Land Capability and Land Use Direction Assessment in the Peusangan Hilir Sub-watershed, Bireuen Regency

by Halim Akbar

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Evaluation of Land Capability and Land Use Direction In the Krueng Peusangan Hilir Sub-watershed, Bireuen Regency

Halim Akbar[1*], Sarifuddin[2], Sakral Hasby Puarada[3]
[1]Agroecotechnology Study Program, Faculty of Agriculture, Malikussaleh University, 24351, Indonesia
[2]Agrotechnology Study Program Faculty of Agriculture Sumatera Utara University, 20155, Indonesia
[3]Agribusiness Study Program, Faculty of Agriculture, Malikussaleh University, 24351, Indonesia
*Corresponding author: email halim@unimal.ac.id

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Abstract- The destruction of forests in watershed areas has now become a concern of many parties, resulting in floods, landslides, and droughts that continue to increase. Watershed damage is accelerated by increased utilization of natural resources due to population growth and economic development, conflicts of interest, and lack of integration between sectors between the upstream-middle-downstream areas. For this reason it is necessary to assess land capability in a watershed so that land development follows the land capability class. The research was carried out in the Krueng Peusangan Hilir Sub-watershed, Bireuen Regency, Aceh, Indonesia, from October 2021 to February 2022, which is geographically located at 96°48"00" - 96°52"00" East Longitude and 5°06"00- 5°17 "00" North Latitude. Land use in the study is dominated by dry land agriculture, covering an area of 19,100.28 ha with a topography area from 0-8% to 25-40%. A survey method by analyzing land capability classes at the study site was carried out for each land map unit (LMU) by comparing land conditions with the land capability evaluation Hockensmith and Steele's criteria (overlaid of determined thematic maps). The result shows that soil erodibility decreased linearly with increasing organic matter in the soil. Soils with high organic matter content have high erodibility. For the limiting factor on slopes in land capability classes found in II, III, IV, and VI class categories that are found in all LMUs, if these LMUs are used for agricultural cultivation, soil conservation measures are needed, such as making mound terraces or canal mound terraces, planting in strips and using mulch. The results show that the land capability classes consisted of 16668.30 ha in the land capability II class, 4184.06 ha land capability in the III class, 4524.91 ha in the land capability IV class, and 190.79 ha land capability VI class with a factor inhibiting soil erodibility (medium – very high) and slopes (wavy - rather steep)

Keywords: Peusangan Hilir Sub-watershed, Land Capability, Land Use Direction

Introduction

A watershed is a land area that is an integral part of a river and its tributaries, which naturally collect, store and channel water from rainfall to lakes or seas (Fitri et al., 2022). The area of the watershed is limited by land topography, and the boundary that separates the area from the waters is still influenced by activities on land (Government Regulation Number 37 of 2012). Watershed management is a form of regional development where a watershed is a management unit interconnected between upstream and downstream in the biophysical aspect through the hydrological cycle. (Fitri et al., 2020). The Krueng Peusangan Watershed crosses five districts, the upstream part is located in Central Aceh District, and the downstream part is located in Bireun Regency and is one of the priority watersheds for restoration (Ministry of Environment and Forestry, 2015).

The destruction of forests in watershed areas has now become a concern of many parties, resulting in floods, landslides, and droughts that continue to increase. Watershed damage is accelerated by increased utilization of natural resources due to population growth and economic development, conflicts of interest, and lack of integration between sectors between the upstream-middle-downstream areas. Unwise land use affects the hydrological function of a watershed. Furthermore, the increasing need for the availability of

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various facilities causes changes in land use (Permana et al., 2019; Sitorus et al., 2012). Increasing the area of certain land uses causes the surrounding land to change dynamically (Munawir et al., 2019). Land use change is both a cause and an effect of environmental change because it can influence climate change and, in turn, affect the physical properties of the land surface and the provision of global ecosystem services (Turner et al., 2007; Foley et al., 2005; Alkama & Cescatti, 2016; Song et al., 2018). Disturbance to the hydrological response indicates watershed damage (Murtiyah, et al. 2019). The results of research by Sitorus et al. (2011) show that population growth is an essential factor influencing changes in the area of space in an area. This population increases significantly affects space requirements, reducing land in the Peusangan watershed. Uncontrolled exploitation of land use in the watershed has resulted in a decrease in the biophysical condition of the watershed, changes in the function of the watershed, reduced forest area, dry land area, and increased human settlements. Changes to land without good spatial planning along the Krueng Peusangan watershed have also caused damage to the ecosystem, impacting the survival of various ethnic groups. (Gayo and Aceh) inhabit the upstream, middle, and downstream areas of the Peusangan watershed (Ilhamsyah et al., 2012).

