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Soil Erosion Study Using Rusle Model In Almora District Of Uttarakhand, India

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Abstract

Soil is the earth's easily offended and ultrasensitive skin that anchors all existence on. Earth disintegration build firstly when the dirt is left release to strong winds, flowing water, and heavy rains. In a few occasion due to human act soil degraded.Earthdegradation brings down the volume and the standard of earthenvirons and agricultural land. In this study earth degradation of the Almora, is being identified utilizing the RUSLE model. After identifying, some of the soil degradation areas using Google earth pro and satellite images; we make an inventory map to train the model. As an input, we will provide the 5 parameters i.e., Crop management factor Slope distance and Steepness Factors (LS), Rainfall erosivity factor(R), Soil erodibility (K-factor), and Soil Conservation Practice Factor (P). These are some important factors/classes in soil. Curve map, Topographic wetness index, and Stream power index, are created using Digital Elevation Model (DEM), created ground database. Here in this study for recognizing soil erosion we are using ArcGIS 10.8 software by which we are generating inventory maps of features and then applying the RUSLE soil loss equation.

Keywords: RUSLE model, LS factor, R factor, P factor, K factor.

Introduction

According to a research done by Bakker et al. (2005), Kumar et al. (2012) globally, soil erosion has recently had an impact on natural resource availability and agricultural output. According to Risti et al. (2012), Ashiagbor et al. (2013), and Tamene and Vlek (2008), surface water flooding on bare land as a result of soil degradation is a serious threat in mountainous locations. The main effects of soil degradation include on-site degradation of soil wealthstandard and loss of soil fertility, whereas off-site effects include sediment settling and water body pollution (Morgan et al. 1984; Blaikie and Brookfeld 2015). In mountainous places, it has an immediate influence on the environs, the wealth, and farming (Vanacker et al. 2003; Navas et al. 2004). Its rate rise because of the altered temperature and rainfall patterns, which sometime changed how the land was used and produced food, drought, and hunger (Nearing, Tapa, and colleagues 2004,Zhao et al. 2013; Dhulikhel 2019). Alternatively, thesilt buildup on the river has an impact on the reservoir and dams, which raises their maintenance expenses, and makes them unsuitable in the longest run (Samaras and Koutitas, 2014). Numerous investigations have been conducted to comprehend this. They regulate soil erosion and ecological restoration according to their findings (Samaras and Koutitas 2014; Shah et al.1991). Mountainsare extremely resourcedand vulnerable. Avalanches, soil privation from abrupt slopes, and other factors make mountain regions particularly susceptible to resource degradation. Deforestation, etc (Toliirism 1995). In Nepal, a little over 45.5% of the lands erode because of the steeper part ofwater (Chalise et al. 2019). There are numerous models for soil erosion forecast based on empirical (USLE/RUSLE), and the data input differs greatly. The RUSLE illustrates the effects of raindrops on the topography, soil, and climate. and land use influences soil erosion in rivers and between rivers (Magdof)weil (2004)). This technique is popular for estimating the risk of soil degradationprivation, which offers a prescription for the creation of preservation strategies and managing erosion in many land-cover scenarios, including rangelands, disturbed forest lands, and farmlands (Milward and Mersey 1999). For the evaluation and geographical spread of soil abrasion in wider areas, remote sensing and GIS approaches are practical (Milward and Mersey 1999; Bahadur 2012). Milward and Mersey (1999) used RUSLE and GIS techniques to monitor the amount of soil degradation lossaccording to station basis.

