LAND USE CHANGE AND ITS INTERACTIONS ON SOIL, WATER RESOURCES, AND RURAL LIVELIHOODS IN HOA BINH PROVINCE

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ABSTRACT

The objectives of the study are to assess the land use change and interaction among soil-water resources and rural livelihoods of Hoa Binh province in Northwestern Vietnam. The land use change was investigated for three time periods using the remote sensing data acquired in the years 1995, 2005, and 2010. The results show that the major land use types with the most significant changes occurring in the five land use classes were: barren land (BRNL), disturbed forest (DTFR), field crop (FCRP), paddy (PDDY), undisturbed forest (UDFR), and urban (URBN). From 1995 to 2005, the proportional extent of FCRP, PDDY, and URBN, was from 5.36% to 11.89%, 10.91 to 15.66, and 5.98 to 8.48%, respectively. On the other hand, the proportion of DTFR and UDFR dramatically decreased from 22.92% to 14.32%, and 30.61% to 24.43%, respectively. Main factors influencing land use decision and crop systems are government policies and commodity prices. Considering soil erosion and water related impacts, expansion of agricultural activities as well as deforestation were causes of increased surface flow and soil erosion, and nutrient losses. The overall livelihood index was 0.514 indicating that the livelihood of the households in the study area is at or above average and there were no significant differences between groups; however, calculated livelihood index indicated that farmers in Cao Phong district have higher overall livelihood indices compared to other households in the area.

Keywords: Hydrology, Hoa Binh province, Land Use Change, Livelihood, Soil Erosion.

Thay đổi sử dụng đất và sự tác động của nó đến tài nguyên đất, nước và sinh kế người dân nông thôn tại tỉnh Hòa Bình

TÓM TẮT

Mục tiêu của nghiên cứu là đánh giá sự thay đổi sử dụng đất, tác động của nó đối với tài nguyên đất, nước và sinh kế người dân tại tỉnh Hoà Bình, Tây Bắc Việt Nam. Thay đổi sử dụng đất được điều tra trong ba giai đoạn sử dụng dữ liệu viễn thám thu thập được trong năm 1995, 2005, và 2010. Kết quả của nghiên cứu cho thấy các kiểu sử dụng đất chính có sự thay đổi lớn nhất xuất hiện trong năm lớp sử dụng đất: đất trống (BRNL), rừng trồng (DTFR), đất trồng cây hang năm (FCRP), đất lúa (PDDY), rừng nguyên sinh (UDFR), đất đô thị (URBN). Từ năm 1995 đến năm 2005, tỷ lệ tỷ lệ thay đổi của FCRP, PDDY và URBN lần lượt tăng từ 5,36% đến 11,89%, 10,91 đến 15,66 và 5,98 đến 8,48%. Ngược lại, tỷ lệ DTFR và UDFR giảm đáng kể từ 22,92% xuống 14,32% và 30,61% xuống 24,43%. Các yếu tố chính ảnh hưởng đến quyết định sử dụng đất và hệ thống cây trồng là chính sách của chính phủ và giá cả hàng hóa. Xét về khía cạnh xói mòn đất và các tác động liên quan đến tài nguyên nước, việc mở rộng hoạt động nông nghiệp cũng như tình trạng phá rừng là nguyên nhân gia tăng dòng chảy bề mặt góp phần tăng lượng xói mòn đất, mất chất dinh dưỡng đất. Chỉ số sinh kế bình quân là 0,514 cho thấy sinh kế của các hộ gia đình trong khu vực nghiên cứu ở mức trung bình khá và không có sự khác biệt đáng kể giữa các nhóm; tuy nhiên, chỉ số sinh kế cho thấy những hộ nông dân ở huyện Cao Phong có chỉ số sinh kế cao hơn so với các hộ khác trong khu vực.

Từ khóa: Sinh kế, thay đổi sử dụng đất, tỉnh Hòa Bình, thủy văn, xói mòn.

