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Assessing land suitability of vegetation of Baramulla District, Kashmir Valley

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Abstract
Baramulla district has rugged and hilly terrain, about 60 percent of the district is mountainous and 40 percent is plain area. The height varies between 1150 to 4400 meters. Vast proportion of land is characterized with steep slopes, devoid of vegetation and rocky outcrop. It also comprises beautiful meadows and glades. Being second rank amongst the forest divisions of Kashmir province in terms of wood yield, it needs to be assess the viability of vegetation expansion in study area. This study examines the biophysical suitability of vegetation in the area. Necessary data and information were collected from both primary and secondary sources. The results of biophysical suitability using variable and equal weights to the indicators showed that 8.01 and 27.17 percent of the area are highly suitable for vegetation growth. The highly suitable areas were primarily located in the Tehsils of Uri, Boniyar and some parts of Baramulla and Sopore. The highly suitable locations were matched with the NDVI, all of the observed sites in study area were located within highly suitable areas on the overall suitability map except some places in Boniyar, Kreeri and Tangmarg. The exceptional features in these places may be attributed to the limitations of temperature and elevation which are found to greatly affect Tangmarg.

Keywords: Vegetation, NDVI, Mountain, Meadows, Biophysical Suitability, Kashmir

1. Introduction
Biophysical environment comprises of the biotic and abiotic components of a given type of land and hence determines the fitness and defined use of the land. Biophysical suitability of the land is widely assessed by the frame work developed by FAO (1976) (Chen *et al*., 2010; Walke *et al*., 2011) [3, 11]. Chen et al., (2010) [3] described the application of this frame work by integration of Multi Criteria Evaluation (MCE) techniques with Geographic information system. The land suitability of a land is determined by many factors; eg; topographic characteristics, climatic conditions and most importantly the soil quality etc (Walke *et al*., 2011) [11].
Remote sensing data are used for estimating biophysical parameters and indices besides cropping systems analysis, and land-use and land-cover estimations during different seasons (Rao *et al.*, 1996 and Panigrahy et al., 2006) [9, 7]. However, RS data alone cannot suggest crop suitability for an area unless the data are integrated with the site-specific soil and climate data. RS data can be used to delineate various physiographic units besides deriving ancillary information about site characteristics, viz. slope, direction and aspect of the study area. However, detailed information of soil profile properties is essential for initiating crop suitability evaluation. Hence, soil survey data are indispensable for generating a soil map of the given region, which helps in deriving crop suitability and cropping system analysis. Remote Sensing data coupled with soil survey information can be integrated in the geographical information system (GIS) to assess crop suitability for various soil and biophysical conditions. The present study was undertaken to demonstrate the usefulness of RS and GIS technologies coupled with soil data to assess land suitability of vegetation in order to implement sustainability for vegetation in the study area. The potential of the integrated approach in using GIS and RS data for quantitative land evaluation has been demonstrated earlier by several researchers (Beek *et al*., 1997 and Merolla *et al*., 1994)[1, 6]. Therefore, the objective of this study was assessment of land suitability using RS and GIS environments. The vegetation of the Baramulla District has however, undergone drastic change. Large tracts of softwood (coniferous) and deciduous forests have been removed by continuous felling of trees. Consequently, about 50 per cent of the total forests are degraded and have sparse density of trees (Qazi, S.A., 2005) [8].Ecological structure of the district Baramulla has however, undergone extreme change. This study describes suitable criteria and indicators for vegetation and integrates the biophysical aspects to assess the viability of vegetation expansion in Baramulla district. Thus, the data presented herein contribute to determining the suitability of vegetation in a northern region of Kashmir valley.

2. Study area
The district Baramulla located in the northern tip of India which covered by three sides (North, East and South) by India and one side (East) by Pakistan, the geographical extents of the study area is from 33º58' to 34º22' North latitudes and 73º54' to 74º42' East longitudes (figure 1). The prepared Digital Elevation Model (DEM) using Shuttled Radar Topographic Mission (SRTM) data for the study area represents that, the elevation varies from 4439.85 meters at North-West, South and South-West to 1154.5 meters at the North and East. The identified slope using the DEM represents that, the slope in the region varies from 45^0 to 0^0 (plain surface), the higher slopes are presents at North-West, South and South-West where the elevation is high and the undulation of surface is high and least and no slopes are presents at North and East where the elevation is less as well as the undulation of surface is almost nil. Aspect were derived from SRTM.