Materials and Methods

Study area

The Almora district was choosing for soil erosion model analysis in this study because soil erosion occurs there often. Between the latitudes of 29.5892° N and 79.6467° E is the Almora district. It is located close to the Kosi River. Due to its messy topography and poor land management, the Almora district of Uttarakhand is in the lower Himalayan zone, which is especially susceptible to soil and plant nutrient loss. Thus, it is essential to research the potential of this region's soils and categorize them according to their traits and landform conditions to rationalize land usage. A.D. There were just three tehsils in the area as of 2001: Bhikiyasain, Ranikhet, and Almora. Nevertheless, there are now nine more tehsils after the addition of six new ones.TheAlmoraregion contains 3144 square kilometers of land, 2289 inhabited cities, and 2184 uninhabited cities, including 39 forest towns. There are 1122 grams of pancakes in the region. The town of Almora is situated on a mountain slope that has the shape of a horse saddle. The ridge's western and eastern halves are referred to as Selifat and Talifat, respectively. Where these two, Talifat and Selifat linked, finish, the market lies at the peak of the ridge. The market is covered in stone slabs and is 1.25 miles (2.01 km) long. Lalmandi was the previous name for the area where the current cantonment is located. The "MallaMahal" (Upper Court) of the Chanda kings was where the collectorate is now. The location of the current District Hospital was once the Chand kings' "TallaMahal" (Lower Court). Simalkhet hamlet is situated on the boundary of Almora and Chamoli. The BhairavGadii temple is situated on a hill.

