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Evaluation of Topographical Factors Influence on Agricultural Land in Poonch District of Jammu and Kashmir, India

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Abstract

Topographical factors such as "elevation, slope, aspect, curvature, relief amplitude, incision depth, surface roughness, and standard deviation of elevation (STD)" significantly impact agricultural land. This study quantitatively assesses the linkage between topographical factors and agricultural lands. With the help of Geographical Information System (GIS) techniques, statistically remarkable digitized data of agricultural lands and ALOS PALSAR DEM were applied to examine the connotation between topographical constraints and agrarian lands. This study used eight topographical factors and the concept of location entropy to determine how agricultural lands were distributed spatially in the study area. It has been found that the topography varied in the study area, location entropy shows that agricultural lands have unique distribution patterns. The findings indicate that agricultural lands are present on plain or less inclined slopy areas. Moreover, with the concept of location entropy (P), agricultural land suitability was classified into three degrees: most suitable (P≥2), standard suitable(P≥1), and unsuited (P<1). The study's outcomes denoted that the standard suitable (37.1% - 77.9%) and most suitable (17.9% - 35.6%) areas are significant in Poonch district compared to unsuitable regions (4.8% - 29.2%).

Keywords: Agricultural land; Geographical Information System (GIS); Location Entropy; Topographical factors

1 Introduction

The complex topography leads to various challenges for farmers in hilly areas. The Poonch district has a complex topography; most of the region is under slope and mountainous. The district landscape is generally mountainous, with rugged areas and a few low-lying valleys. Surprisingly, the complicated profile implies they are inherently vulnerable to hydrogeological disorder, which involves soil deterioration through top runoff or more catastrophic mass displacements. Additionally, there are numerous regions around the globe where mountainous farming has significance for culture and history. These seem incredibly beneficial wherever the terrain's slopes are arduous[1].

Several obstacles, such as poor soil quality, periodicity and fluctuation of rainfall, lack of surface water, sloping surfaces, and limited acreage, restrict the growth of agriculture in the mountain area. Mountainous soils are not ideal for agriculture because of their excessive erosion rates, poor capacity to store water, and predominance of stony, shallow, and unproductive soils [2]. With their distinct features, hill cultivation is full of potential. This is because of some terrain characteristics, including fluctuating topography, a dearth of advancements peculiar to the commerce, outdated facilities for sales and the manufacturing process, and inadequate enhancing systems. Organic cultivation is still a feasible alternative for distributing distinctive merchandise, such as agricultural products. It also can produce high-quality seeds and engage in commercial activities [3].

Topographic elements such as height, slope, and geographic roughness demonstrate the basis for the occurrence of ways to use land, and these patterns have significant consequences on the ability to grow crops; the topographical gradient influences land used for farming, especially in sensitive and sustainably essential areas [4]. Topography is the most significant and evident reason for variation in cultivation practices, affecting the environment, climate, soil characteristics, cultivators, and crops [5]. It is evident that terrain and weather impact agricultural land's output. These are two crucial elements that affect yields and are never to be disregarded in agriculture [6,7]. Additionally, production is affected by the terrain in various ways. Subsequently, it affects soil minerals, fertilizer substance, and production, which alters the slope and terai region's structural and physical characteristics [8].

The requirement of agrarian products is growing daily due to the increase in population and the increase in the per capita income of the people. In India, agriculture and its related industries provide the majority of jobs. Nearby 70% of rural families still rely mostly on agriculture in order to sustain their lives, and 82% are small growers (FAO India) [9]. As far as district Poonch is concerned, approximately 58% of those living in rural areas rely largely on farming for their sustenance. Most of the district population resides in rural and hilly areas. Significantly, the district's flat area is experiencing water stagnation, sloppy terrain with soil erosion issues, and more elevated areas having problems with gully erosion. (C-DAP 2016) [10].