The calculated distribution of average rainfall using 32 continues years depicts that, the highest rainfall received by the study area is 1493.48 mm while low is 702.11 mm, the concentration of highest rainfall distribution is presents in the southern part of the region which decreased towards North and ends with the least rainfall distribution. The calculated distribution of average maximum temperature that is based on the 32 continues years depicts that, the southern part of the study area receives least temperature that is 11.73^0C, that increased up to 20.94^0C at the central part of the study area, then the average minimum temperature distribution shows, the least temperature in minimum average is 2.58^0C at southern part while high minimum is 9.61^0C at the central part.

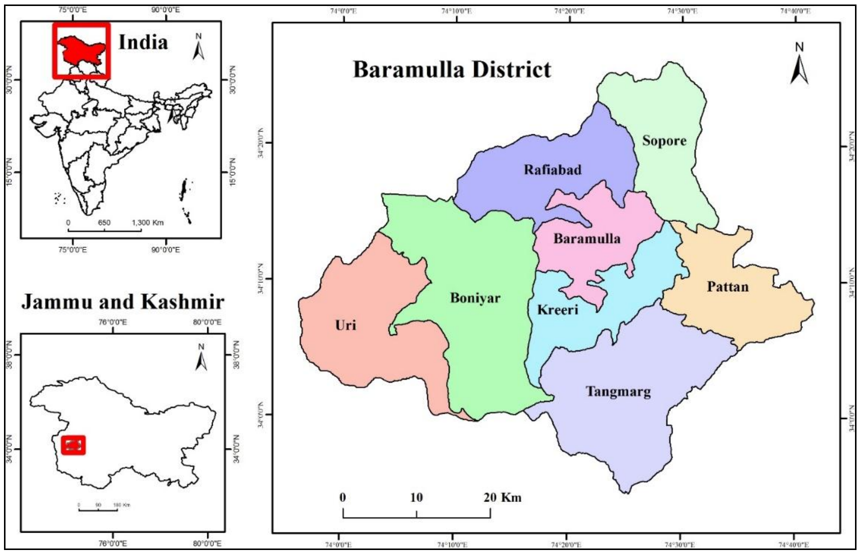

Fig 1: Location of the study area.

3. Materials and Methods

3.1 Remote sensing data and ancillary data

Data used in this study are LANDSAT 8 satellite Operational Land Imager (OLI) which have been downloaded from the USGS website. Also the degree of slope and aspect were derived from SRTM (downloaded from http://www.usgs.gov) and Topographic maps (figure 2 and 3). Toposheet (1:50,000) used in this study which has prepared by the Survey of India Sheet number 43J/3, 43J/7, 43J/8, 43J/11, 43J/12, 43J/14 and 43K/5. In the present study the types of soils have been identified based on the data collected from the Soil Survey of India (figure 3).

The temperature data has been collected from the Indian Meteorological Department (IMD), Pune and Srinagar. The IMD collects the data only on the Indian vicinity. Total six monitoring stations are available in and around the study area namely, Baramulla, Gulmarg, Kupwara, Srinagar, Badgam and Poonch. The spatial location of each monitoring station has been found and it has been placed in the ArcGIS software. Then the average temperature of each station has been calculated based on the 32 years continuous data, further this has been connected with respective monitoring stations in GIS database. The variation of average rainfall in the study area was calculated based on the 32 years continues data collected from the selected meteorological. Then these average rainfall data have been connected with its respective rain gauge stations (figure 2). After the base data preparation was over, the well-known interpolation method called Inverse Distance Weightage (IDW) has been used to find out the spatial variation of average temperature and rainfall with the spatial resolution of 100 meters. The reason for selecting IDW interpolation method is minimum number of available monitoring stations and its random distribution.

3.2 Digital image processing

Digital image processing techniques were carried out for Landsat satellite 8 (OLI). Radiometric correction, Geometric corrections and image geo-referencing, image enhancement and color composites, were carried out to change and alter the original raw spectral data to increase the information availability, and to provide the best possible product for analysis and interpretation for information extraction normalized difference vegetation index (NDVI) figure 3. GIS was also used to build the soil properties.

