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Application of geo-spatial technology in crop suitability analysis for wheat in parts of Doon Valley, Uttarakhand

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ABSTRACT

Land is an important natural resource which determines prosperity of a given region. Proper land use planning is essential for effective utilization of land resources for various socio-economic operations. Land capability analysis is proven method for delineating land capability zones using given spatial parameters. Crop suitability analysis is one of the important land capability classifications which help in determining the areas suitable for cultivation of a particular crop. Several geo-spatial parameters are used as input data layers to identify suitable areas for cultivation of a given crop. Standard range for each parameter is defined based on crop requirement and scores are assigned to each parameter accordingly. The present study aims at delineating suitability zones for wheat crop in parts of Doon valley in Uttarakhand State, India. The main focus of the study was to identify suitable land for wheat cultivation so as to attain optimum utilization of cultivable land in the study area. The parameters including land use, land cover, soil depth, soil texture, soil erosion and slop angle are used as input data layers for crop suitability analysis. Criteria for soil site suitability for wheat crop have been used from United States Department of Agriculture and National Bureau of Soil Survey & Land Use Planning, Nagpur. Remotely sensed data, Survey of India topographical maps and soil maps are used to derive required thematic data layer for analysis. All the data layers are combined to produce crop suitability map for wheat. Results of the study indicate that over 78 thousand hectares of land of the study area is delineated as moderate to highly suitable land for wheat cultivation. The concentration of suitable land for wheat cultivation is attributed to the alluvial deposits of Doon valley. Soil and slope conditions in the middle to lower piedmont are most suitable for wheat cultivation.

1. Introduction

Land is one of the fundamental natural resources for sustenance of life on the earth surface. The problem of land degradation is increasing with the increasing population. More over the land resources are not utilized properly to get maximum benefits with minimum losses. The proper utilization of land is an important task before planners. It is therefore the necessity to have detailed information about various elements associated with land. The land degradation due to various natural as well as anthropogenic processes is a common phenomenon. Comprehensive information on the spatial distribution of land use and land cover categories and the patterns of their change is a prerequisite for planning, utilization and management of land resources. Land evaluation is the most

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important part of planning the land resources. Different empirical techniques of land evaluation help in planning the best suited land use for any region. Proper understanding of the soil characteristics and cropping pattern is the basic requirement of land capability analysis. Soil is a fundamental natural resource which determines social and economic development of region. In fact, the capacity of soil determines the prosperity of the region. Hence, detailed information of the soil is required for land capability analyses.

The capacity of soil varies to a great extent depending among the factors, on the agro-ecological settings. Therefore, the information about land use and land cover combined with geomorphic characteristics is taken into consideration while studying the land characteristics. The space technology particularly the satellite remote sensing data and its derived information have been an integral component of the natural resource management system that can provide reliable, accurate and updated information on land resources. Satellite remote sensing has emerged as an effective tool for acquisition and analyses of land resources with advanced models and techniques. It also helps in getting the detailed information about land resources with high aerial coverage. Satellite remote sensing techniques have proved to be of immense value for preparing the accurate land use land cover maps and monitoring the changes with regular time interval. It also helps in acquiring the information about the land resources even in the remote areas. The present study is an attempt to analyze the land use, land cover, crop suitability and land evaluation of the part of Dehradun District. The study revolves around the land capability analyses for the area under investigation particularly the delineation of crop suitability zones for wheat in the study area.

2. Study Area

The area under investigation is situated in the southern part of lower Himalaya, covering about 1,94,752.2 hectares of area of Dehradun district. The area lies from 78°18'20.814"E to 77°35'18.377"E longitude and 29°57'0.128"N to 30°34'21.171"N latitude. The climate is sub tropical to temperate at varying altitude. The average annual rainfall is 170 cm and more than half of the annual rainfall is received during July and August. The mean summer and winter temperatures are 33.3^0C and 15.8^0C respectively. The temperature and soil moisture regions are hyper thermic and udic respectively. Winter rains occurs from December to February which facilitates wheat cultivation in non-irrigated areas. Geomorphologically, the study area has three distinct landscapes *i.e.* piedmont plains, river terraces and steep sloping areas of Shivaliks. River terraces are flat comprising well sorted sediments drained by river and streams. In middle and lower flood plains of the area are adversely affected by stream bank erosion through heavy surface runoff. Sugarcane, wheat and rice are intensively cultivated crops in middle and lower flood plains. However, most of the areas are under forest cover. Surface soil erosion and crop damage are important problems of the area. The land degradation is mainly due to its mismanagement.