2 Study area

Poonch is a remote area and is referred to as "Mini Kashmir" due to its harsh weather conditions. Poonch district is located between latitudes 33°-75' and 34°-00' north and longitudes 73°-58' and 74°-33' east. It covers an area of 1674 sq. km. With 476835 residents, the district accounts for 3.8% of the total population of Jammu and Kashmir according to the (2011) census. Poonch district encompasses the southern part of the Pir Panjal range, which act as a natural boundary between the district and the valley of Kashmir. The districts of Baramulla and Badgam occupy its north and northeast. Rajauri forms its southern border. On the western side, the district has an international border with Pakistan. The district has a steep and hilly landscape. Its terraced farmland on the low-lying slope that constitutes the district's small valleys are the only area with much land accessible for cultivation. The primary crops grown in the district are maize, wheat, and rice. [11]

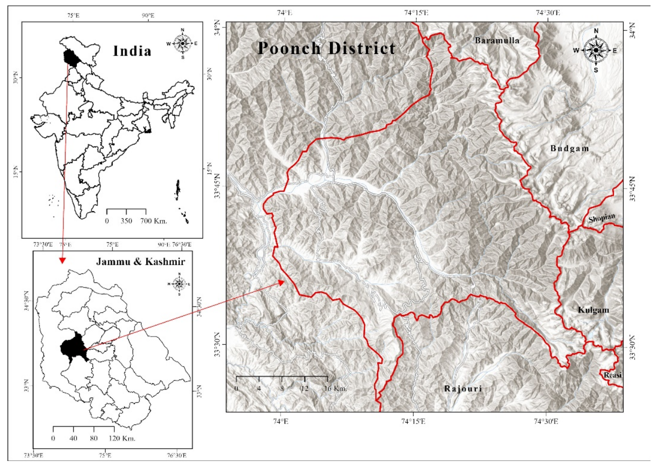

Fig. 1. Study area

3 Materials and Methods

3.1 Materials

This study is based on secondary data, and "ALOS PALSAR Digital Elevation Model (DEM)" data with 12.5m spatial resolution was downloaded from Earth Data maintained by the "U.S. National Aeronautics and Space Administration (NASA)" [12]. To ensure the accuracy, the agricultural land of the Poonch district is digitized from Google Earth and exported as shape files, as shown in Figure 2.

3.2 Methods

For this study, eight different topographical elements such as "elevation, slope, aspect, curvature, relief amplitude, incision depth, surface roughness, and STD" [13,14] were selected to represent the topography. These terrain features can define the factors in macro and micro scale. In this study, elevation, slope, aspect, curvature, and surface roughness are executed at a micro-scale with an actual spatial resolution of 12.5 meters, while the standard deviation of elevation done at 125 meters' resolution scale and other factors such as relief amplitude and incision depth are performed at macro-scale with a window of 1 km. The window concept used by Tu and Liu (1990) is also used in this study [15].

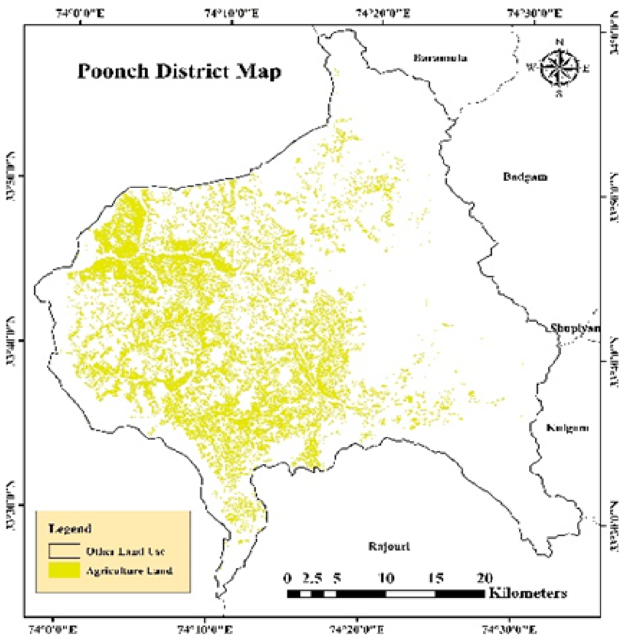

Fig. 2. Map showing the distribution of Agricultural Lands in the Poonch District

Table 1. Topographical factor and scale used

Topographical Factors	Analysis Scale
Elevation	12.5 m
Slope	12.5 m
Aspect	12.5 m
Curvature	12.5 m
Relief Amplitude	1 km
Incision Depth	1 km
Surface Roughness	12.5 m
Standard Deviation of Elevation	125 m

3.2.1 Location Entropy

Location entropy was applied by the Xi et al. (2018) in their study to find out how the settlements are clustered together in a specific location [16]. This study applied the same technique to determine how the agricultural lands are clustered within a specific location. The below given equation is used to get the location entropy (P).

$$P = \frac{\left(\frac{Sie}{Si}\right)}{\left(\frac{Se}{S}\right)}$$

Based on specific intervals, the topographical factors are categorized into numerous levels, and the area of agricultural lands classified into each class is measured for calculating location entropy. In the above equation P signify the “location entropy” for the topographical factors in a specific class. Similarly, Sie signifies the area of agricultural land under the particular class of the variables, and Si indicates the total area of agricultural land. While Se is the total area under the class and S is the total area of the study area. P value demonstrates the accumulation of the agricultural land for a specific topographical factor.