The Krueng Peusangan Hilir sub-watershed is one of the sub-watersheds of the Krueng Peusangan watershed, which has an area of 29,267.72 ha. The Peusangan Hilir sub-watershed uses land mainly for agricultural activities such as dry land and wetland farming. The agricultural potential in the Krueng Peusangan Hilir Sub-watershed is quite large. However, significant land use constraints need to follow the principle of land capability by paying attention to the soil's ability to have good water absorption (BPDAS Aceh, 2020).

Land use that is not in accordance with their abilities will also add to the problem of poverty and other social problems besides causing land damage (Hardjowigeno & Widiatmaka, 2015). Classification of land capability is an attempt to evaluate land regarding specific uses. In contrast, land capability evaluation is a systematic assessment of land (land components) and classifying it into several categories based on characteristics that have the potential to hinder its sustainable use (Arsyad, 2010).

Judging from the problems in the Peusangan Hilir sub-watershed, the development of agricultural land must include principles and needs, including soil and water conservation, to ensure increased production and community income to create a sustainable watershed (Sinukaban, 1997). For this reason, it is necessary to assess land capability in a watershed so that land development follows the land capability class.

Materials and Methods

The research was conducted in the Peusangan Watershed of Aceh Province from October 2021 to February 2022. The research location is located in Bireuen Regency. The Krueng Peusangan Hilir sub-watershed is one of the sub-watersheds of the Krueng Peusangan watershed, which is geographically located at 95°58'00" - 96°52'00" E and 5°06'00" - 5°17' 00" North Latitude.

The Krueng Peusangan Hilir sub-watershed one of the sub-watersheds of the Krueng Peusangan watershed, which is geographically located at 95°58'00" - 96°52'00" East Longitude and 5°06'00"- 5°17'00" North Latitude. The research was carried out from October 2021 to February 2022. The research location is located in the Bireuen Regency (figure 1).

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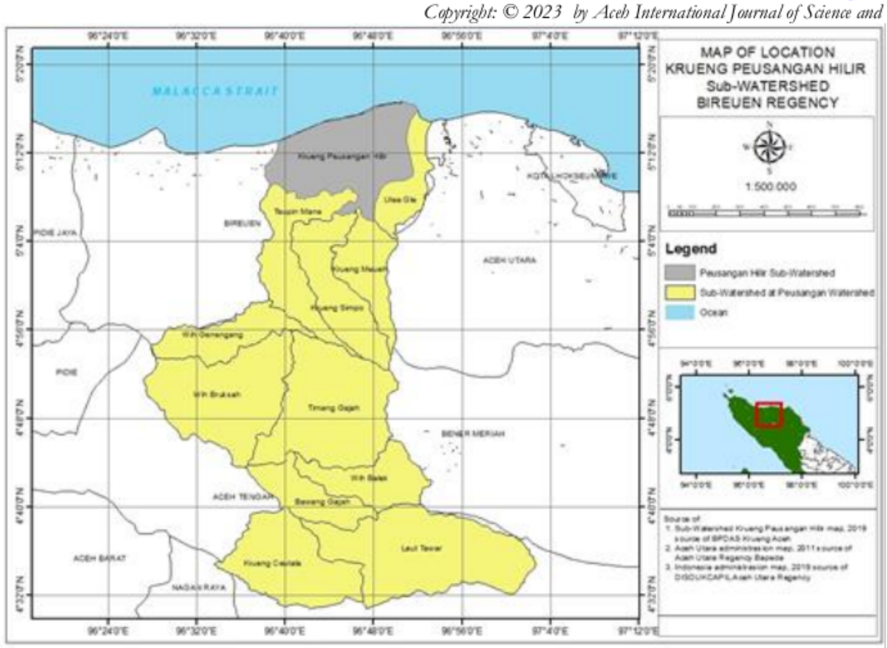

Figure 1. Map of Location Krueng Peusangan Gilir Sub-Watershed Bireuen Regency

The tools used in this study consisted of GPS, compass, Abney level, soil drill, Munsell soil color chart books, hoes, machetes, stationery, topographic maps, soil type maps, land use maps, and land unit maps (LMU). The materials used in this study were soil samples (intact soil and non-intact soil) and chemicals used for soil analysis in the laboratory.