Therefore, it calls for proper investigation and planning for effective land management.

3. Materials and Methods

The present study involves crop suitability mapping of Dehradun District, of Uttarakhand State. The data from various sources were used for analyses.

A) Satellite data: IRS-1D, LISS- III
Type: Standard FCC (Geocoded)
Bands: 3, 2, 1 (Infra red, Red, Green)
Projection: UTM WGS84

B) Survey of India Topographical Maps: Map No. 53F/11,13,14,15, 53J/03,04
Scale: 1:50000

C) Soil Map: Report on Soil Resource Mapping of District Dehradun, Uttaranchal, Remote Sensing Centre, New Delhi

D) Software used: ERDAS IMAGE 9.1. ILWIS 3.3 ACADEMIC, ARC GIS 9.2.

The parameters including soil texture, soil depth, soil erosivity, land used / land cover and slope angle were put into

GIS (Geographical Information System) environment and scores are assigned to each parameter based on requirements for wheat crop. All the thematic data layers were then integrated to produce suitability map for wheat crop using criteria developed by NBSS and LUP and USDA.

4. Results

The remotely sensed data and soil information along with the land use / land cover data were processed and maps were prepared for each parameter. The scores were assigned to each sub-class for every parameter using FAO (Food and Agricultural Organization) framework. Finally, all classified data layers were combined together in GIS environment to to generate land suitability zones for wheat crop. All the thematic data layers were reclassified using FAO framework of crop suitability (Table 1). The details of classified images for all the data layers are presented in Figure 2. Based on land use/land cover map following major land classes were found in the study area. The major land was covered by the forest, fallow and non-vegetated land area. It clearly implied that the land available for cultivation was only 13.36%. The major crop in the region was wheat followed by sugarcane in small patches where irrigation facilities were available. Since the availability of land for cultivation was very limited supplemented by severe soil erosion, there was a need to manage land properly so as to get maximum output with minimum loss of soil.