If the farmers choose agricultural lands randomly, then the value of P will be near 1. If the residents select diverse land for cultivation according to various topographical factors, the agricultural lands will not be distributed randomly, then the value of P will vary. If the value of P > 1, this denotes that the cluster of agricultural land in this specific level is more significant than usual. On the other hand, if the value of P < 1, this denotes that the agglomeration of agricultural land in this specific level is less significant than usual. Thus, it has been considered that the greater the P value, the more significant for agricultural activities in an area, and the lesser the value of P, refer to the area is less appropriate for agricultural activities.

4 Results

4.1 Computation of topographical factors

The topographical factors were computed with the ALOS PULSAR DEM data and Surface Tools from Spatial Analyst Tools in ArcGIS v10.7 were applied to determine the slope, aspect, and curvature. While Zonal Statistics Tools and the Raster Calculator from Spatial Analyst Tools were applied in this study to determine the “relief amplitude, incision depth, STD and Surface Roughness” respectively of the study area. With the use of DEM file incision depth was calculated with 1km grid, and STD with 125m grid. Similarly, the surface roughness was measured with the equation with raster calculator [17].

$$R = \frac{(FSmean - FSmin)}{(FSmax - FSmin)}$$

Where R indicates Surface Roughness, and FSmean, FSmin, and FSmax are mean, minimum, and maximum Focal Statistical layers, respectively, were made with the Neighbourhood Tool.

4.2 Location Entropy Statistics

The existing agricultural lands provide information on the topographical preferences of the farmers. After extracting each topographical factor for agricultural land, this study determined the location entropy for each factor to analyse the suitable cultivable area. A small interval classified each topographical factor to attain accuracy in results. The graphs in Figure 4 display the statistical findings.

The bar graphs in Figure 4 depict the location disparities and the connection between the topographical factors and agricultural lands. Blue bars indicate the land area in each level, and red bars indicate agricultural land area in each level.

