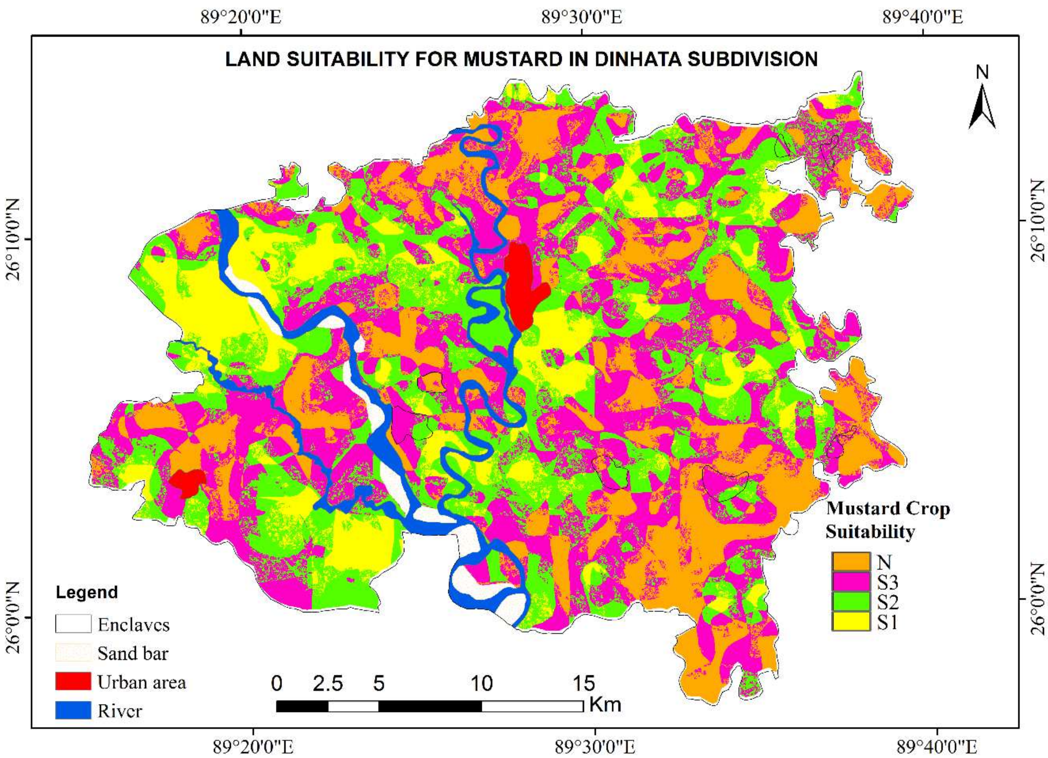


Figure: 5.19 Land suitability for mustard in the study area

Soil and Site Requirements: Wheat grows well in the fertile, well-drained, medium-textured (loam to clay loam) soils. The crop can also be grown on clay or fine sandy loam texture. Very sandy or poorly drained soils are unsuitable for wheat crop. The optimum pH range of 6.0 to 8.2. Moderate to fertile with high manganese, copper and boron content are considered best for wheat (Sys at el., 1993). The land suitability criteria and rating for wheat are formulated and presented in Table 5.37.

Table: 5.37: Soil-site suitability criteria for Wheat

Land characteristics		Class and Degree of limitation			
		Highly Suitable	**Moderately suitable**	**Marginally Suitable**	**Unsuitable**
		S1	**S2**	**S3**	**N**
Topography	Slope	<10	10-18	18-36	>36
	Erosion Hazard	Moderately slight	Moderate	Moderately severe	-
Soil	Texture	Coarse loamy texture	Fine texture	Fine loamy texture	Sandy texture
	pH	Neutral	slightly alkaline & slightly acidic	moderately acidic	strongly acidic
	Organic Carbon	High	Medium	Low	-
	Nitrogen	High	Medium	Low	
	Phosphorous	Very High, High	Medium	Low	-
	Potassium	High, Medium	Low	-	-
	Sulpher	very high	high	medium & low	-
	Zinc	Very High	High	Medium	Low
	Boro	Very High	High	medium & low	-
	Manganese	Very High	High	Medium	Low

Source: Compiled from, NBSS&LUP, 2006; Dent and Young, 1981; FAO, 1983; FAO/UNDP, 1984ab; IIASA/FAO, 2002; IIASA/FAO, 2012; Jones, 2003; Sanchez et al., 2003; Sys and Riquier, 1980; Sys et al., 1991ab; Sys et al., 1993; Van Diepen et al., 1991

Result indicated that about 77.34% of agricultural area is suitable for wheat cultivation and out of which 16.90%, 25.01% and 35.43% are highly (S1), moderately (S2) and marginally suitable (S3). Strongly acidic soil, sandy texture, low zinc, manganese are the major curbs which exclude about 22.66% of area from cultivation (Fig.5.20).