Data Collection Technique

The data collection technique used in this study was a survey method which consisted of a preparatory stage, namely the preparation of secondary data, including base maps and thematic maps. During the preparation stage, a map of land units (LMU) was also made; this map will later be used to determine soil sampling in the field. The LMU map is obtained from the overlay of topographic maps, land use maps, and soil type maps.

The next stage is the main survey stage: observation, measurement, and collection of biophysical data in the field. Soil sampling was carried out in two ways, namely for disturbed soil (using a drill) and taking intact soil (using a sample ring). The types, sources, and uses of data needed in this study are:

Primary data:

Soil physical properties (structure, texture, soil depth, drainage and permeability, slope and erosion susceptibility, flood susceptibility, and rock on the surface), soil chemical properties (C-organic). Both data sources are land map units in the field and laboratory analysis using soil erodibility class determination and soil capability. Map of the Krueng Peusangan Hilir watershed. Source of data from BPDAS Krueng Aceh using the Determination of the boundaries of the Krueng Peusangan Hilir sub-watershed. Land Use Map, Topographic Map, and Soil Type Map. DLHK Aceh data source using Determination of land map units. Other supporting data such as literature studies, journals, and other supports

Data Analysis

The assessment of land capability classes at the study site was carried out for each land map unit by comparing land conditions with the land capability evaluation criteria proposed by Hockensmith and Steele (1943) and Klingebiel and Montgomery (1973) in Arsyad (20[illegible]) and then evaluating land capability. The land capability classification criteria used in this study can be seen in Table 1.

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Table 1 Criteria for land capability classification

Inhibiting / Limiting Factors	Land Capability Class							
	I	II	III	IV	V	VI	VII	VIII
1. Surface Slope	A (l_0)	B (l_1)	C (l_2)	D (l_3)	A(l_0)	E (l_4)	F (l_5)	G (l_6)
2. Erosion sensitivity	KE_1,KE_2	KE_3	KE_4,KE_5	KE_6	(*)	(*)	(*)	(*)
3. Erosion rate	e_0	e_1	e_2	e_3	(**)	e_4	e_5	(*)
4. Depth of soil	k_0	k_1	k_2	k_2	(*)	k_3	(*)	(*)
5. Top layer texture	t_1,t_2, t_3	t_1,t_2, t_3	t_1,t_2, t_3, t_4	t_1,t_2, t_3, t_4	(*)	t_1,t_2, t_3, t_4	t_1,t_2, t_3, t_4	t_5
6. Undercoat texture	sda	sda	sda	sda	(*)	sda	sda	t_5
7. Permeability	P_2,P_3	P_2,P_3	P_2,P_3, P_4	P_2,P_3, P_4	P_1	(*)	(*)	P_5
8. Drainage	d_1	d_2	d_3	d_4	d_5	(**)	(**)	d_0
9. Gravel/rock	b_0	b_0	b_1	b_2	b_3	(*)	(*)	b_4
10. Threat of flooding	O_0	O_1	O_2	O_3	O_4	(**)	(**)	(*)
11. Salt/salinity (***)	g_0	g_1	g_2	(**)	g_3	g_3	(*)	(*)

Source : Arsyad, 2010.
Information :
(*) = can have any properties;
(**) = not applicable
(***) = generally found in dry climates

Results

Land Mapping Unit

The map of land mapping units (LMU) in the Krueng Peusangan Hilir sub-watershed was obtained from the overlay of a 1:150,000 scale land use map, a 1:150,000 scale soil type map, and a 1:150,000 scale topographic map resulting in 14 land map units (Table 2 and Figure 2), then the intensive observations in this study were on land map units 2, 5, 6, 7, 8, 10, 11, 12, 13, and 14.