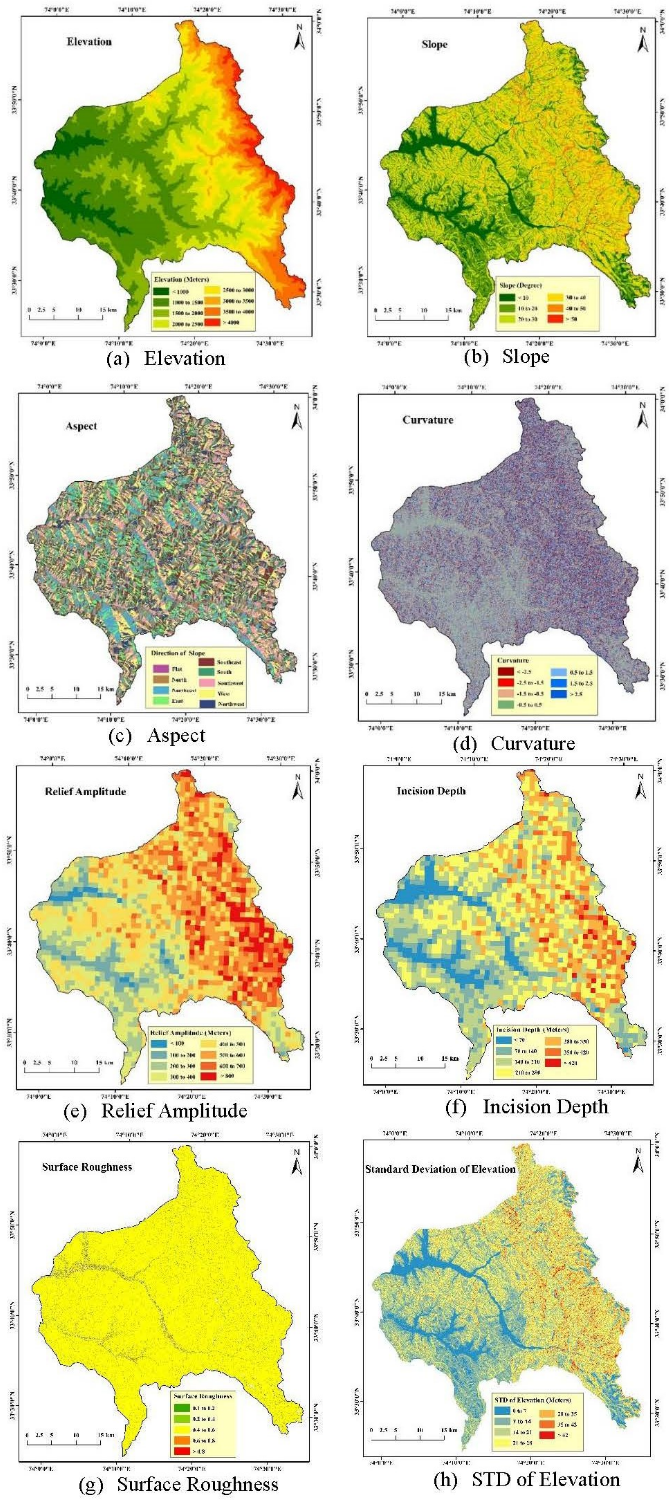

Fig. 3. Topographical factors

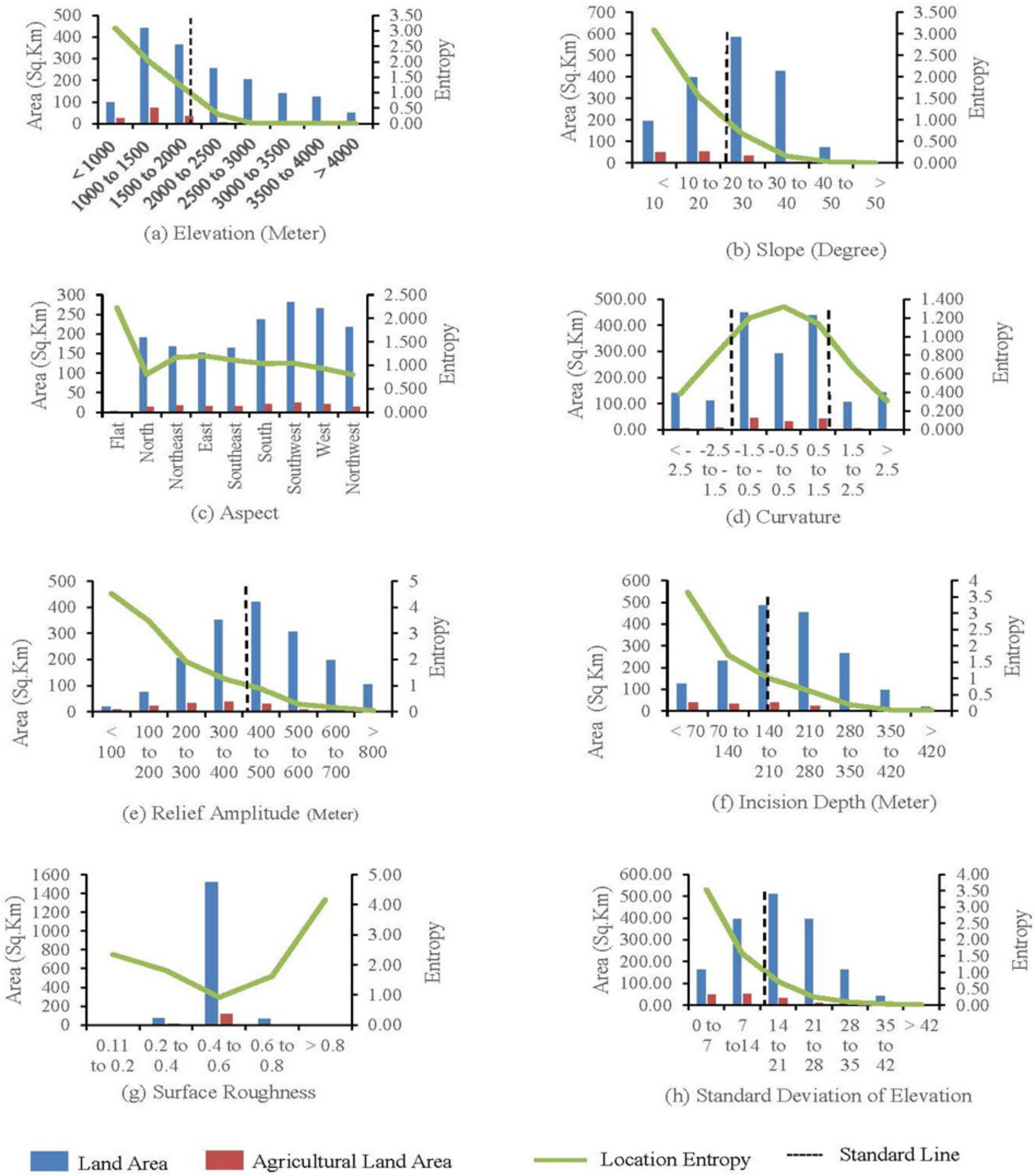

Fig. 4. Statistical findings showing Location entropy, agricultural land, and total area

Green lines show location entropy calculated statistically, and standard lines represent the value of location entropy at one of each topographical factor.

The statistical intervals for elevation, relief amplitude, incision depth, and STD were established at 500 meters, 100 meters, 70 meters, and seven meters, respectively; the statistical intervals for slope and curvature were established at 10 degrees and one degree, respectively; the aspect was reclassified using nine directions including flat; the statistical intervals for surface roughness were established at 0.2. If P > 1, agricultural lands are considerably clustered and considered as regular areas for cultivation; If P < 1, agricultural lands are less considerably clustered and considered as not suitable areas for cultivation; If P > 2, agricultural lands are more considerably clustered and considered as suitable areas for cultivation.

The tendencies of variation of location entropy values of topographical factors are comparable for elevation, slope, relief amplitude, incision depth, and STD. For aspect, this statistical result does not indicate a noticeable pattern. For curvature and surface roughness, the location entropy values are indicated in a slight stretch, and the entropy line is presented as concave and convex curves, respectively. Location entropy value decreases with increasing topographical factor value. Still, the variations in each topographical factor's range indicate their importance. The significance of the topographical factors increases with the variation in the location entropy. In this study, the relief amplitude is related to the highest entropy value; thus, it is the most crucial topographical factor [16].

5 Discussion

5.1 Elevation