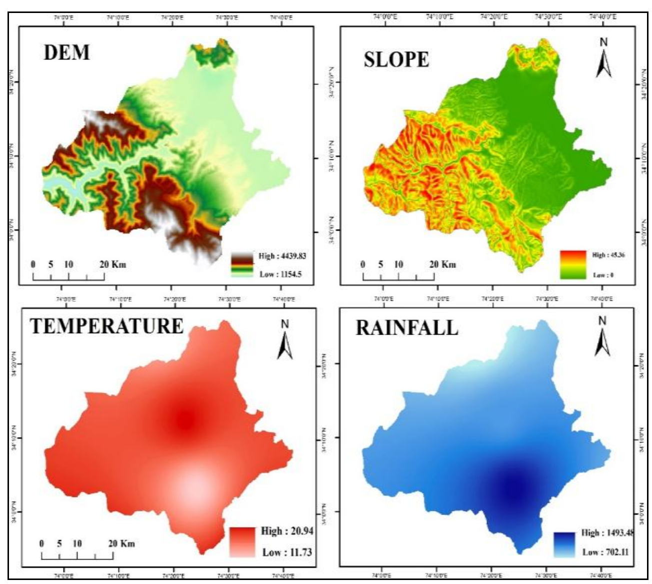

Fig 2: Spatial distribution of biophysical indicator values in the study area.

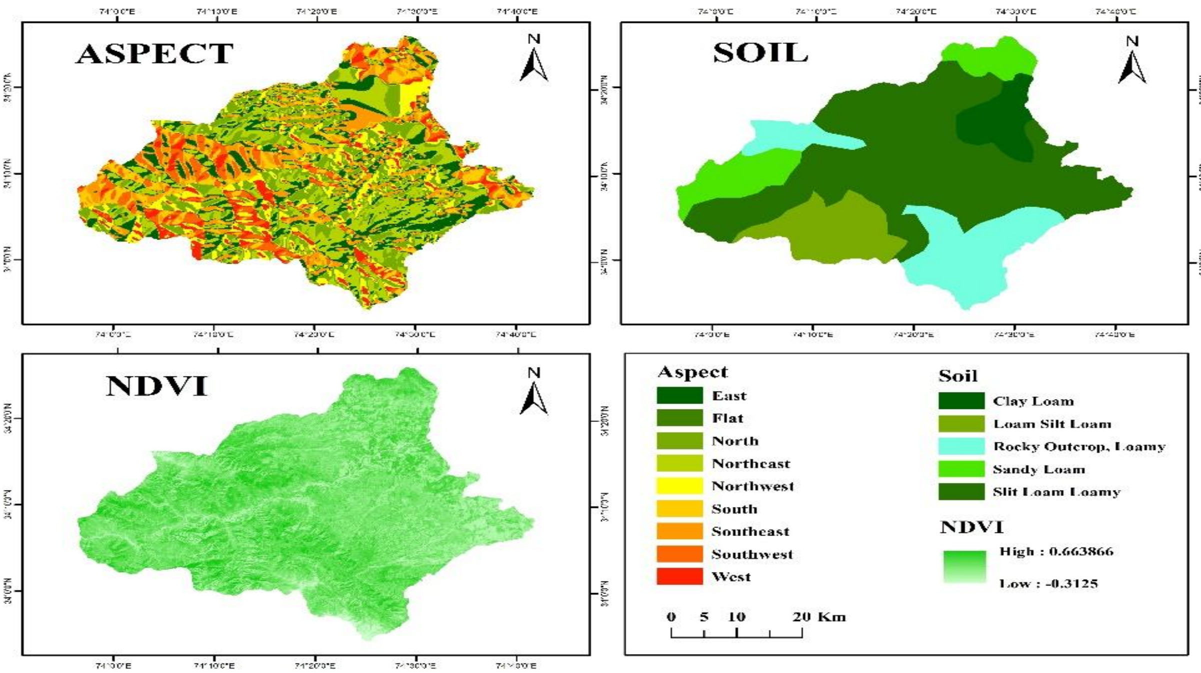

Fig 3: Spatial distribution of biophysical indicator values in the study area.

3.3 Biophysical Suitability Assessment

In the present study, seven indicators were identified for the assessment of biophysical suitability for vegetation in Baramulla District. Despite the identification of indicators, it is still a challenge to land suitability as several previous studies describe different classes, names and ranges of values for the classes (Bydekerke *et al.*, 1998; Walke *et al.*, 2011) [2, 11].