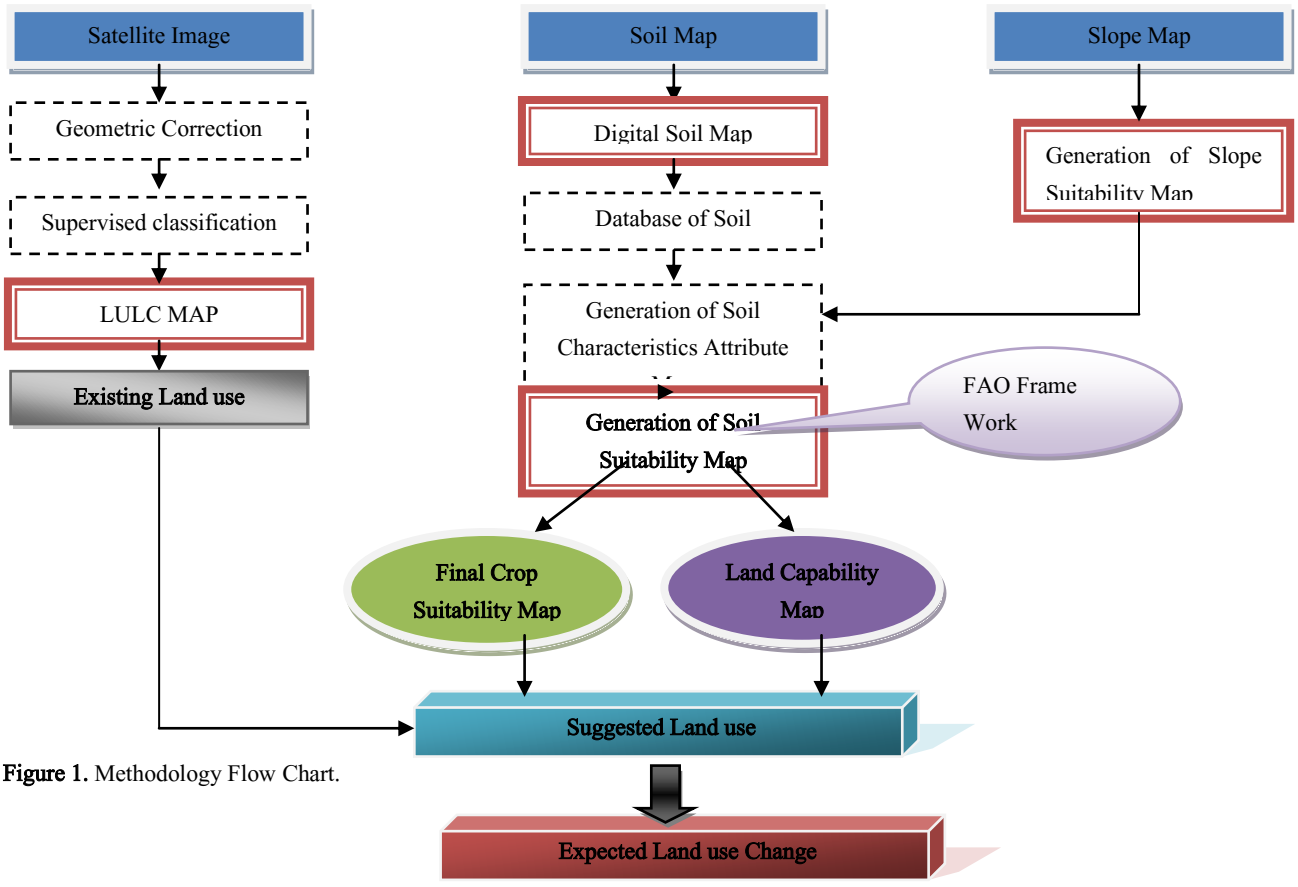

Figure 1. Methodology Flow Chart.

Table 1. Criteria for evaluating Soil site Suitability for Wheat.

Soil Site	Degree of Limitations & Suitability Class				
	0 (None)	1(Slight)	2 (Moderate)	3(Severe)	4(Very Severe)
Slope (%)	0-3	3-8	8-15	15-25	>25
Drainage	Well	Mod. Well		Poor- very excessive	Very Poor
Texture	sicl,cl,sil	sc,scl,l,sl,sic	Sic,c,ls	Ls	S
Depth (cms)	>80	50-80	20-50	<20	-

(Based on FAO framework of wheat crop requirement)

Land Suitability Analysis for Wheat:

The wheat suitability map was prepared by using crop requirement, land utilization and soil characteristics. The wheat suitability analysis was carried out for the study area and map is prepared (Table 2, Figure 3). The wheat suitability map clearly shows that the soil and slope conditions in middle and lower piedmont are more suitable for cultivation of wheat. Following table shows the area suitable for wheat cultivation in different classes.

Table 2. Land Suitability for Wheat

Sr.	Wheat Suitability Class	% Area	Area in hectares
1	S1(Highly Suitable)	10.44	20332.13
2	S2 (Moderately Suitable)	36.28	70656.10
3	S3 (Marginally Suitable)	36.53	71142.98
4	N (Not Suitable)	16.75	32621.00

(Based on analysis done using FAO guidelines)

