

Characteristics Of Sloping Soils And Sustainable Use Of Sloping Land Resources For Agricultural And Forestry Development In Thai Nguyen Province

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Abstract:

Thai Nguyen is a well known province located in a midland and mountainous region in Northern Vietnam. The features of sloping land in Thai Nguyen province are quite diverse, which is an important foundation for agricultural and forestry development. In Thai Nguyen province, mountainous land accounts for 76.47% of the province's natural area. The soil was formed due to the result of rapid, strong and thorough weathering, but with the characteristics of mountainous terrain, it is also susceptible to degradation, washout and erosion. In this article, the authors research some solutions for sustainable use of sloping land resources for agricultural and forestry development in Thai Nguyen province based on the potential of sloping land, the actual state and viewpoints of using sloping land for the agricultural and forestry development in Thai Nguyen province.

Keywords: Sloping land, sustainable development, agricultural, forestry, Thai Nguyen.

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I. Introduction

Land is an important component of the synthesis of natural geography, and is the main material for agricultural and forestry production, the territorial basis for the distribution of the national economic branches. For a country where three-quarters of the area is hilly and mountainous like Vietnam, the sustainable use of land resources is mainly to use the sloping land resources rationally and effectively to develop the economics, stable society, protect and improve the environment.

Thai Nguyen is a well known province located in a midland and mountainous region in Northern Vietnam, has diverse natural conditions and natural resources, especially rich sloping land scale - a favorable basis for the development of agriculture and forestry. In recent years, the use of sloping land in Thai Nguyen province for agricultural and forestry development has seen positive changes. However, besides these achievements, the use of sloping land in the province still has some limitations such as: unused land, especially bare land and hills remains abundant; land degradation; land pollution due to irrational agriculture and forestry cultivation or mineral exploitation; the level of agricultural and forestry production of ethnic minorities is not high, so that the production efficiency is not commensurate with its potential; land degradation due to erosion, leaching,... Therefore, studying some solutions for sustainable use of sloping land resources for agricultural and forestry development in Thai Nguyen province is a necessary research direction, making an important contribution in improving economic efficiency, stabilizing society, protecting and improving the ecological environment, which all lead to the sustainable development of agriculture and forestry.

II. Material And Methods

Research on sloping lands and sustainable use of sloping lands has been studied by a number of authors such as: research by authors Nguyen Cong Vinh, Mai Thi Lan Anh (2011) has analyzed the role of sloping land in socio-economic development, distribution and formation conditions of sloping land in Vietnam. In particular, in this study, the group of authors also raised the issue of sustainable use of sloping land resources in Vietnam; research by authors Nguyen Thai Phien, Tu Siem (2002), Nguyen Xuan Quat (1994), Nguyen Viet Khoa and his coworkers (2008),... have studied farming techniques on sloping land and gave a solutions for sustainable development of sloping land in Vietnam.

Researches on land resources in Thai Nguyen province have research by the author Duong Quynh Phuong "Ethnic community with the use of land and forest resources towards the goal of sustainable development in Thai Nguyen province" (2007), research by author Le Thi Nguyet on assessment of natural potential, including potential land and the use of land for agricultural development in Thai Nguyen province (2011). In addition, every year, the Department of Natural Resources and Environment of Thai Nguyen province has an inventory and assessment of the current land resource status of the province.

Research methods on sustainable use of sloping land resources for agricultural and forestry development in Thai Nguyen province are used, including: document collection and processing method, systematic analysis method, and field survey method. The data and documents used in the study were collected and analyzed from various reliable sources such as: Statistical Yearbook of Thai Nguyen Province (2005-2023), Synthesis Report of Development Master Plan agriculture and rural areas of Thai Nguyen province to 2025 and orientations to 2045 by the Department of Agriculture and Rural Development of Thai Nguyen (2020); Results publication of land area inventory in 2022 of the Ministry of Natural Resources and Environment (2023); Research on sustainable use of sloping land by Thai Phien, Nguyen Tu Siem (2002), Nguyen Xuan Quat (1994). In addition, the additional data had been updated from the author's research and field investigation in Thai Nguyen province by the authors.

III. Result

Characteristics of sloping soils in Thai Nguyen province

Sloping land is land with sloping steep, often rough, uneven or undulating and heaving. That inclination is called the slope or slope surface. The angle formed between the slope and the plane (the horizontal plane), is called the slope of the ground or the slope of the terrain (Nguyen Xuan Quat, 1994).