In the present investigation, four classes were adopted; highly suitable, moderately suitable, marginally suitable and not suitable. The classes and value ranges (table 1) were finalized after a detailed review of the available literature; interviews with the local residents, officials of the forest department etc. Data were collected from various sources for each indicator (table 2). Used the analytical hierarchy process (AHP) to estimate the weight of the indicators used to create a suitability map which reflects the contribution of all indicators. Experts in our study area and the persons having adequate knowledge of vegetation of different areas in Baramulla District were requested to put forth their views on the importance of the different criteria.

Table 1: Land Suitability Criteria for Vegetation in Baramulla District

Indicators	Highly Suitable (4)	Moderately Suitable (3)	Marginally Suitable (2)	Not Suitable (1)
Soil	Clay Loam, Sandy Loam	Silt Loam Loamy	Loam Silt Loam	Rocky Outcrop, Loamy
Elevation	2000-2500	2501-3000	1600-2000, 3000-3300	<1600, >3300
Slope	40-50	30-40	20-30	<20, >50
Annual Rainfall	700-900	901-1000	500-700, 1100-1200	<500, >1200
Temperature	20-26	18-20, 26-30	15-19, 30-35	<15, >35
Aspect	East	South, South east	West, South west	North, North west, North east
NDVI	0.4-0.6	0.3-0.4	0.2-0.3	<0.2

Table 2: Data and Sources

Data Layers	Data Sources
Soil Texture	Soil Survey of India
Digital Elevation Model (DEM), Aspect, Slope.	USGS; aspect and slope were derived from DEM
Temperature and Precipitation	Indian Meteorological Department Pune, India
Vegetation	Calculated by Researcher
Administrative Boundary	Census of India

4. Results and Discussion

4.1 Biophysical Suitability of Vegetation

Based on the expert opinions, weights to each biophysical criterion and indicator were assigned (Table 3). Eco-climatic conditions received the highest weight (0.59) followed by land cover (0.24) and soil conditions (0.21).

Table 3: Biophysical Indicators, areas under different land suitability classes and their weights

		Area in (%)				
Criteria	**Indicators**	**Highly Suitable(S1)**	**Moderately Suitable(S2)**	**Marginally Suitable(S3)**	**Not Suitable(4)**	**Weight**
Soil	Soil	17.31	11.06	53.63	18.00	0.21
Eco-Climatic Conditions	Elevation	17.08	71.94	10.22	0.76	0.15
	Slope	19.22	37.48	13.05	30.25	0.10
	Annual Rainfall	6.25	17.74	52.42	23.60	0.09
	Temperature	16.01	21.10	62.23	0.66	0.15
	Aspect	15.86	15.82	20.75	47.56	0.09
Land Cover	NDVI	72.19	2.26	25.54	0.01	0.24

Our investigation revealed that temperature (below 10^0C) plays a pivotal role in the determination of the vegetation growth and was found determining only at certain elevations. Hence, temperature and elevations were ranked first as the main criteria for analysis of eco-climatic conditions. In our study area, only 16.01% of central and western part of the study area has favorable temperature conditions for suitable vegetative growth. In the present study area, 19.22% of the area was slope and hence was ranked as second important indicator. The whole vegetation of the Baramulla district under forest, horticulture, agriculture, plantation etc. entirely depends on the rainfall. Hence rainfall, as a potent criterion has been ranked as the third indicator. The Tangmarg tehsil and northern areas of Rafiabad and Sopore tehsils are characterized by heavy snow and scanty rainfall respectively covering area of 23.60% and are not suitable for dense vegetation. Eastern facing slopes have been reported to be highly suitable for standing vegetation.

Land cover, weighing 0.23 and contains the area of 72.19 % was found to be the second most criteria in the biophysical suitability assessment is highly suitable for vegetation and has least area of not suitable land. Soil conditions are of less priority than land cover and eco climatic conditions as they can be improved through various management practices (Manandhar et al., 2014). Soil texture as a selective soil indicator was considered in the present study and was given a weight of 0.21.