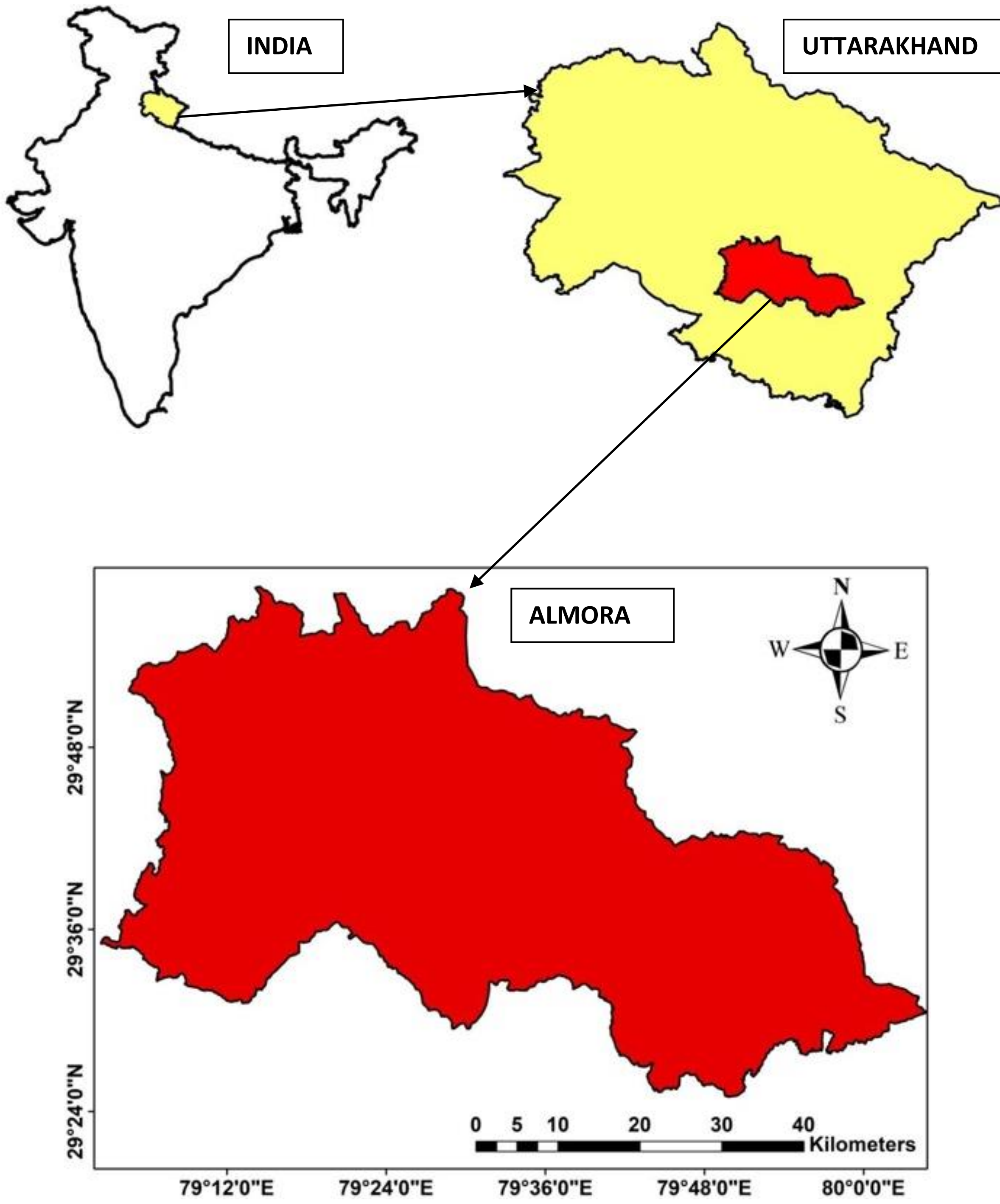

Fig.1 Study area

Methodology

For slopes of ground, the GISprogrammer RUSLE model examines soil damage using geological and land cover variables to calculate the annual soil privation from a parcel of land. Ciesiolka et al. (1995) and Boggs et al. (2001)evaluate the danger of erosion in the study region, which has its characteristics and applicability ranges.Milward (1999) and Tang et al. (2015) defined that due to its ease and interoperability with GIS, its global model anticipates soil loss. Modern technology of GIS and remote sensing build it possible to evaluate the calculation's inputs more precisely according to TolIIrism(1995), Park et al. (2005). Following method utilized for monitoring degradation;

$$A = [R] * [K] * [LS] * [C] * [P]$$

RUSLE Model

Rainfall Erosive Factor (R-Factor)

According toKoirala et al. (2019) and Tapa et al. (2019) the quantity of soil degradation caused by rainfall at a certain site, the rainfall erosion factor (R) defined the strength of precipitation at that place. Stocking (1984) research is useful for evaluating the risk of soil degradation under changes of land uses and climatic conditions. It measures the impact of the number of raindrops that fall and the rate of runoff that results from rainfall and is given in mm. The precipitation map of NASA was utilized in this work to monitor the rainfall erosion factor (Wischmeier and Smith 1978).

$$R = 38.5 + 0.35P$$

Where R=precipitation erosive factor,

P= annum average precipitation in mm

Soil Erodibility Factor (K)

The soil erodibility factor (K) gauges how easily soil particles can separate and be carried away by rain and runoff. According to Erencin et al. (2000) the absorptive of the soil outline, soil structure, resources, and soil quality all influence the K factor.Kouli et al. (2009) states the equationwhich was utilized to calculate the soil privation.

$$K = Fcsand * Fsi - cl * Forgc * Fhisand * 0.1317$$

Where,

$$\text{Fcsand} = \left[0.2 + 0.3\exp\left(-0.0256\ \text{SAN}\left(1 - \frac{SIL}{100}\right)\right)\right], \quad (4)$$

$$\text{Fsi-cl} = \left[\frac{SIL}{CLA + SIL}\right]^{0.3}, \quad (5)$$

$$\text{Forgc} = \left[1.0 - \frac{0.25C}{C + \exp(3.72 - 2.95C)}\right], \quad (6)$$

$$\text{Fhisand} = \left[1.0 - \frac{0.70\text{SN1}}{SN1 + \exp(-5.51 + 22.9SN1)}\right],$$

Where, SAN is sand%, SIL is silt%, CLA is clay%.