The agricultural land has been classified into different elevation classes, and results illustrate that 70.5% of the agricultural lands are situated in the region under 1000 meters. The location entropy is greater than two in this region, indicating that regions below 1000 meters have favourable conditions for cultivation compared to regions above 1000 meters from sea level. Until the elevation exceeds 2000 meters, the location entropy remains greater than one.

From 2000 to 3500 meters, the area of agricultural lands is less, and the location entropy is low. Beyond 3500 meters, there are no agricultural lands present. Based on this study, the breaking points in elevation can be adjusted to 1500, 2000, and 3500 meters, and also confirms that elevation is a major topographical factor in finding the optimal site for agricultural lands. The low elevation is usually suitable for cultivation compared to highly elevated areas. The temperature decreases with an increase in height, making cultivation difficult at higher elevations. Also, the high elevation makes it challenging to construct built-ups, which is another drawback contributing to the lesser agricultural land area at higher altitudes [16].

5.2 Slope

The slope impact is confirmed based on the distributions of agricultural land as mentioned in Figure 4. It is found that 72.5% of the agricultural lands are in the region below 20 degrees. The entropy is greater than two in the region below a 10-degree slope, indicating that farmers favour flat terrain for cultivation compared to hilly terrains.

Until the slope exceeds 20 degrees, the location entropy remains greater than one. From 30 to 50 degrees, the area of agricultural lands is less, and the location entropy is very low. Beyond 50 degrees, there are no agricultural lands. The outcomes illustrate that inhabitants tend to cultivate in flat areas compared to highly inclined areas despite terrace cultivation being a significant agricultural practice in mountainous areas.

5.3 Aspect

The agricultural land of the study area has been categorized in eight directions, as given in Figures 3 and 4, and entropy has been calculated for every direction and found that agricultural land is consistent in all directions. Most of the farming area around 65.4% is lies in Northeast, east, southeast, south, and southwest respectively.

