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SUSTAINABLE SLOPING LAND USED MODELS IN MAI SON DISTRICT, SON LA PROVINCE, VIETNAM

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ABSTRACT

The population growth accelerated in the mountainous areas of Vietnam as well as expanded the development of Mai Son district, Son La province, which driven by migration from the low lands by farmers seeking improved livelihoods. In order to meet the people's basic needs, the growing population led to the intensified cultivation of natural resources including forests and forest land whose more than 10° steep slopes tolerating strong soil erosion, moisture shortage during the most important growing period, low crops as well as has increased pressure on the environment. This research focused on the improvement the utterly necessary to assist local people in cultivation to minimize erosion and soil degradation and simultaneously improve efficiency of sloping land. The research shown intercropping of forest trees, coffee, Guinea grass and black beans was the most effective treatment. The results also shown the effective treatment can reduced up to 55% of soil loss compared to the control and approximately 32% compared to other intercropping formulas.

Keywords: sloping land used, agroforestry, intercropping model, soil erosion, Vietnam.

INTRODUCTION

The term of agroforestry can be defined as: "Agroforestry is a sustainable management system for land that increases overall production, combines agriculture crops, tree crops, and forest plants and/or animals simultaneously or sequentially, and applies management practices that are compatible with the cultural patterns of the local population"[1].The basic components of agroforestry (trees, crops and animals) have been used to describe structural categories within agroforestry since its commencement as a science: agrosilviculture, silvopastoralism and agrosilvopastoralism representing the mixing of crops and trees, trees and animals, and crops, trees and animals, respectively [2, 3].

In recently, forestry and agriculture remains play key roles in the sustainable development and food security in the world. Forests play key roles in the water cycle, soil conservation, carbon sequestration, including for climate change. The sustainable management on the sector of forestry is crucial for sustainable agriculture and food security. Agriculture remains the most significant driver of global deforestation, and there is an urgent need to promote more positive interactions between agriculture and forestry. Accordingly, FAO (2016), progress towards sustainable agriculture, food security and sustainable forest management, core elements of the sustainable development goals, should be made simultaneously [4].

Agroforestry is consideration a sustainable management system in the sloping land. Sharma *et al.* (2017) reported by application one row of cowpea in two rows of maize in, the maize crop can be increased up to 13%, and reduced run-off and soil loss by 26% and 43%, respectively than only maize crop in India [5].

The mountains of Vietnam are key important sources of water and food, but they are facing to the soil degradation due to the vulnerable to soil erosion because of their steep slopes. The sustainable development base on the agroforestry is considered as one of the best approaches to deal with shifting cultivation and climate change in the sloping land. From the second half of the last centuries, the term of 'agroforestry' has been known in Vietnam. Accordingly, Nguyen Thi Hoa (2012), the practice of agroforestry in sloping land in Vietnam can be classified in two mainly agroforestry systems: VAC (garden/fish pond/livestock) and the R-VAC (forest/garden/fish pond/livestock) systems [6].

Agroforestry in sloping land can improvefarm productivity through nutrient recycling and soil protection, using spatial ortemporal intercropping of trees and other species, and diversifying farm products.In recent years, population growth accelerated in the mountainous areas of Viet Nam and Mai Son district, Son La province is not an exception, driven by migration from the lowlands by farmers seeking improved livelihoods. In order to meet people's basic needs, the growing population led to the intensified cultivation of natural resources including forests and forest land whose more than 10° sleep slopes tolerating strong soil erosion, moisture shortage during the most important growing period, low crops as well as organism yields. With population of approximate 5,164 persons, Muong Bon communities' lives mainly rely on agricultural production which has increased pressure on the environment, while the land available for cultivation does not. Furthermore, the majority of population is Thai people, hence, their awareness along with cultivation practices are limited. Poor traditional practices cause low efficacy; in some cases, they even cause soil degradation which implies replacement of climax vegetation by secondary one, alteration of humus quantity and composition, and adverse changes in soil quality as well as related ecosystem services. Besides, Muong Bon commune is famous for its coffee with high productivity in the beginning; however, the limited ability of cultivation, fluctuated market price resulted in the lack of passion with

coffee cultivation. Therefore, it is utterly necessary to assist local people in cultivation to minimize erosion and soil degradation and simultaneously improve efficiency of sloping land.

This research conducted to contribute in theoretic and practical basis to develop the agroforestry systems to minimize some natural condition constrains on the cultivation in sloping land in Mai Son district, Son La province. The research' results can be used as scientific basis for the local community to use agroforestry models to enhance socio - economic as well as environmental perspectives follows the trend of sustainable development in the mountainous areas of Viet Nam.