Slope Length and Steepness Factor (Ls)

The slope length and steepness factor (Ls), both calculated from the DEM, are combined to produce the topographic factor (LS). Morgan et al. (1992) method used to monitor overland flow, the distance of slope and parameter of gradient is essential for soil degradation models. L and S stand for the outcome of slope distance and abruptof degradation, also when grow in soil privation per unit area.

$$L = (\lambda/22.13)m$$

Where m = factor ranging from 0.2 to 0.9.

$$S = 65.41\sin 2A + 4.56\sin A + 0.065$$

Where,A is slope angle. Merging both the equation we get,

$$LS = \left(\frac{\lambda}{22.13}\right)m(65.41\sin 2A + 4.56\sin A + 0.065)$$

Cover Management Factor (C Factor)

Cropping and other techniques have an impact on erosion rates through the cover-management factor (C) (Chalise et al. 2019). According to Nearing et al. (2004) due to its ability to track the dynamics of plant development and rainfall, it is the most spatiotemporal sensitive. This factor is non-dimensional. With a value between 0 and 1 denoting the amount of rain soil privation due to degradation ratio for a specific piece of land and the comparable loss from vegetative conditions constant fallow bareness (Wischmeier and Smith 1978).The LULC, generated for this study, was creating a map of the C-factors (Sheikh et al. 2011).

Table.1 C factor

Land use classes	**C-Factor**
Forest land	0.030

shrub land	0.030
grass land	0.010
urban land	0.210
waste land	0.450
water bodies	0
snow	0

$C = 0.431 - 0.805 * NDVI$(Vatandslar et al. 2017),

$C = (-NDVI + 1)/2$ (Durgion et al. 2014)

Conservation Practice Factor (P Factor)

According to Park et al. (2005) three techniques, including terraces, crops, and contours, are essential for preventing erosion. Values for the land cover were taken from the research done by Yue-Qing et al. (2008); Coughlan and Rose (1997).

Result and Discussion

In the current study, the 30year rainfall data was taken from Giovanni & then the clip was done to enclose withinthe Almoradistrict. Build precipitation map foraverage annual precipitation of the Almora district (Fig.2).

R-factor calculated by using the following method given by Koirala et al.(2019)

$R = 38.5 + 0.35P$
Where R=rainfall erosive factor,

P= averageprecipitation per year in mm

Values of rainfall erosive factor lies between 2.73 to 3.07.

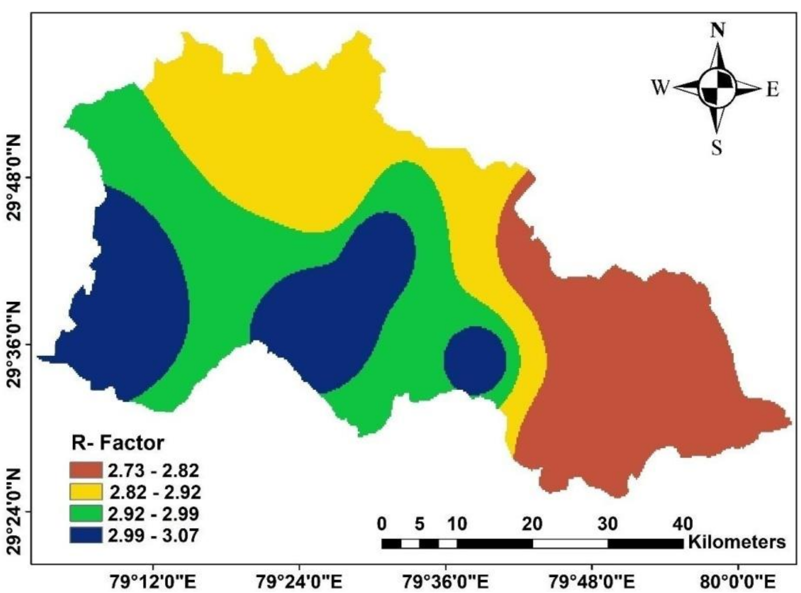

Fig.2 R-Factor map

The soil samples were collected from the soil & land use survey of India and five division using Robinson's pipette method for particle size analysis. To monitor the soil erodibility, the method of Wischmeier and Smith was utilized. The k factor ranges from 0.33 to 0.42 (Fig.3).