Table 2. Land Map Units in The Krueng Peusangan Hilir Sub-Watershed

LMU	Land Use	Type of Land	Slope (%)	Areas	
				Ha	%
1	Settlement	Inceptisol	0 - 8	957.11	3.27
2	Wetland Agriculture	Inceptisol	0 - 8	5145.40	17.58
3	Water Body	Inceptisol	0 - 8	281.84	0.96
4	Pond	Inceptisol	0 - 8	2359.15	8.06
5	Shrubs	Inceptisol	0 - 8	526.84	1.80
6	Dryland farming	Inceptisol	15 - 25	1961.01	6.70
7	Dryland farming	Inceptisol	25 - 40	190.79	0.65
8	Wetland Agriculture	Inceptisol	8 - 15	216.87	0.74
9	Swamp	Inceptisol	0 - 8	101.56	0.35
10	Open field	Inceptisol	0 - 8	578.67	1.98
11	Dryland farming	Inceptisol	0 - 8	10996.05	37.57
12	Dryland farming	Ultisol	25 - 40	2563.90	8.76
13	Dryland farming	Inceptisol	8 - 15	2180.92	7.45
14	Dryland farming	Ultisol	8 - 15	1207.61	4.13
	Total			29267.72	100.00

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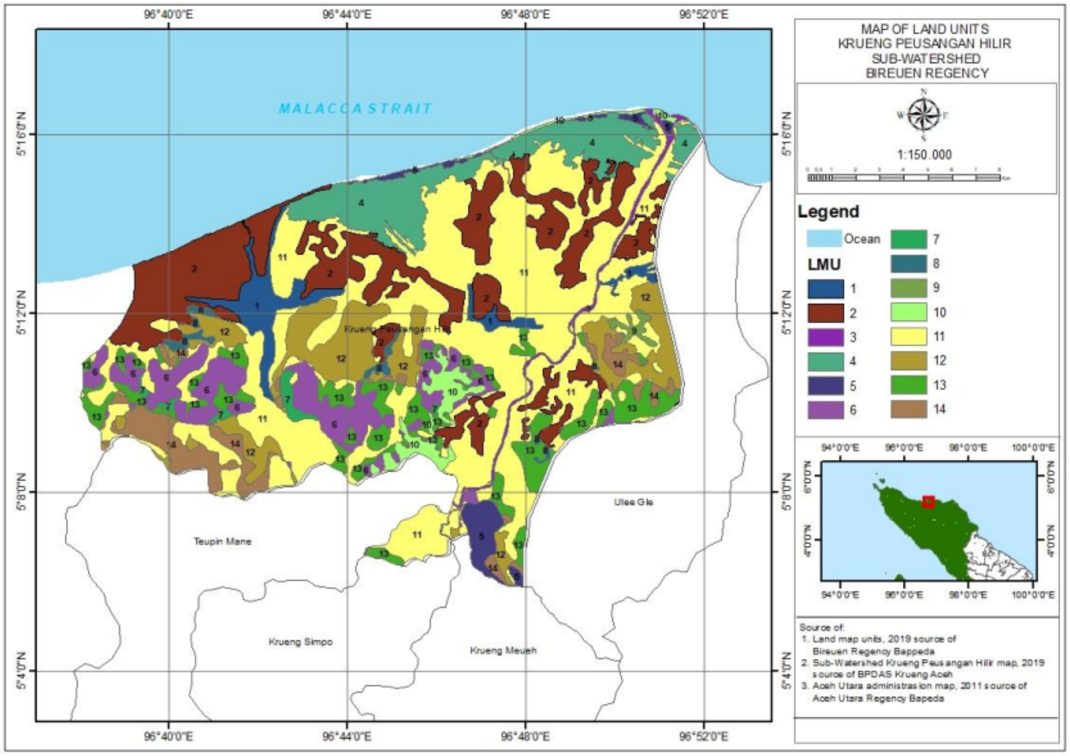

Figure 2. Map of Land Units Krueng Peusangan Hilir Sub-watershed, Bireuen Regency

Land Capability

The results of the analysis of land capability evaluation (results of field observations and analysis of soil samples) in each land map unit in the Krueng Peusangan Hilir Sub-watershed were then assessed using land capability evaluation criteria (Arsyad, 2010) which consisted of class II land capability with an area of 16668.30 ha, land capability class III covering an area of 4184.06 ha, land capability class IV covering an area of 4524.91 ha and land capability class VI covering an area of 190.79 ha with inhibiting factors of soil sensitivity to erosion (medium-very high) and slopes (wavy - slightly steep).