1. INTRODUCTION

Land-use change is a common phenomenon in relation to human population growth, technical innovation, market development, and policy action (Müller, 2003). There have been various consequences of land use change such as changes in vegetation cover, alteration of physical soil characteristics or hydrology (Müller & Zeller, 2002; Liu *et al.*, 2008; Hernandez *et al.*,, 2010; Franczyk & Chang, 2009; Ghaffari, *et al.*, 2010; Mohammad & Adam, 2010). In addition, land use change leads to climate change, biodiversity loss, and negatively affects the sustainability of the human-environment interaction (Shrestha, 2016). Over the past three decades, the changes in land use in HoaBinh province, such as the removal of forests and the inappropriate conversion of land in order to expand agricultural areas, as well as land use mismanagement, has caused negative effects directly on the soil, water, and food production (MONRE, 2009). Those negative effects can have consequences for soil productivity as well as for food production. According to the land use planning report (2010), the major land use types in HoaBinh province are forests (47.9% of the total natural area) and field crops (10.7%). Paddy rice accounts for 14.2% of the land area while urban areas comprise less than 8.7% of the area. The remaining land use types are barren land (10.4%), rocks (4.1%), and water surface (4%). The area has experienced considerable land use change, particularly from forest to field crop, because the prices corn and sugarcane have increased over the past few decades (Thanh, 2009). Changes in land use are associated with changes in land use practices, which can have significant effects on land, water quality, and rural livelihoods. Therefore, the objective of this study was to understand the effects of land use change on the quality of land and water resources, and rural livelihoods in order to mitigate land and water degradation. The study of land use change can be also useful for food production prediction, which has to be addressed in order to provide guidance for sustainable land and water resources management, and to achieve food security in order to help prevent hunger. In short, the outcomes of the study support designing a proper land use policy towards a better future land use in terms of sustainability of land use planning and management.

2. MATERIAL AND METHODS

2.1. Site selection

HoaBinh province, located in Northwestern Vietnam, was selected as the study area. The province, with a total natural area of 4,698 km^2 (Figure 1), is characterized by land use change, substantial soil degradation, and nutrient losses due to inappropriate conservation practices (MONRE, 2010). The elevation ranges from 200 to 1,373m above sea level. The climate is subtropical monsoon with a mean annual rainfall of 1,900 mm, with 80% of the rainfall falling in May through October. The maximum temperature is about 42°C in the summer and the minimum is 3°C in the winter. The total population is approximately 794,000 people. Over the past few decades, there have been many identifications that the province has been overexploited of the rich resources and environment for economic development (Thanh, 2009). Land use change is one important issue. The area has experienced considerable land use change, particularly from forest to field crop due to the prices of corn and sugarcane increasing over the past few decades. Change in land use is associated with change in land use practices, which can have significant effects on land, water quality, and rural livelihoods.

2.2. Analysis of Land Use Change

In order to obtain information of land use change, landsat images from 1995, 2005, and 2010 were used for this study. Landsat images were downloaded from http://glovis.usgs.gov/. Remote sensing data were interpreted to produce land use maps of the three time periods, i.e. 1995, 2005, and 2010. The interpretation was done using a supervised maximum likelihood classification procedure in the ERDAS IMAGINE software. The maximum likelihood classification algorithm requires identifying a training area for every class that represent the spectral behavior within every class. The land use/cover classes used in this study were based on eight classes. (Xiao *et al.*, 2008; Yili, *et al.*, 2009). The characteristics of land use type considered for image classification are shown in Table 1. The final land use classifications of all dates were examined against all available reference data, field information, and the author's experience in the study area by constructing the confusion matrices. The confusion matrix compares on a category-by-category basis, the relationship between known reference data and the results after classification.

2.3. Household sampling

Using the land use change map, information from provincial government officers, and guidance from district officers, three districts belonging to Hoa Binh province, each having distinctive evidence of land use change, were selected for socio-economic data collection. Firstly, basic information about the main livelihood activities focusing on land use change and water resources, and policy implementation were collected to get general data on land use change and its effects on human life through key informant interviews with the head of each district, commune, and village. A household survey was conducted in 60 randomly selected households in each district. In total, 180 households were interviewed, which consisted of 120 households of the Muong ethnic minority group. In each district, the 60 households were divided into three groups based on the differences in the effects of land use change on livelihood, crop production, soil fertility, and water quantity, including having a high effect (20 households), normal effect (20), and low effect (20). Five households were randomly interviewed for pre-testing the questionnaire, and then the questionnaire was modified and completed accordingly based on the pre-test results.