Table no 1: Classification slope of land

Ordinal	Slope	Level
1	Below 8 ⁰	Low slope
2	8 – 15 ⁰	Average slope
3	16 – 25 ⁰	slightly strong
4	26 – 35 ⁰	strong slope
5	More than 35 ⁰	Very strong slope

Sources: Nguyen Xuan Quat, 1994

In Thai Nguyen province, mountainous land accounts for 76.47% of the province's natural area. The soil was formed due to the result of rapid, strong and thorough weathering, but with the characteristics of mountainous terrain, it is also susceptible to degradation, washout and erosion.

The characteristics of the main sloping soils in Thai Nguyen province are as follows:

- Red and yellow soil on clay and metamorphic rocks (Fs): This is the type of soil with the largest area of 168,789 ha, accounting for 47.75% of the province's natural area, distributed in large areas in Phu Luong district, Vo Nhai, Dong Hy, Dai Tu, DinhHoa. Soil with mechanical components from medium to heavy earth, lumpy structure, long flooded will have strong biodegradation processes. On this soil type, there is about 48.5% of the area, which has a slope of 8 - 250 that is very suitable for the development of tea trees and fruit trees.
- Red yellow soil on acid magma rock (Fa): This soil covers an area of 30,533 ha, accounting for 8.64% of the natural area of the province, distributed concentratedly in Dai Tu and DinhHoa. This type of soil is susceptible to erosion and leaching because the topsoil has a light mechanical composition, porous, acidic soil and about 50% of its area was distributed at a slope of above 250.
- Light yellow soil developed on sandstone (Fq): This soil is about 34,034 ha, accounting for 9.63% of the natural area of the province. This is hilly soil with the second largest area, which is only smaller than the red and yellow soil on clay and metamorphic rocks. This soil type is scattered in all districts and towns in the province and usually has a slope of below 250. The area with a slope of above 250 is only about 23%. This soil's top is usually gray, has a light mechanical composition and many quartz stones, and is acidic.
- Reddish brown soil on basic and neutral magma (Fk): Covering an area of 15,329 ha, this soil accounts for 4.34% of the province's natural area, distributed concentratedly in Dai Tu, DinhHoa, Phu Luong. This soil contains a lot of iron and manganese. When being interacted with hot and humid, it is easy to weather and the top part is easy to curdle. This is a good soil type, about 63% of this has a slope of 80 to 250, can be exploited and put into agriculture and agroforestry production.
- Yellow brown soil on ancient alluvium (Fp): 12,468 ha, accounting for 3.53% of the natural area of the province. The land is distributed concentratedly in Phu Luong, Pho Yen, Vo Nhai, Dong Hy, PhuBinh and Dai Tu. The land usually has a low slope, 58% of the area has a slope of less than 80, which is very suitable for growing crops, short-term industrial crops (sugarcane, peanuts, soybeans,...).
- Red brown soil on limestone (Fv): Covering an area of 4,464 ha, accounting for 1.26% of the natural area, concentrated in Vo Nhai and Phu Luong districts. Overall, this is a good, but dry and discrete texture, medium mechanical composition, fairly basic saturation level, less acidic. On this land type, about 70% of the area has a slope of less than 200, which is suitable for agricultural production and production in the form of agroforestry.
- Red yellow humus soil on acid magma (Ha): Covering an area of 2,559 ha, accounting for 0.72% of the province's natural area. This soil type is located in areas with an altitude of 700m or more. At this height, the

intensity of the feralite process is reduced, the humus accumulation increases. Most of them are distributed at the slope of above 350. The soil layer is 0.6 - 1.2m thick, with medium - light mechanical composition. Due to its high and steep terrain, it is easy to be eroded.

- Red and yellow land changes due to rice cultivation (Fl): 1,116 ha, accounting for 0.32% of the natural area of the province. This soil is distributed at a slope of 0 - 80, in most valleys in the province's districts, it is now used for rice cultivation and some other short-term crops.

- Black soil on the accretion product of basalt rock (Rk): has a very small area of 973 ha, accounting for 0.28% of the total natural area of the province. This soil formed by the accretion of basalt, black, or gray-black soil, distributed at a slope of 0 - 80.