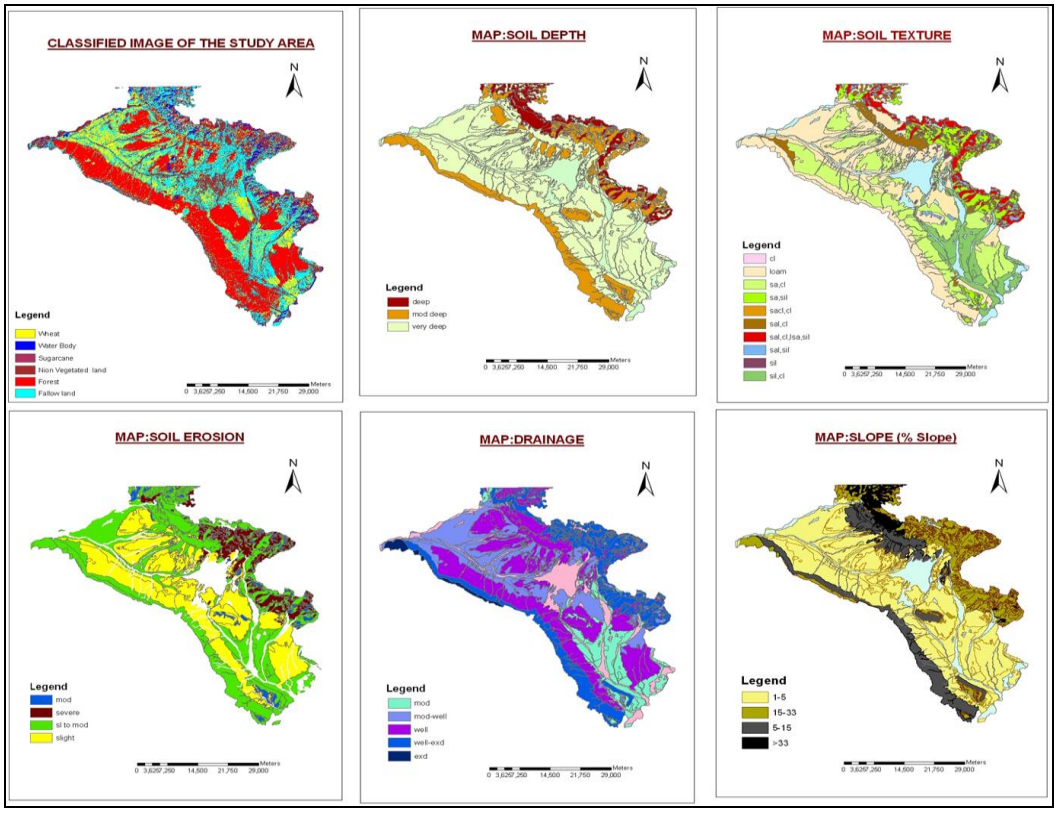

Figure 2. Thematic layers of parameters used in Crop Suitability Analysis for Wheat.