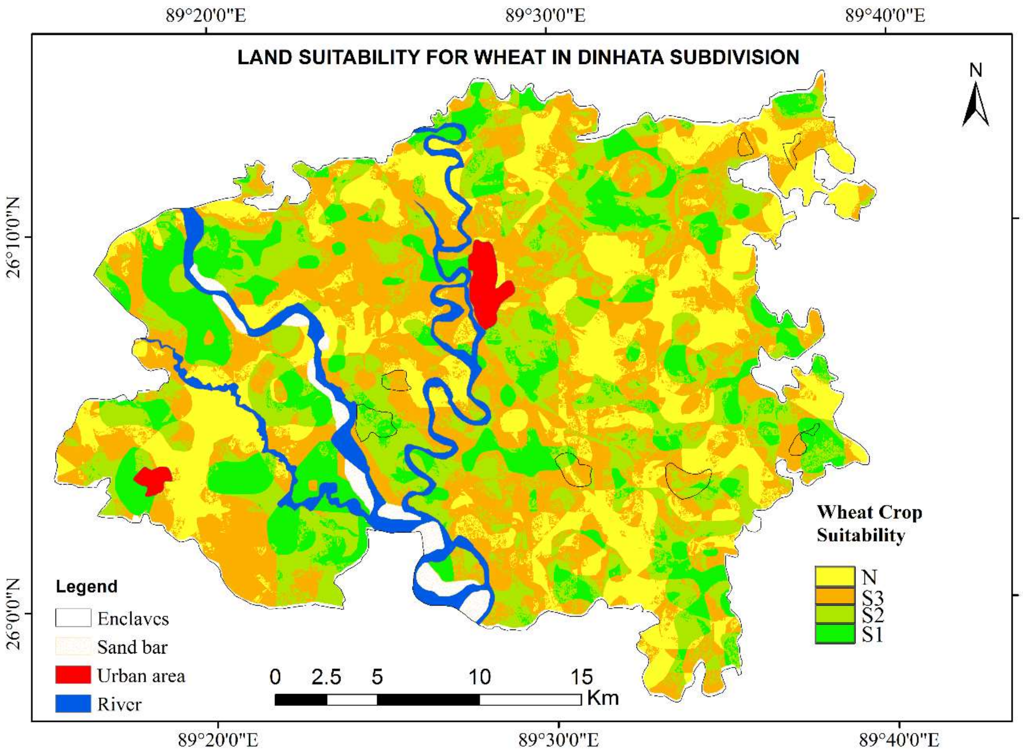


Figure: 5.20 Land suitability for wheat in the study area

5.3.2.6 Multi crops suitability for alternative crops of tobacco

The result in table 5.38 revealed that about 55.04 percent of area is suitable (S) for growing the five alternative crops of tobacco with order of potato + maize + boro paddy + mustard + wheat, whereas only 4.2 percent of the study area is not suitable (N) for these crops (figure 5.22) due to lack of soil quality in this region. About 108.87 sq km agricultural land, which accounting 15.35 percent of the total area have four crops suitability such as maize + wheat + potato + mustard. About 10.51, 7.95 and 6.96 percent of the study area are suited for growing together of maize + wheat + potato, potato + mustard, maize + wheat respectively.