5.4 Curvature

The 84.6% of agricultural area is found at curvature between -1.5 and 1.5. which indicates that flat and less steep areas are more appropriate for the various types of crops. A slight tendency for agricultural land to cluster in low in low curvature areas can be seen in the location entropy line.

5.5 Relief Amplitude

It is a crucial feature to objectively characterize the geomorphological shape and landform type. In this study, with the calculation of location entropy, it is revealed that entropy reaches its highest at 4.5 when the relief amplitude is below 100 meters. This is higher compared to other factors, and 70.8 % of agricultural areas are below 400 meters of relief amplitude. The more concentration of cultivable area in low amplitude is due to the source of irrigation, temperature, and fertile soil, respectively.

5.6 Incision depth

Around 80 % of agricultural land is situated below 210 meters of incision depth, while the remaining area is above 210 m. Among all the categories, the higher concentration of farming land at the incision depth is below 70 meters, which indicates that a lesser incision depth is more favorable. The increase in

Table 2. Influence of topographical factors on agricultural land

Topographical Factors		Most Suitable	Standard Suitable	Not Suitable
Elevation	Degree	< 1000 m	1000 - 2000 m	> 2000 m
	Area (%)	17.9	77.3	4.8
Slope	Degree	< 10°	10° - 2 0°	> 20°
	Area (%)	35.6	36.9	27.5
Aspect	Degree	Flat (-1)	Northeast, East, South-east, South, South-west	North, West, North-west
	Area (%)	0.4	65.4	34.2
Curvature	Degree	-	-1.5 - 1.5	< -1.5, > 1.5
	Area (%)		84.6	15.4
Relief Amplitude	Degree	< 200 m	200 - 400 m	> 400 m
	Area (%)	20.9	49.9	29.2
Incision Depth	Degree	< 70 m	70 - 210 m	> 210 m
	Area (%)	27.4	52.6	20
Surface Roughness	Degree	-	< 0.4, > 0.6	0.4 - 0.6
	Area (%)		15.7	84.3
Standard Deviation of Elevation	Degree	0 - 7 m	7 - 14 m	> 210 m
	Area (%)	34.3	37.1	28.6

the incision depth minimizes the location entropy.

5.7 Surface roughness

In this study, it has been found that 84.3% of agricultural land falls in a range of 0.4 to 0.6 of surface roughness, and the entropy value is less in this region. Agricultural land with surface roughness values below 0.4 and above 0.6 exhibits significant agglomeration.

5.8 Standard deviation of elevation (STD)

The STD has a range of 0 to 75 meters. Most agricultural lands (37.1%) are situated between 7 and 14 meters. However, statistical entropy values show that below 7 meters have robust clustering with location entropy greater than two. The location entropy value is greater than one between 7 and 14 meters and less than one above 14 meters for the STD**.** The STD shows that farmers usually prefer less inclined areas for cultivating various crops.

The eight topographical factors thoroughly supplied the terrain elements on micro and macro scales and denoted the agricultural land suitability at various levels. The location entropy executed well in investigating the agglomeration of the agricultural lands. This study classified the agricultural lands into three degrees of suitability: most suitable ($P \geq 2$), standard suitable ($P \geq 1$), and not suitable ($P<1$), as indicated by the location entropy (P) estimate that was earlier performed.

6 Conclusion

Agricultural lands are essential for cultivating crops, income generation and meeting essential food requirements for the inhabitants' lives and livelihoods. Eight topographical factors that highly influence the cropping patterns of agricultural lands in the Poonch district are statistically analysed, and the location entropy values are acquired for each topographical factor is in this study. It has been found that topography and agricultural land are interconnected. Hence, the distribution of agricultural land is influenced by various topographical factors.

This study is an innovative effort to evaluate the influence of topographical factors and agricultural lands statistically, which can be helpful for the researcher for further studies. The location entropy provides a clear indication of the farmer's decision to choose topographical features for agricultural activities. To sum up, farmers usually favour plain or less inclined agricultural lands in sloppy areas, because of more accessibility to the irrigation sources, suitable temperatures, etc. Therefore, we conclude that topographical features have a significant impact on farming techniques in the Poonch district.