Table 4: Land Suitability Classification for Vegetation

Classes	Area (Km^2)	Weight
Very High Suitability	166.05	5
High Suitability	562.98	4
Moderate Suitability	813.66	3
Low Suitability	345.96	2
Very Low Suitability	184.11	1

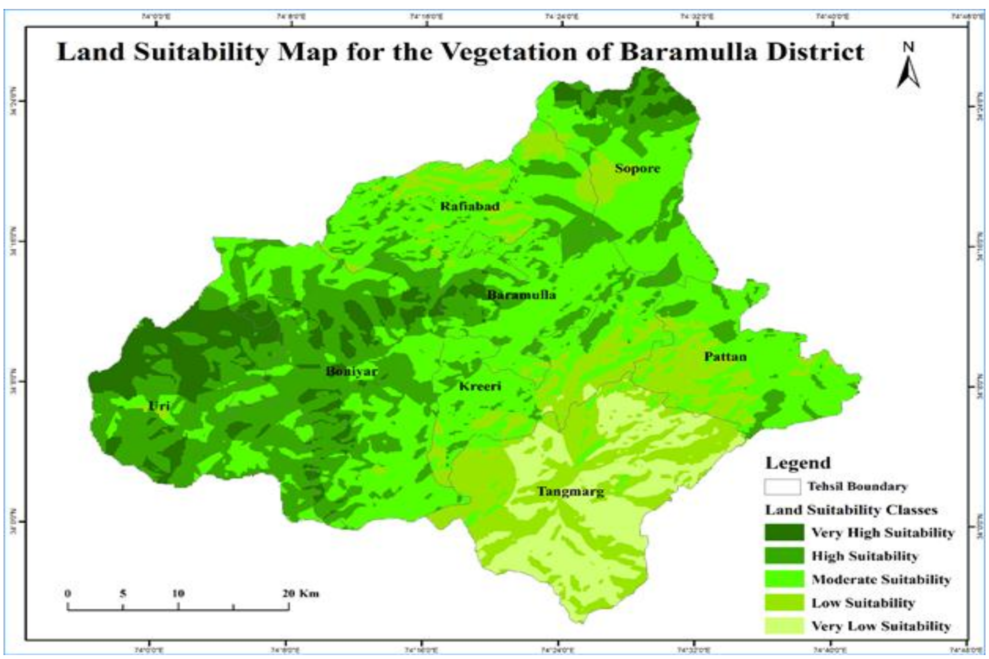

Fig 4: Land suitability map for the growth of vegetation in Baramulla district.

The biophysical suitability assessment, with varying weights of soil, eco-climatic, and land cover indicators, showed that, 166.05, 562.98, 813.66, 345.96 and 184.11 Km^2 of area found in Baramulla under the categories of very high, high, moderate, marginal, low suitability and very low suitability of vegetation, respectively (table 4). The highly suitable areas were primarily located in the Tehsils of Uri, Boniyar and some parts of Baramulla and Sopore (figure 4).

Matching the current highly suitable locations with the NDVI, the overall suitability map was validated. All of the observed sites in study area were located within highly suitable areas on the overall suitability map except some places in Boniyar, Kreeri and Tangmarg. The exceptional features in these places may be attributed to the limitations of temperature and elevation which are found to greatly affect Tangmarg. However it may be speculated that any increase in temperature in future in the elevated mountainous areas may push the vegetation to ascend further into higher elevation and the significance of elevation would decrease. Thereby the suitability of land for vegetation may spread in the higher areas.

The areas which is lying in the peneplains are found to contain the least available vegetation. The contention is not to say that these areas do not possess the potential for the growth of vegetation, but vegetation has been cut down for the expansion of human habitat. The forest resources are made use for domestic purposes such as firewood, timber, etc. while cleared land is put to agriculture, horticulture, ranching, etc. Unsuitable rainfall in the lower-most region of study area is partly responsible for limiting the highly suitable vegetative areas, whereas soil profile has the least impact.

5. Conclusion

The application of GIS-based multi criteria evaluation approach were used to identify biophysically suitable areas for vegetation growth in Baramulla District. The analysis included seven indicators related to three criteria such as soil, eco-climatic and land cover. The biophysical suitability was assessed using different and equal weights for various indicators. The results using different weights to test biophysical suitability indicators revealed that 8.01, 27.17, and 39.26 % of areas were very highly, highly and moderately suitable, respectively. Eco-climatic conditions and land cover in the district were found to be more restrictive than soil conditions. The suitability maps of this study provided a valuable tool for the identification of suitable areas for vegetation growth, which can also be used for specific land-use planning and management purposes in Baramulla District.

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