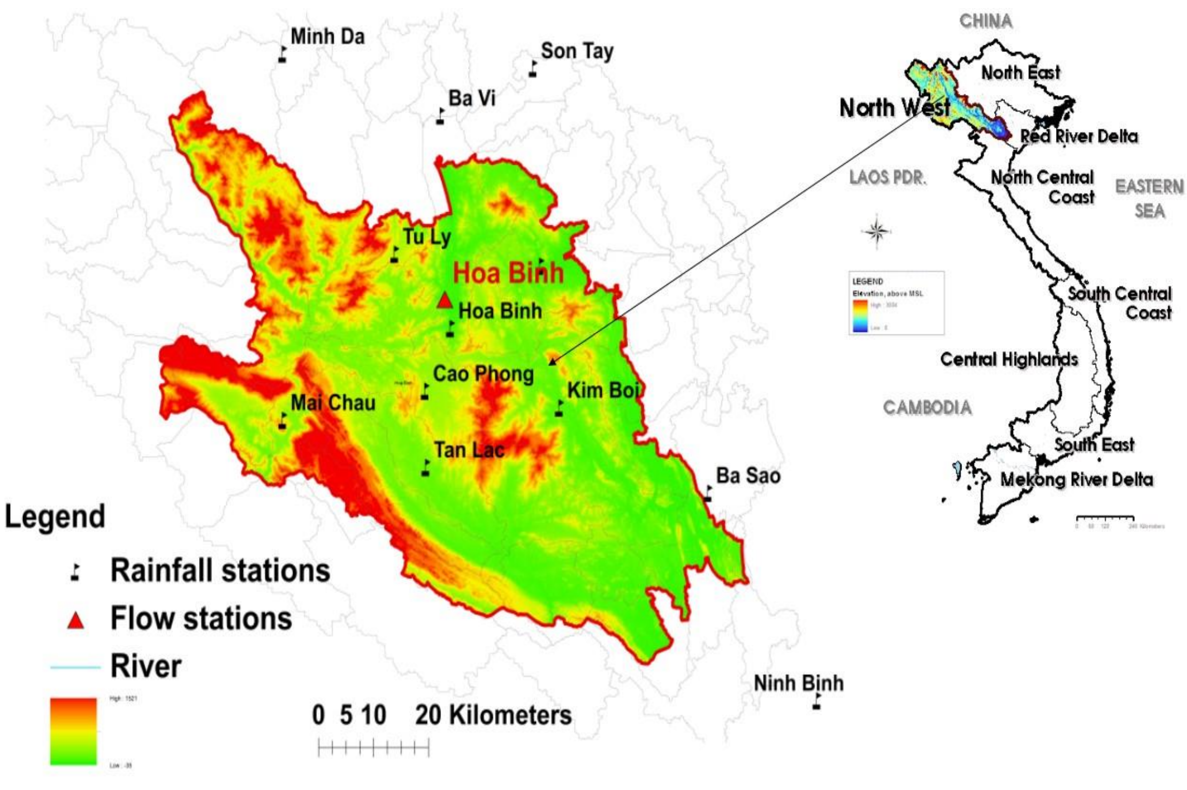

Figure 1. Study area

Table 1. Land use types in the study area

Abbreviation	Land use	Description
BRNL	Barren land	Land is dry and bare and has very few trees
DTFR	Disturbed forest	Forest has been disturbed by human activities such as cutting, burning, and regrowth
FCRP	Field crop	Only a small area has irrigation facilities. Major crops are corn, cassava, and sugarcane
PDDY	Paddy	Land is used as rice field support with/without irrigation facilities
ROCK	Rock	Land is almost dominated by rock and very few plants
UDFR	Undisturbed forest	Natural forest
URBN	Urban	Land cover by built up areas such as, housing, buildings, and roads with surrounding home gardens
WATR	Water	Body of water