- The gray soil on ancient alluvium: 4,331 ha, accounting for 1.3% of the natural area, distributed concentratedly in the Southern districts of the province. Degraded soil was initially used in agricultural production.

Research shows that red and yellow soil on clay and metamorphic rocks (Fs) occupies the largest area in the province at 47.75%. This type of soil is suitable for long-term crops in agriculture to develop well, especially tea and fruit trees. However, bare land and hilly areas are also distributed mainly on this type of land.

In general, the soil quality in Thai Nguyen province is quite good, the soil layer is thick in many places and the hilly soil has a high amount of humus. It has been exploited for agricultural production; food, industrial crops, fruit trees and forestry cultivation. However, in many places, due to industrial exploitation, indiscriminate deforestation such as in Phu Luong, Pho Yen, Dai Tu district..., the land is degraded, eroded, poor in nutrition, too dry to easily overcome in a short time.

Research on unused bare land and hills of the province shows that 65% is red yellow soil on clay and metamorphic rock and about 15% is light yellow soil on sandstone. Thus, bare soil and hills of the province are mainly distributed on the soils formed on the base of shale, metamorphic, acid sputum, which are suitable soil types for perennial plants in developing agriculture and forestry (Le Thi Nguyet, 2011).

The actual state of using sloping land for agricultural and forestry development in Thai Nguyen province

Thai Nguyen province has a natural area of 352.196 ha, including agricultural, non-agricultural and unused land. Agricultural land accounts for the largest natural land area of 85,64%, mainly of which is forestry land (52,84%), and agricultural production land 31,35%. The area of sloping land for agricultural and forestry development is mainly forestry land, land for perennial agricultural crops and a part of land for annual crops and fruit trees. The unused land area is still quite large 3.207 ha (accounting for 0,91% of the natural area) (Table 2) (Thai Nguyen Statistical Office, 2023). Therefore, the direction of researching and exploiting the unused land scale in Thai Nguyen for the purpose of effective agricultural and forestry development and avoiding waste is very necessary.

Table no 2:State of using land in Thai Nguyen province in 2022

Standard	Area (ha)	Structure (%)
Total natural area	352.196	100,00
1. Agricultural land	301.624	85,64
<i>1.1. Agricultural production land</i>	<i>110.403</i>	<i>31,35</i>
1.1.1. Annual crop land	55.921	15,88
- Land for planting rice	42.206	11,98
- Land for planting other annual crops	13.715	3,89
1.1.2. Land for perennial crops	54.482	15,47
<i>1.2. Forest land</i>	<i>186.085</i>	<i>52,84</i>
<i>1.3. Aquaculture land</i>	<i>4696</i>	<i>1,33</i>
<i>1.4. Other agricultural land</i>	<i>440</i>	<i>0,12</i>
2. Non-agricultural land	47.365	13,45
3. Unused land	3.207	0,91

- Unused plain land	346	0,10
- Unused hilly and mountainous land	770	0,22
- Rock mountains without forest trees	2091	0,59

Sources: Processing data from the Statistical Yearbook of Thai Nguyen province, 2023

Research shows that the limitations in the development of agriculture and forestry on sloping land in Thai Nguyen province are as follows:

- Strong erosion and leaching in areas with a slope of above 25⁰, concentrated in Vo Nhai, Phu Luong, DinhHoa, Dai Tu district, which caused the loss of nutrients and the fertility of the topsoil leading to acidification in soil.
- Land degradation is caused by destroying and burning forest land in order to grow annual crops for food. Of the total degraded land area of Thai Nguyen, the degree of degradation from weak to very weak accounts for about 75%. If including the area of land with average degradation degree, this rate is up to 94%. Only 4% of the area has not been degraded yet and needs attention to invest and protect. The areas with medium to strong degradation of land accounts for 26% of the total land area of the province, which are heavily deforested and the land there can be abandoned. The main reason is mostly due to the impacts of human production and exploitation of natural resources.
- Drought often occurs in the dry season, so water retention on sloping land is a really difficult problem, the cultivation depends on the rainfall. There are droughts in the dry season, and some areas do not have enough water to meet the production needs. Drought is a major problem for sloping land, which reduces productivity and quality of the products.
- The mineral exploitation has narrowed a part of the agricultural and forestry land area of the province, and at the same time discharging wastewater also pollutes the soil.
- People in the sloping lands are mainly ethnic minorities with high poverty rates and low levels of education, which also cause significant obstacles in the sustainable use of sloping resources. In addition, the activities of anti-erosion, protecting water resources and planting trees for economic efficiency require higher investment and farming techniques.