MATERIAL AND METHODS

An experiment area was established in Muong Bon commune, Mai Son district, Son la province. Mai Son is a rural district of Son La province in the Northwest region of Vietnam, between the latitudes 20°52'30"N and 21°20'50"N, and the longitudes 103°41'30"E and 104°16'E.Mai Son district topography is fragmented, complicated where high mountains are interwoven hills, valleys, basins and plateaus. The average altitude compared to sea level is about 800 meters - 850 meters and there are two major mountain systems where Eastern mountain range runs along Northwest - Southeast and the other runs along Northwest - Southwest, creating many subregions with different advantages to develop diversified economic. Mai Son district is characterized by tropical monsoon climate of the northwestern mountainous areas which is divided into two distinct seasons, including the winter from November to the next March and the summer from April to August.

The soil types in the project area is yellow brown soil (xanthic ferrasols), wich has medium fertility. The basic characteristics of this soil on physico-chemical of nitrogen, phosphorus, potassium, calcium, magnesium having medium contents which is suitable for planting plants such as rice, maize, cassava, beans, peanuts, rubber, coffee, tea, oranges, medicinal plants. However, almost of the area is located on steep slopes with low vegetation cover, backward farming practices, so the phenomenon of washing away and erosion occurs strongly and widespreadly which reduces the soil productivity. The sloping land in the project area is about 31^0.

There are 5 formulas that are established, namely:

- The 1st formula (the control): intercropping of forest trees and only coffee which follows the local people's farming method under experts' guidance;
- The 2nd formula: intercropping of forest trees, coffee and black beans;
- The 3rd formula intercropping of forest trees, coffee and soy beans;
- The 4th formula: intercropping of forest trees, coffee, Guinea grass and black beans;
- The 5th formula: intercropping of forest trees, coffee, Guinea grass and soy beans.

Digging a standard runoff collector 5m long, 0.8m wide and 1m deep with nylon cover inside. It is to monitor erosion by collecting the wet soil loss once a month. The runoff collector aims to evaluate the efficiency of erosion mitigation of each formula (Figure-1).

Figure-1. Runoff collector.

In summer 2017, the observation indicators include:

- Erosion mitigation in agroforestry models: amount of soil loss;
- Coffee productivity: weigh total harvest coffee in a $50m^2$ plot;
- Legume productivity: weigh total harvested legumes in a $50m^2$ plot;
- Economic efficiency: economic efficiency of legume is calculated as Profit = Gross revenue - Total variable cost.

RESULT AND DISCUSSIONS

Sustainable development: Efficiency of erosion mitigation in agroforestry models

Accelerated soil erosion has been a perennial problem in Vietnam for a long time, especially its environmentally destructive consequences in mountainous

areas. Soil erosion is of special concern in agricultural lands; therefore, reducing soil erosion is widely recognized as a key to sustainable agriculture in Northern Vietnam where local cultivation accelerates without soil-protected measures. The usefulness of legumes in intercropping and other soil-conserving agronomic practices is now recognized, and the part legumes thus play in controlling erosion. The amount of soil loss after 3 observed months in summer 2017 is shown in Table-1.

Table-1. The amount of soil loss.

Formula	**Average wet soil weight in 50m^2** (Kg)	**Soil loss after 3 months** (tons/ha)			
		May	**June**	**July**	**Total**
1st formula *(control)*	64.07	6.08	10.52	9.56	26.16
2nd formula	49.10	5.68	6.68	8.38	20.74
3rd formula	47.40	5.27	6.63	7.76	19.66
4th formula	30.07	3.17	4.1	4.71	11.98
5th formula	31.67	3.29	4.03	4.85	12.17

In the control formula, which follows the traditional farming method, the average amount of wet soil in 50m^2 during 3 months is weighed as 64.07 kg. Therefore, the total soil loss after 3 months is calculated as 26.16 tons per ha which is assessed as very strong erosion, about 78.48 tons/ha/year.

In contrast to intercropping with forest trees, coffee and legumes, the amount of soil loss considerably reduces in each established formula during the 3-month period. To black beans, collected wet soil per 50m^2 is just 49.10 kg which is approximately 15 kg less than that of the control. The amount of soil loss in this formula decreases to 20.74 tons per ha compared to the control. A similar pattern is repeated with intercropping of soy bean where 47.10 kg wet soil is collected in a 50m^2 plot. The amount of soil loss is calculated as 19.66 tons per ha which is 6.5 tons and roughly 1 ton per ha less than that the control and the intercropping with black beans, respectively. In two cases, the level of eroded soil is both strong erosions although they are slightly lower than the control level.

When intercropping with forest trees, coffee, legumes and Guinea grass, the results of erosion mitigation are remarkable. Compared to the control, the amount of wet soil in 50m^2 during 3 observed months reduces by more than a half in both formulas with only 30.07 kg and 31.67 kg in intercropping of black beans and soy beans, respectively. To be more specific, the average amount of soil loss after 3 months significantly falls to about 12.08 tons per ha which reduces up to 46.2% compared to the traditional farming method. Only 11.98 tons of soil per ha is eroded in the intercropping formula of forest trees, coffee, Guinea grass and black beans, at the same time, the amount of soil loss during 3 months is 12.17 tons of per ha in the similar formula of soy beans. The obviously positive point is that these intercropping formulas have a remarkable reduction in erosion mitigation when the level of eroded soil is just medium.