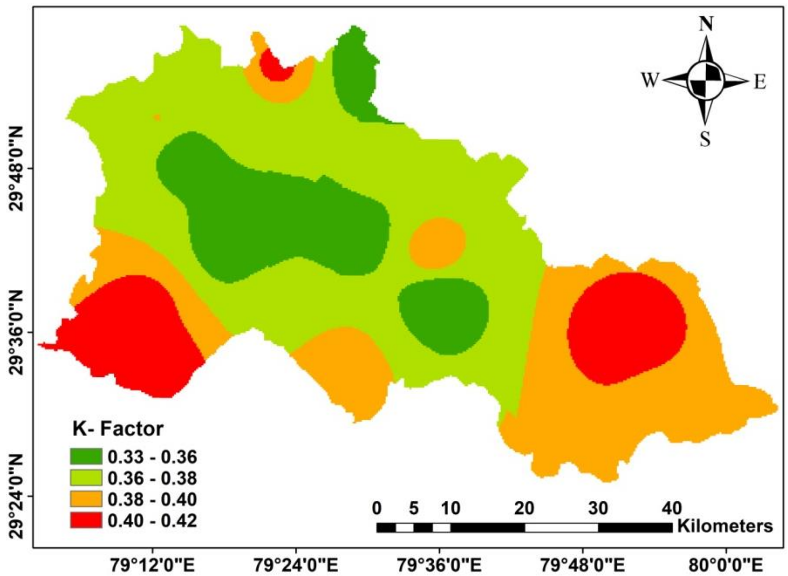

Fig.3 K-Factor map

The LS factor ranges from 0 to 1000 (Fig.4).

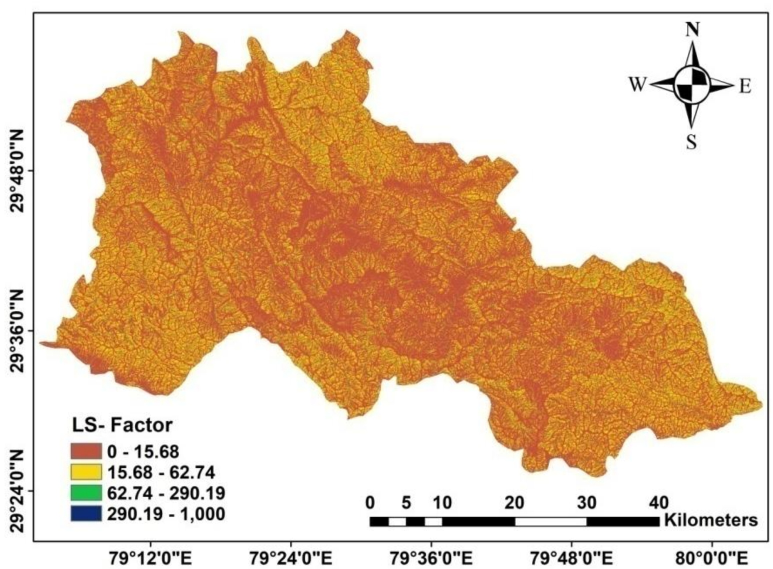

Fig.4 LS factor map

For the constructing C factor map, lulc map developed by utilizing maximum likelihood method. For every land use sample, C values appointed via reference values lies between 0-

1, lowest values of C shows no privation and highest values of C shows significant soil loss . C factor values lies between 0.2-0.55 (Fig.5).