Some solutions for sustainable use of sloping land resources for agricultural and forestry development in Thai Nguyen province

Committee of Thai Nguyen province has proposed views and land use objectives for the agricultural and forestry development of Thai Nguyen province are as follows (The Department of Agriculture and Rural Development of Thai Nguyen Province, Synthesis Report on the Master Plan for Agricultural and Rural Development of Thai Nguyen Province to 2025 and Orientations to 2045):

- The agricultural and forestry land policy must aim at encouraging the subjects directly zusing the land to develop effective agriculture and forestry.
- The use of land for agricultural and forestry development must be linked to the hunger eradication and poverty alleviation program in rural mountainous areas.
- The use of land for agricultural and forestry development must be linked to the process of agricultural and rural industrialization and modernization.
- The use of land for agricultural and forestry development must capture market demand and be consistent with domestic and international labor division.
- Pay attention to ensuring enough food for the whole society, keep and plant forests in all vital regions and sloping lands to preserve water and create a sustainable ecological environment.

From the point of view of sustainable use of sloping land, Thai Nguyen province's planning on agricultural and forestry development province to 2045, and based on the characteristics of slopes, the real state of using sloping land for agricultural and forestry development in Thai Nguyen province, the author offers some solutions for sustainable use of sloping land for agricultural and forestry development in Thai Nguyen province in order to ensure the harmonious development among three aspects, namely economy, society and environment are as follows:

Solutions for using and planning sloping land in agriculture and forestry

Some specific solutions for using and planning sloping land resources in Thai Nguyen province are as follows:

- It is necessary to pay attention to afforestation. Because the province's land is mostly sloping, planning the area for afforestation to prevent soil from being washed away and eroded is very important.
- Construct high-tech agricultural and forestry zones for the production of concentrated and high-quality goods associated with the processing industry and continuous commercial services from production to collection

agents, to distributors and to users (or exportation). High-tech agricultural and forestry zones such as: Tan Cuong, PhuocTriu tea area (Thai Nguyen city), Trai Cai tea area (Dong Hy), La Bang tea area (Dai Tu); HoaBinh fruit tree areas (Dong Hy), Minh Tien (Dai Tu), production forests in Dong Hy, DinhHoa,...

Solutions on legal systems and policies

In order for the use of sloping land resources to be effective, Thai Nguyen province needs to improve policies on agricultural extension, poverty reduction, forest land allocation, grant stable and long-term allocation of land use to the people, medium and long term capital loan,... At the same time, it is necessary to implement the program of land degradation prevention and environmental protection, the program of afforestation, the program of agroforestry, household economic development, farm development,...

Scientific and technical solutions to prevent erosion and sloping land protection

Contour cultivation with row of green trees. With this farming method, food crops are grown between legumes or grass beds on terraced fields. This system both limits erosion and retains soil fertility from year to year. Thickly planted patches of trees, shrubs or grass strips act as living barriers to prevent the leaching of the soil during heavy rain.

If the contour farming system with row of green trees is applied, the terraced fields will be flat along the fences, because the soil will be gathered and gradually accreted behind the trees, the hillside will be less steep and easier to plant.

Development of agroforestry models in Thai Nguyen such as:

- Forest - garden model (forest - tea, or forest - medicinal plant): Applied to areas in the province with strong slope (26 - 35⁰), slightly strong (16 - 25⁰). The highest part of the terrain retains the natural vegetation. Slopes which are of 15 - 25⁰ are planted with forestry trees. Where there is good soil, it is reasonable to choose cinnamon, canarium, pine, paving; whereas the bad soil grows acacia. Under the forest canopy, there are a number of medicinal plants that can be planted such as ginger and amomum. Slight slopes are easy to grow tea (intercropped with soybeans in the first stage).

- Model of garden - forest: (forest - tea - rice, forest - tea - fruit trees): Applied to areas in the province with medium slope (8 - 15⁰). The highest part of the terrain is planted with several types of forest trees: acacia, fat, palm, crayon, cinnamon, and canarium. Slight slopes intensify tea (intercropped with soybean in the first stage). The foothills are planted with rice, crops and fruit trees.