The results of field observations and analysis of soil samples from each land map unit in the Krueng Peusangan Hilir sub-watershed were then assessed using land capability evaluation criteria with the results shown in Table 3.

Table 3. Results of Land Capability Evaluation Analysis

Obstacle factor	LMU 2	LMU 5	LMU 6	LMU 7	LMU 8	LMU 10	LMU 11	LMU 12	LMU 13	LMU 14
1 Surface Slope (%)	L1	L1	L3	L4	L2	L1	L1	L3	L2	L2
2 Erosion sensitivity	KE3	KE3	KE3	KE4	KE2	KE4	KE3	KE6	KE3	KE2
3 Erosion rate	to	to	e1	e2	to	to	eo	e2	e1	eo
4 Soil Depth (cm)	[illegible]	ko	ko	ko	ko	ko	ko	[illegible]	ko	ko
5 Top Layer Texture	t2	t2	t3	t2	t2	t3	t2	t2	t2	t2
6 Underlay Texture	t2	t2	t3	t2	t2	t3	t2	t2	t2	t2
7 Permeability (cm/jam)	p3	p2	p2	[illegible]	p2	p2	p3	p2	p2	p2
8 Drainage	d1	d1	d1	d1	d1	d1	d1	d1	d1	d1
9 Gravel/rock	[illegible]	bo	bo	bo	bo	bo	bo	bo	bo	bo
10 Flood threat	o1	o1	o1	o1	o1	o1	o1	o1	o1	o1

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Based on the data in Table 3, an analysis of land capability was carried out whose results consisted of land capability class II covering an area of 16668.30 ha, land capability class III covering an area of 4184.06 ha, land capability class IV covering an area of 4524.91 ha and class VI land capability covering an area of 190.79 ha with inhibiting factors of soil sensitivity to erosion (medium – very high) and slopes (wavy – rather steep) (Table 4). Soil erodibility (soil sensitivity to erosion) generally occurs due to rainfall. In tropical countries like Indonesia, the power of falling rainwater and the ability of surface runoff to erode the soil surface are the main destroyers of soil aggregates (Muliatiningsih, and Zulaeha, 2018). According to Harahap, et al. (2021), apart from soil properties, soil management/treatment factors also significantly affect the level of soil erodibility. Furthermore, Sinaga, et al. (2020). It was also added that soil with high dust content is the most eroded soil. Efforts need to be made against the limiting factor of soil erodibility by adding organic matter to maintain the stability of soil aggregates.

Table 4. Land Capability Classes in the Krueng Peusangan Hilir Sub-watershed

Land Capability Class	Land Map Unit	extensive	
		Ha	%
II l_1,KE_3	2, 5, 11	16668.30	65.19
III l_2	8, 13, 14	3605.39	14.10
III KE_4	10	578.67	2.26
IV l_3	6	1961.01	7.67
IV l_3, KE_6	12	2563.90	10.03
VI l_4	7	190.79	0.75
Total		25568.07	100.00

Note: Roman numerals indicate land capability class; KE = soil erodibility inhibiting factor; l = inhibiting factor of the slope; Latin numerals indicate the level of the inhibiting factor. Source: Analysis of primary data (2022).