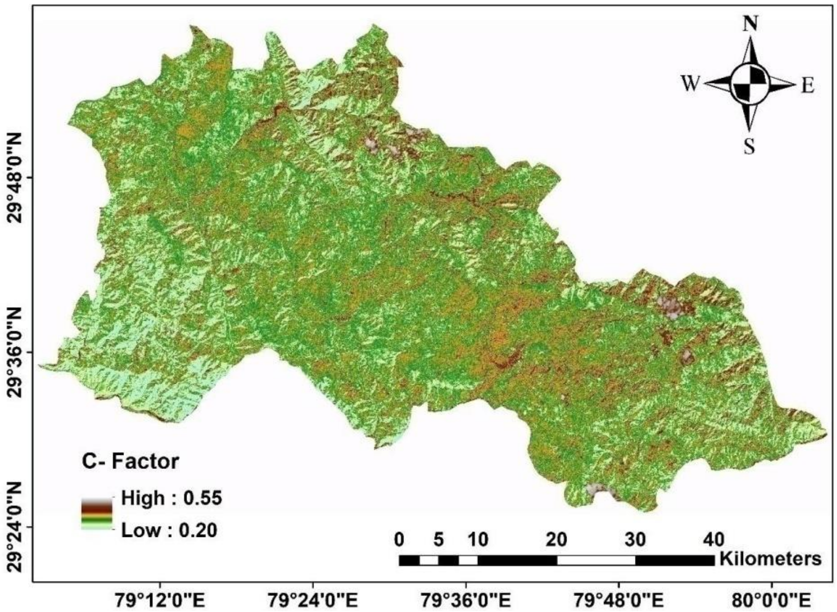

Fig.5 C-Factor map

From the agricultural utility the amount of soil privation indicated by the support utility factor. Kouli et al. (2009) introduced a contouring method utilized with P values liesin between 0 to 1, where 0 indicate proper anthropic degradation and 1 show non-anthropic degradation (Table 3). The preservationutility factor (P) stands for the whole area lies between 0 -1 (Fig.6).

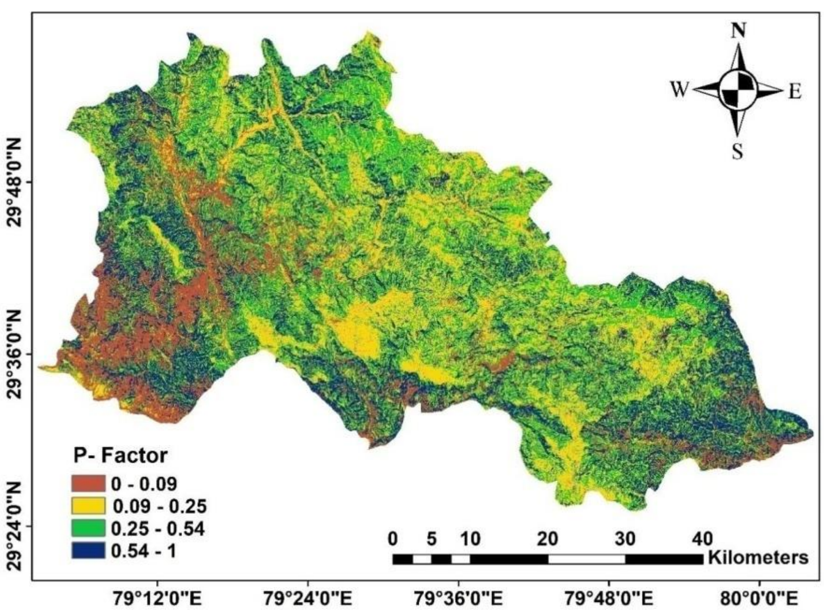

Fig.6 P-Factor map

Conclusion

Soil contingent by rainfall is the most detectableprocess during a short time period and high-strength thunderstorm. It is detected that the dissemination of rainfall erosive factor (R) of Almoralies between 400-700, which divided into five classes.

Soil erodibilityis usually utilized to evaluatethe capability of earth to withstand degradation, according to the quality of a specifiedsoil. Soils with fastestirruptionrates, highestlevels of organic matter and revised soil structure generally have greater withstandto degradation. K-factor values classifiedinto four classes, i.e.<0.33, 0.33-0.38, 0.38-0.40, and >0.42.

When in an area there is no vegetation cover or a little vegetation cover then degradation in that area likely increase. The C-factor ranges for Almora district is 0.20 to 0.55.

The topographic factor monitored in between gradient and distance of slope at every location of slope at each location of grid observation. Soil degradation by water accelerates as the slope distance risesfor the greatest accumulation of runoff. The LS value ranges from 0-1000 in study area as shown in figure 5.

The P factor ranges for Almora district is 0.55 to 1, where area with no preservation utility was having maximum values, build-up land and crop farming having minimum values.

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