Solutions on investment capital

The good settlement of investment capital will help people living on sloping land in the province to exploit sloping land resources effectively and to bring high economic value. The first source of capital that can be mobilized is direct investment capital from the state budget; the second is mobilize capital from the people, create all favorable conditions (with open preferential policies, reasonable regimes which are guaranteed by law); the third is the development of co-operative, joint-venture and economic cooperation activities to attract investment capital from outside. It is necessary to focus on capital investment for projects with high economic value such as: high-class tea development project, specialty tea, integrated development under the forest canopy project, and projects of planting production forests for the processing industry.

Investing funds to build infrastructure to develop production models such as irrigation stations, agricultural and forestry seed stations, net houses,...

Sustainable management solutions for sloping land with the participation of the community

There are 8 ethnic groups living in Thai Nguyen province, of which the most important are the Kinh, Tay, Nung, Dao and Mong. The ethnic structure shows the diversity of customs, practices, lifestyles and experiences in agricultural and forestry production.

The life of ethnic minorities in Thai Nguyen province has always been closely linked with natural resources in general and sloping land resources in particular. Therefore, the exploitation and use of this resource also has its own identity for each ethnic group. Mong and Dao people with narrow distribution ranges on the highest land, burning milpa is the main method. Tay and Nung people live in lower elevation areas and valleys, which is convenient for wet rice cultivation, cash crops and industrial crops. Kinh people gather mainly in towns, trade and cultivate wet rice, growing crops and industrial crops.

A good combination of indigenous knowledge of ethnic minorities and scientific knowledge in agriculture and forestry will bring about a high effect. In order for modern scientific knowledge to be mastered and applied to the local people in production, local authorities need measures to support the community such as:

- Strengthen education to improve educational attainment for mountainous people in districts in the province. When the education level of the people is improved, the transfer of new technology by staff will be easy.

- Open more training courses on agricultural and forestry extension at district level, smaller level is the village one in order to train key people in the community to become community guides. They will be the main force in the transfer of new technology in the community.
- Propaganda to people about economic models with high efficiency thanks to knowing how to promote local knowledge with the application of new and modern techniques in production. Organize for people in the area to visit, learn and exchange experiences.

Solution for the environment

- Popularize farmers to use organic and microbiological fertilizers instead of inorganic fertilizers, thoroughly collect all kinds of plant protection chemical packaging for treatment. Create bio-fertilizers, organic fertilizers (such as the model VAC, VACB ...) and appropriate farming methods to enhance the ability to enrich soil nutrients, especially in poor land areas. Strictly control the use of chemicals, pesticides and antibiotics in production and processing to limit soil degradation and pollution.
- Strengthen the implementation of planned afforestation programs and take effective measures to prevent forest fires and protect forests effectively in order to prevent erosion, soil leaching, and to protect soil.
- Educate and propagate about environmental protection in general and the use and protection of sloping land resources in particular for ethnic minorities in the province.

IV. Conclusion

Due to the combined effects of nature, Thai Nguyen province has formed many types of soil which are specific to hilly and mountainous areas, with high usability in agricultural and forestry production as: Red and yellow soil on clay and metamorphic rocks (Fs), red yellow soil on acid magma rock (Fa), light yellow soil developed on sandstone (Fq), reddish brown soil on basic and neutral magma (Fk), yellow brown soil on ancient alluvium (Fp), red brown soil on limestone (Fv), red yellow humus soil on acid magma (Ha),... Nowadays, sloping land in Thai Nguyen province has been planned to use quite appropriately. However, besides the achieved results, there are still some limitations such as: soil is eroded, washed away in the sloping area, land degradation, land pollution due to irrational agriculture and forestry, mineral exploitation activities, the level of agricultural and forestry production of ethnic minorities is not high, so that the production efficiency is not commensurate with its potential.

The solution of sustainable use of sloping land resources in Thai Nguyen province for the development of agriculture and forestry needs to ensure a harmonious development of all three aspects: economy, society and environment. Solutions need to be implemented synchronously including: rational use and plan of sloping land, perfecting the policy system on slope land use, applying scientific and technical advances in cultivation to prevent erosion, protection of slopes, good settlement of investment capital for people, sustainable management of slopes with community participation and strengthening of environmental protection measures.

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