2.4. Socio-economic analysis

2.4.1. Livelihood analysis

The livelihood status of three districts belonging to the Da River basin with high effects of land use change, namely Da Bac, Cao Phong and Ky Son, were analyzed at the household level by using the Sustainable Livelihoods Framework of the UK Department for International Development (DFID) (Carney, 1998). Five livelihood assets were analyzed using ten indicators. The human asset was obtained from household size and education. The natural asset includes two indicators, namely soil loss and land availability. The assessment of financial asset was based on income and the amount of credit and loans. The social asset was based on membership in society and neighborhood, whereas the physical asset was evaluated by using the access to main roads and facilities. The representation of indicators in those five livelihood assets varied between characteristics and measured units. Therefore, livelihood indices needed to be standardized before calculating them. The linear scaling technique was used to standardize indicators as shown in the equation below.

$$X_i = \frac{(R_i - R_{\min})}{(R_{\max} - R_{\min})} \quad (1)$$

where:

X_i: Computed or normalized value

R_i: Raw value to be normalized

R_{min}: Actual minimum value of the variable

R_{max}: Actual maximum value of the variable

The results indicated that within an indicator category, the maximum observed value was 1 and the minimum observed value was zero. In each particular variable, the maximum values were considered as the highest value whereas the minimum values were the lowest value. Those values were used to standardize almost all the indicators except for the amount of credit and loan wherein no or less credit indicates better livelihood.

Similarly, the scores of 'increase' was set as 1; 'decrease' as 0; and 'no change' as 0.5 were received from the perception of household responses. The scores were an index to determine the rural livelihood status of the different households in the study area. One-way analysis of variance (ANOVA) was used to validate and compare different perceptions in selected livelihood indicators of the three household groups. The rural livelihood status of the rural people was assessed based on what they have and hold (Allison & Ellis, 2001). This is more relevant than assessing their livelihood based on what they lack (Moser, 1998).

2.4.2. Interaction of land use, soil erosion, and water resources

The interaction of land use, soil erosion, and water resources was analyzed by calculating an Index of Perceived Change (IPC) as presented in the equation below. The positive

IPC shows an increasing perception whereas the negative indicates a decreasing perception.

$$IPC = \frac{I\,(1.0) + D(-1.0) + N(0.0)}{I + D + N} \quad (2)$$

where:

I: Increase

D: Decrease

N: No change

2.4.3. Data analysis

The data collected from the household survey was analyzed using the Statistical Package for the Social Sciences (SPSS) and Microsoft Excel to determine the differences in the socio-economic status of households in different categories. The results were displayed using tables, charts, and graphs through percentage, mean, maximum, minimum, and frequency parameters. ANOVA (analysis of variances) was used to verify the differences among the three districts

3. RESULTS

3.1. Land Use Change

In recent decades in HoaBinh, rapid land use change has occurred and the area is known for its traditional farming system called "composite swidden farming". Table 2 shows the major land use types with the most significant changes occurring in the five land use classes: barren land (BRNL), disturbed forest (DTFR), field crop (FCRP), paddy (PDDY), undisturbed forest (UDFR), and urban (URBN). From 1995 to 2005, the proportional extent of FCRP, PDDY, and URBN, was from 5.36% to 11.89%, 10.91 to 15.66, and 5.98 to 8.48%, respectively. On the other hand, the proportion of DTFR and UDFR dramatically decreased from 22.92% to 14.32% and 30.61% to 24.43%, respectively. The reason for these changes was the expansion of cash crops grown in monoculture being replaced by the swidden and multi crop systems as reported by many researchers (Lam *et al.* 2004; Thanh 2009). According to the land use planning report (2010) and interview data, many parts of the forest were converted to agricultural land, timber was exploited, and there was a lack of regulations to protect and sustainably use the forest resources which led to a reduction of natural forest cover. The expansion of field crops and paddies were due to population pressure, food demand, and the transition from a subsistence and planned economy towards a market oriented economy. After 2005, the proportion of the extent of land use was changed due to the decrease in BRNL, FCRP, and PDDY, and the increase in DTFR and UDFR land uses. The reasons for such change can be attributed to peoples' awareness about soil fertility decline, and soil erosion and degradation. Aside from this, a decreased productivity could be the cause of increasing FCRP and decreasing DTFR and URBN. In addition, government policies to protect forests were implemented, such as handing over forest protection to local people and applying mulching or crop residue for upland fields.