References

1) Tarolli P, Straffelini E. Agriculture in Hilly and Mountainous Landscapes: Threats, Monitoring and Sustainable Management. *Geography and Sustainability*. 2020;1(1):70–76. Available from: https://doi.org/10.1016/j.geosus.2020.03.003.
2) Choenkwan S, Fox JM, Rambo AT. Agriculture in the Mountains of Northeastern Thailand: Current Situation and Prospects for Development. *Mountain Research and Development*. 2014;34(2):95–106. Available from: https://doi.org/10.1659/MRD-JOURNAL-D-13-00121.1.
3) Wani MH. Hill Agriculture in India: Problems and Prospects of Mountain Agriculture. *Journal of Agricultural Economics*. 2011;66(1):64–66. Available from: https://www.researchgate.net/publication/296017679_Hill_agriculture_in_India_Problems_and_prospects_of_mountain_agriculture#:~:text=The%20hill%20agriculture%20has%20its%20own%20characteristics%20that%20distinguishes%20it,Wani%202011%3B%20Sarial%202019).
4) Gong Q, Sun P, Liu Q, Mo J. Topographical Gradient Characteristics of Land-Use Changes in the Agro-Pastoral Ecotone of Northern China. *Land*. 2022;11(12):1–19. Available from: https://doi.org/10.3390/land11122195.
5) Godwin RJ, Miller PCH. A review of the technologies for mapping within-field variability. *Biosystems Engineering*. 2003;84(4):393–407. Available from: https://doi.org/10.1016/S1537-5110(02)00283-0.
6) Kumhálová J, Kumhála F, Kroulík M, Š Matějková. The impact of topography on soil properties and yield and the effects of weather conditions. *Precision Agriculture*. 2011;12(6):813–830. Available from: https://doi.org/10.1007/s11119-011-9221-x.
7) Senbeta F, Schmitt C, Woldemariam T, Boehmer HJ, Denich M. Plant Diversity, Vegetation Structure and Relationship between Plant Communities and Environmental Variables in the Afromontane forests of Ethiopia. *SINET- Ethiopian Journal of Science*. 2014;37(2):113–130. Available from: http://ejol.aau.edu.et/index.php/SINET/article/view/7148.
8) Kravchenko AN, Bullock DG. Correlation of corn and soybean grain yield with topography and soil properties. *Agronomy journal*. 2000;92(1):75–83. Available from: https://doi.org/10.2134/agronj2000.92175x.
9) FAO in India. *Food and Agricultural Organization (FAO) of the United Nations*. Available from: https://www.fao.org/india/en/.
10) Comprehensive-District Agriculture Plan (C-DAP). *Department of Agriculture, Poonch, Govt of Jammu & Kashmir*. 2016;p. 1–68. Available from: https://diragrijmu.nic.in/C-DAP-Poonch/C-DAP-Poonch.pdf.
11) District Census Handbook, Poonch. *Directorate of Census Operations, Jammu & Kashmir*. 2011. Available from: https://censusindia.gov.in/nada/index.php/catalog/515/download/1708/DH_2011_0105_PART_B_DCHB_PUNCH.pdf.
12) ASF Data Search Vertex. *Nasa Earthdata*. 2022. Available from: https://search.asf.alaska.edu.
13) Maqsoom A, Aslam B, Khalil U, Azam S, Kazmi ZA, Rana MUA. Discovering patterns in the topography of existing settlements: the case of the China-Pakistan Economic Corridor (CPEC) route. *Arabian Journal of Geosciences*. 2023;16(1). Available from: https://doi.org/10.1007/s12517-022-11096-0.
14) Ma S, Liu J, Zhao Z, Wang Y, Yang W, Gu Y. Research on the terrain differential characteristics of rural residents in Fuping County, Hebei Province. *Research of Soil and Water Conservation*. 2016;6:327–332. Available from: https://caod.oriprobe.com/articles/49714458/Research_on_the_Terrain_Differential_Characteristi.htm.
15) Tu H, Liu ZD. Demonstrating on optimum statistic unit of relief amplitude in China. *Journal of Hubei University*. 1990;3:266–271.
16) Xi C, Qian T, Chi Y, Chen J, Wang J. Relationship between settlements and topographical factors: An example from Sichuan Province, China. *Journal of Mountain Science*. 2018;15(9):2043–2054. Available from: https://doi.org/10.1007/s11629-018-4863-z.
17) Mukherjee I, Singh UK. Delineation of groundwater potential zones in a drought-prone semi-arid region of east India using GIS and analytical hierarchical process techniques. *CATENA*. 2020;194. Available from: https://doi.org/10.1016/j.catena.2020.104681.