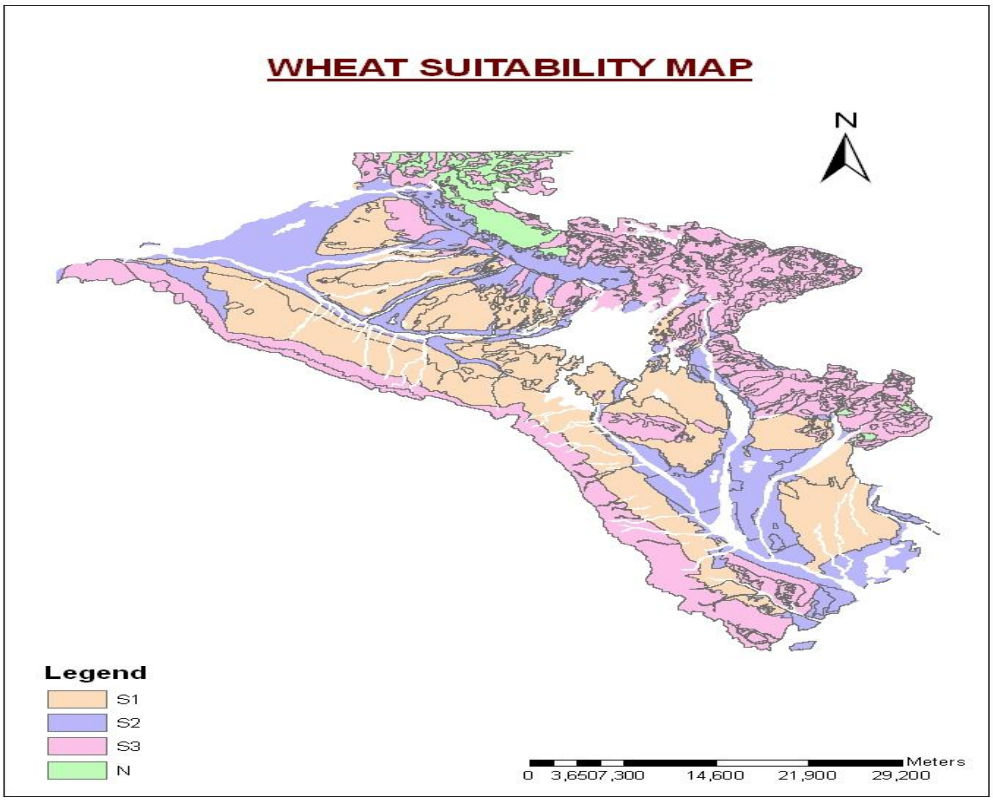

Figure 3. Soil Site Suitability map for Wheat crop

The crop suitability map for wheat crop in the study area clearly indicate that over 46% of the total geographical area of the study region is classified as moderate to highly suitable land for cultivation wheat. However, the actual land use pattern indicates that only 12.95% of the total land is actually utilized for wheat cultivation. It reveals that still large amount of fallow land and non-vegetated land can also be brought under cultivation of wheat crop in order to increase total yield of wheat production.

5. Conclusion

The results derived from crop suitability analysis in Dehradun District of Uttarakhand reveals that only 10.44 % (20332.13 Hectares) of the total geographical area is marked as the most suitable land for wheat cultivation as against 12.95% of the total area actually under wheat cultivation. The crop suitability analysis based on soil characteristics, drainage and geomorphic characteristics can also be applied for other crops so as to prepare multi-crop suitability maps which will provide guidelines for appropriate agricultural land use planning. The relevance of the present study lies in the applicability of RS and GIS technology in crop suitability analysis. The review of existing literature also reveals that the application of remote sensing in agricultural research is proved to be instrumental particularly in soil survey and crop suitability analyses. Remote sensing techniques are widely utilized to generate spatial information and mapping of natural resources. In agriculture and soil studies, the remote sensing techniques were used to generate land capability maps, land irrigability maps, crop suitability maps and land capability classification. Several researchers have applied remote sensing and Geographi Information System for thematic mapping of agricultural resources (Behra, 1986; Burrough, 1996). Karale *et al.*, 1991 confirmed that, capability of IRS-1A data for soil mapping in areas of complex soil scapes and demonstrated that LISS-II data has good potential for preparation of maps on 1:50000 scale. Subramanyam *et al.,* 1993 interpreted false color composite of IRS LISS-II imagery at 1:50000 scale for soil mapping in The representative soil map indicating soil association at family level was generated and the mapping units were evaluated for their suitability for crops such as rice, sugarcane, groundnut, cotton, sunflower, sorghum and tobacco *etc.* Kumar *et al.*, 1998

carried out soil mapping using IRS-1A, LISS-II, FCC imagery at 1:50000 scale in part of Mahendragarh district, Haryana. The prepared soil mapping units were represented indicating association units at family level. Using the soil attributed the mapping units were evaluated according to their suitability to accommodate major crops namely, wheat mustard, gram and pearl millet (Dent and Young, 1981).

There is a wide applicability of Remote Sensing and GIS in natural resource management. Its applications in agriculture sector can provide practical solutions to the problems of agricultural productivity and may also be useful for farmers in decision making for choosing crop for cultivation in their farms based on the lithological and geomorphic characteristics of given area.

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