This is also in accordance with the opinion of Vorone et al. (1981) soil erodibility decreased linearly with the increase or addition of organic matter in the soil. Several research results also show that soils with high organic matter content have high erodibility (Asdak, 2022). For the limiting factor of slopes in land capability classes II, III, IV, and VI that are found in all LMUs, if this LMU is used for agricultural cultivation, soil conservation measures are needed, such as making mound terraces or canal mound terraces, planting in strips and using mulch (Arsyad et al., 2018)

Land Use Directives

Directions for land use that need to be carried out in the Krueng Peusangan Hilir Sub-watershed for land with ability class II can be recommended for seasonal crop farming and mixed gardens accompanied by moderate soil conservation measures, such as alternating cropping patterns and additional treatment with ground cover crops. Land with capability class III, which previously used the land as open land and dryland farming, can be recommended for mixed garden farming accompanied by soil conservation measures, namely by giving mulch as much as 6 tons/ha and making rorak. (Murtilaksono et al., 2008). Land capability class IV, the previous land use was as dryland farming, it can be recommended to use the agroforestry model of agriculture accompanied by the creation of individual terraces and land with capability class VI, which is previous land use as dry land farming has a relatively narrow slope limiting factor. Steep (32%), then it should be directed to pasture or grazing, and this must also be appropriately managed so that erosion does not occur.

Discussion

Based on the land capability class obtained from the results of field research, namely land with capability class II (suitable for limited to intensive agricultural land) with wavy slope limiting factors (LMU 2, 5, and 11), class II land can be recommended for use, seasonal crop farming and mixed gardens. Judging from the limiting factors obtained, are still light, and so that this land can be used sustainably, moderate soil

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conservation measures are needed, such as planting leguminous cover crops or utilizing plant residues in the research location as mulch to prevent erosion and surface flow can be controlled. Land preparation according to the contour, crop rotation with ground cover, and making mound terraces can also be done to protect the soil from damaging raindrops (Nasir et al., 2019).

Land with land capability class III (suitable for limited to moderate agricultural arable land) with slope limiting factors (LMU 8, 13, 14) and soil erodibility limiting factors (LMU 10). Land use in class III can still be maintained for medium agriculture. However, conservation actions need to be carried out at the research location by making terraces, planting in strips, and crop rotation with ground cover crops to maintain the sustainability of land use to support the future life and welfare of farmers and their families.

Murtilaksono *et al.,* 2008 added that for the use of mixed garden agricultural land, the soil conservation action that needs to be done is to apply mulch as much as 6 tons/ha followed by making rorak, while efforts must be made to limit the erodibility of the soil so that land use remains sustainable is by adding organic matter and adding compost, this is in line with the results of research by Kalaati et al., (2019) where to reduce soil erodibility, it can be done by adding organic matter and adding compost followed by planting legumes so that it can withstand the ground from the rain. Meanwhile, Pratiwi and Narendra (2012) added that the application of soil conservation techniques to mahogany plantations with a combination of vertical mulch was able to control runoff and erosion.

Land with land capability class IV (suitable for limited agricultural arable land) where land use in the research location is dryland farming, then the land use directions can be recommended for dry land farming with the use of agroforestry farming models which are included with the creation of individual terraces. The agroforestry system is very suitable to be applied in research locations because the land management system with more optimal land use and higher soil surface cover, besides that it can also increase optimal yields because it combines agricultural crop production. According to Naharuddin (2018) the agroforestry farming model besides providing benefits for improving the environment of the watershed ecosystem, which can reduce the rate of erosion, also provides benefits for farmers around the site,

Land with land capability class VI (LMU 7) where the previous land use in the research location was dry land cultivation which has a rather steep slope limiting factor (32%), the direction of land use is directed to grazing, and this must also be appropriately managed so that this does not occur erosion.

Conclusions

The results showed that the land capability class consisted of 16668.30 ha II land capability class, 4184.06 ha III land capability class, 4524.91 ha IV land capability class, and 190.79 ha VI land capability class with soil erodibility inhibiting factors (moderate - very high) and slopes (wavy - rather steep). The effort that needs to be made on the limiting factor of soil erodibility is by adding organic matter to maintain the stability of soil aggregates, while for the limiting factor of slopes, the soil conservation measures that need to be done are by making mound terraces or canal mound terraces, planting in strips and using mulch.

Directives for land use for class II, namely with moderate soil conservation measures, namely by crop rotation cropping patterns and additional treatment with ground cover crops, class III can be directed to agricultural areas accompanied by the provision of mulch as much as 6 tons/ha and making *rorak*. In contrast, class IV is directed to use the agroforestry model cropping pattern, which is included making individual terraces, and class VI land is directed for pasture or grazing, and this must also be appropriately managed to avoid erosion.

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