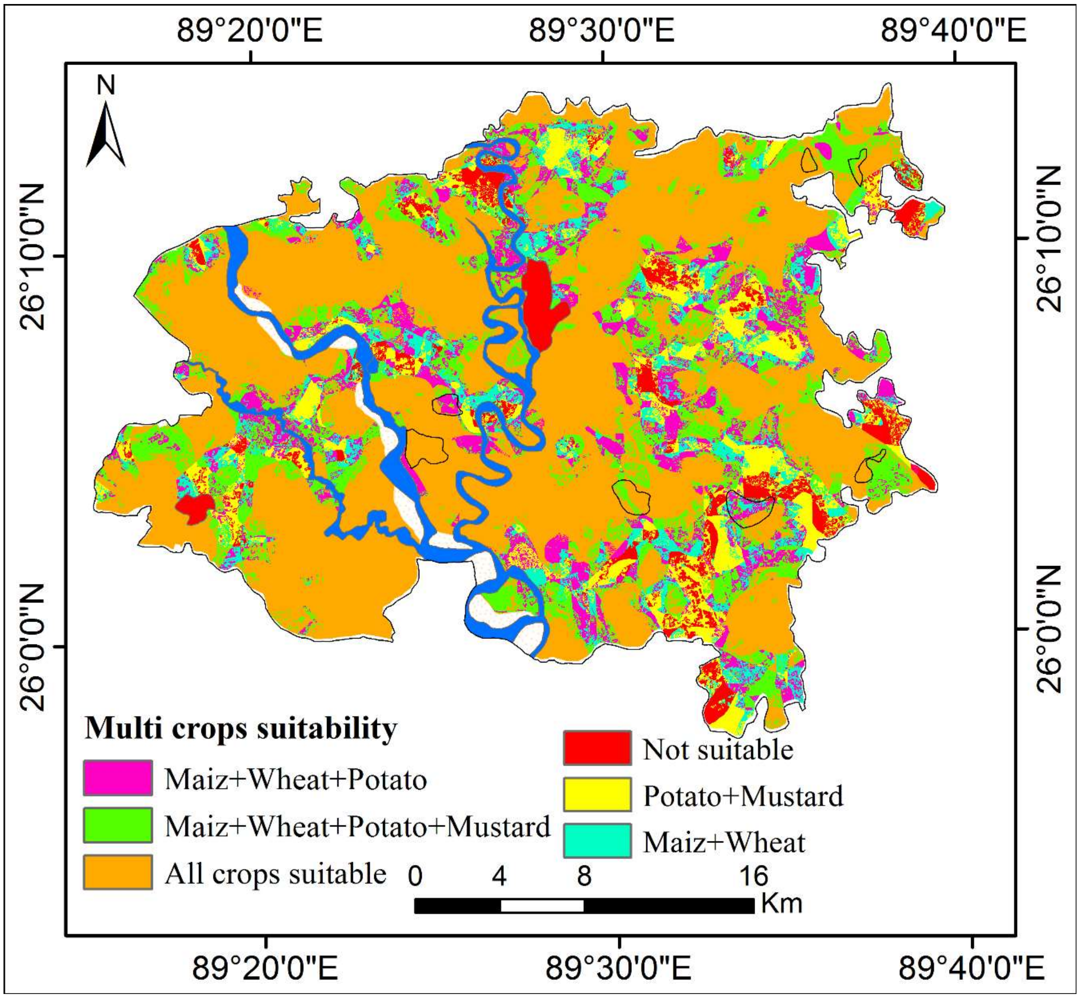


Figure: 5.21 Land suitability for five alternative crops of tobacco in the study area

Table: 5.38 Area and percentage of suitable area for alternative crops growing

Crop	Area in Sq km	Area in %
Maize+ wheat+ potato+ mustard + Boro paddy	390.39	55.04
Maize+ wheat+ potato+ mustard	108.87	15.35
Maize+ wheat+ potato	74.51	10.51
Potato + mustard	56.39	7.95
Maize+ wheat	49.37	6.96
Not suitable	29.76	4.2