Overall, the efficiency of erosion mitigation among four established intercropping formulas is higher than the control - traditional farming method and the intercropping of forest trees, coffee, Guinea grass and black beans seems to be the most effective one to reduce soil erosion.

Biomass: Plant yield in agroforestry models

Coffee

Table-2 shows coffee productivity per ha by harvesting coffee in 50m^2 in July and August 2017 in five established formulas.

Table-2. Coffee productivity.

Formula	**Harvested coffee in 50m^2** (kg)			**Productivity** (kg/ha)
	July	**August**	**Total**	
1st formula *(control)*	3.0	3.9	6.9	1,380
2nd formula	3.2	4.3	7.5	1,500
3rd formula	3.1	4.3	7.4	1,480
4th formula	3.1	4.2	7.3	1,460
5th formula	3.2	3.9	7.1	1,420

In the control formula, which follows the traditional farming method, harvested coffee in 50m^2 is 6.9 kg in total and the coffee productivity is 1,380 kg per ha. However, coffee productivity experienced obvious improvements in intercropping formulas. The intercropping of forest trees, coffee and black beans have the largest productivity with 1,500 kg per ha, closely followed by the similar formula with soy beans with 1,480 kg per ha, meanwhile, the figure increases to 1,460 and 1,420 kg per ha when intercropping with Guinea grass in the last two formulas.

The differences among five formulas are not too large, however, intercropping, to some extents, contributes to improving the coffee productivity. The increase in coffee productivity among intercropping formulas compared to the control varies from 40 kg/ha to 120 kg/ha which is an about 5.8% increase in average.

Therefore, coffee not only can remain at a relatively high productivity but also increases its yield in four established intercropping formulas compared to the traditional farming method in Muong Bon commune.

Legumes

The legumes are harvested in 50m^2 in all intercropping formulas and the legume productivity is shown in Table-3.

Table-3. Legume productivity.

Formulas	**Harvested legume** (kg)	**Productivity** (kg/ha)
1st formula (*control*)	0	0
2nd formula	1.3	260
3rd formula	1.8	360
4th formula	1.2	240
5th formula	1.7	340

The harvested legumes are similar in each kind of intercropping formulas with the average harvested legume is approximate 1.5 kg in 50m^{2}and the mean productivity is 300 kg/ha. The average legume productivity of intercropping with black beans (in 2nd and 4th formulas) and soy beans (in 3rd and 5th formulas) is 250 kg/ha and 350 kg/ha, respectively. The soy bean productivity is relatively higher than black bean yield. When legumes are intercropped with forest trees and coffee, soy beans have a 360 kg/ha productivity which is 100 kg/ha higher than its black bean counterparts. When adding Guinea grass to both intercropping formulas, soy bean yield is 340 kg/ha while black bean yield is 240 kg/ha which is about 32% less than its counterpart. Overall, the well-developed soy beans, as well as black beans have ensured the target for short-term rising. Moreover, the obtained products can be used for domestic consumption and livestock. Intercropping of forest trees, coffee and soy beans appears to be the most efficient formula which has the largest legume (soy bean) productivity.

Economic efficiency in agroforestry models

The added economic value in agroforestry models are shown in Table-4. The average profit of intercropping formulas is relatively high in Muong Bon commune which is about 5.200.000 VND per ha. The intercropping of forest trees, coffee and black beans have the highest profit of 6.500.000 VND per ha and it is slightly smaller at 5.800.000 VND per ha when adding Guinea grass into the formula. Intercropping with soy bean has the average profit of 4.200.000 VND per ha which is slightly smaller than intercropping with black beans.

Table-4. The added economic value in agroforestry models.

Formulas	**Profit/ha** (VND)
1st formula *(control)*	0
2nd formula	6.500.000
3rd formula	4.320.000
4th formula	5.800.000
5th formula	4.080.000

Note: 1USD=22,795 VND

CONCLUSIONS

a) All established agroforestry formulas in Mai Son district, Son La province have remarkably positive impacts on mitigating soil degradation, along with enhancing plant production and economic efficiency compared to the traditional method.

b) The intercropping of forest trees, coffee, Guinea grass and black beans is the most effective treatment to deal with soil erosion when it can reduce up to 55% of soil loss compared to the control and approximately 32% compared to other intercropping formulas.

c) The intercropping of forest trees, coffee and soybeans have the highest legume yield with 360 kg/ha among established agroforestry formulas.

d) The intercropping of forest trees, coffee and black beans is considered the best formula when it has not only the highest coffee productivity of 1,500 kg per ha but also the highest added profit which is 6,500,000 VND higher than the traditional method.

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