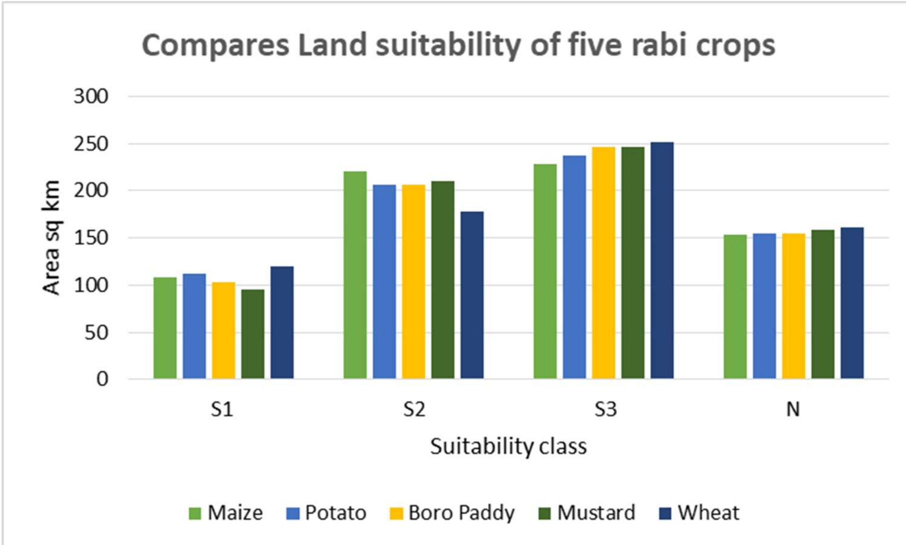


Figure: 5.22 Comparison of land suitability rate of five alternative crops of tobacco

Conclusion

1. The study of evaluation of soil fertility status revealed that the most of the soils (85.65%) of study area are acidic in nature. Greater parts of the study area (78.6%) are loamy soils. Low status of organic carbon was noticed in 39.08% area. The available nitrogen and potassium in the soils are low to medium category. However, higher content of phosphorous was observed in 52.02% soils. There is deficiency observed in boron, sulphur and zinc in 46.89%, 14.70% and 63.98% area respectively. The availability of iron on soils was observed sufficient in the entire study area and copper and manganese deficiency was observed in some patches in the study area. In general Sitai block possesses comparatively better position in term of soil fertility status than Dinhata-I and Dinhata-II blocks. Most of the areas of Dinhata-II block suffer from either sufficiency or deficiency of one primary element alone or in combination. Fertilizer recommendations on the basis of soil fertility data can be done for maximum crop yield. Improper agriculture practices, intensive farming, monoculture, type of cropping pattern and over irrigation is responsible for the deterioration of soil quality in the study area. To overcome the adverse effect of these chemical cultivation efforts should be made to exploit all the available resources of nutrients under the theme of integrated nutrient management (INM). Under this approach the best available

option lies in the complimentary use of biofertilizers, organic manures in suitable combination of chemical fertilizers. 'Organic agriculture' system should be inculcated which begins to consider potential environmental and social impacts by eliminating the use of synthetic inputs such as synthetic fertilizers, pesticides etc. The camps, rallies and training programs for the farmers should be arranged for increasing awareness regarding the benefits of organic agriculture, biofertilizers etc. in crop production and thereby improving soil fertility and nutrient status.

2. In this chapter, land suitability evaluation has been determined for five alternative rabi crops such as potato, maize, boro paddy, mustard and wheat in Dinhata subdivision of Koch Behar district, West Bengal by using parametric method for climate suitability and Analytical Hierarchy Process for soil-site suitability. Analytical Hierarchy Process is a powerful tool for evaluating land suitability for these crops followed by FAO (1976) method. The parametric method examined climatic suitability for five major rabi crops, alternative to tobacco under irrigated condition, result showed that potato and wheat had high suitability (S1), with suitability rating 94.45 and 85.05 percent respectively, while boro paddy, maize, and mustard were moderately suitable (S2) with suitability rating 67.63, 77.92 and 62.59 percent respectively. The selected theme layers includes slope, soil texture, soil reaction, organic carbon, nitrogen, phosphorous, potassium, boron, sulphur, manganese, zinc and soil erosion, which are most influencial crop suitability parameters that have been combined by the adopted methodology. Overlay operations have been done on these layers according to weighted significance of each of the factor. Result of the land suitability evaluation for maize, potato, boro paddy mustard and wheat indicated that highly suitable class (S1) accounts 15.29%, 15.88%, 14.52%, 13.46% and 16.90% while moderately suitable (S2) constitutes 30.99%, 29.01%, 29.06%, 29.62% and 25.01% and the marginally suitable (S3) are 32.14%, 33.38%, 34.69%, 34.62% and 35.43% respectively. Whereas not suitable (N) areas for maize, potato, boro paddy mustard and wheat accounts 21.58%, 21.73%, 21.73%, 22.31% and 22.66% respectively. From this study it can be concluded that majority of the area reasonably suitable for growing alternative crops of tobacco and development efforts should therefore be directed towards realising this potential.

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