Table 2. Land Use Change in the period of 1995, 2005, and 2010.

Period of time	BRNL (%)	DTFR (%)	FCRP (%)	PDDY (%)	ROCK (%)	UDFR (%)	URBN (%)	WATR (%)
1995	16.97	30.61	5.36	10.91	3.53	22.92	5.98	3.73
2005	17.18	24.43	11.89	15.66	4.04	14.32	8.48	4.01
2010	10.35	31.90	10.74	14.24	4.05	16.04	8.71	3.98
2005/1995	0.21	-6.18	6.53	4.75	0.52	-8.60	2.50	0.27
2010/2005	-6.83	7.47	-1.14	-1.42	0.00	1.72	0.23	-0.03

Table 3. Household size

Family members	Da Bac (60)	Cao Phong (60)	Ky Son (60)	Total (180)
<2	10.0	15.0	18.0	14.0
3-5	65.0	75.0	70.0	70.0
>5	25.0	10.0	12.0	16.0
Total	100.0	100.0	100.0	100.0

Source: Field survey, 2011
Note: <2: small family; 3-5: medium family; >5 large family

Table 4. Ages of household respondents

Age (yr)	Da Bac (60)	Cao Phong (60)	Ky Son (60)	Total (180)
<15	34.0	31.0	40.0	35.0
15-60	50.0	57.0	46.0	51.0
>60	16.0	12.0	14.0	14.0
Total	100.0	100.0	100.0	100.0

Source: Field survey, 2011
Note: <15: young group; 15-60: working group; >60 retired group

3.2. General information of household characteristics and socio-economic activities

Most of surveyed households (70.0%) belong to medium size families of 3-5 household members (Table 3). Da Bac had the highest percentage of large households (25.0%) and Cao Phong had the smallest number (12.0%). Household sizes play a principal role in influencing household income, expenditures, and labor availability.

Regarding the ages of household respondents, more than 50% of surveyed households belong to the working group aged 15-60 years old, 35% to young group (<15 years old), and only 14% to retired group (>60 years old) (Table 4). It can be seen that the potential labor sources will be contributing to the future development of agriculture in these regions.

Table 5 describes the education level of the local people who are in the ages of 18-60. The majority of household heads have a low education level with 19.0% of respondents found to be illiterate. About 32% of respondents completed primary school, and only 7% of respondents completed a college or university level of education. Most of the interviewed households' heads said that they had no ability to go to school for several reasons such as their having to work in the fields, not having enough financial support, and also, the far distance from their homes to schools. On the other hand, the education level of the younger generation improved recently; however, they have fewer chances for getting a higher education because they do not have enough money for paying tuition fees, food, accommodation, and other expenses, and their parents need them to work in the fields.

In terms of income, the major income source of households (77.0% of interviewed households) was from agro-forestry-fishery (Table 6). Among these sources, agricultural production (rice, corn, cassava, orange, and sugarcane) contributed more than 65.0% to total income; the rest (35.0%) was from forest products (25.0%) and fishery (10.0%). According to the poverty line, about 30% to 40% of total households in these areas were facing food shortages from 2 to 4 months per year and classified as having a poor income level (less than 10 USD per capita per month). It may be a possible reason why many households are looking for additional income sources such as working for industry (15.0%) and services (8.0%). Total money household groups earned from industry and services ranged from 15 to 50 USD per capita per month. It is considered as a medium income based on poverty classification criteria.

3.3. Factors influencing land use decision and cropping system

Several factors contribute to land use change. The findings show that changes in land use have the greatest impact on commodity price as reported by 63 out of 180 surveyed households. The agrarian reforms, macro-economic environment improvements, infrastructure and communication facilities improvements, as well as the free community market were the principal influencing factors to the changes. More than 34% of households claimed that the increasing price of corn, sugarcane, and orange contributed to the conversion of forest to intensive cropping systems for food production, and also a decrease in composite swidden system and a shortened fallow period lead to increased farming systems at individual households.

Government policies, according to 30.15% households, had the second greatest impact on the farmer's agricultural practices and the land use decisions (Figure 1). Agrarian reforms started in 1980s with the purpose of transition from co-operative land use type to individual households' that have resulted in a huge amount of forest cover losses in the last 15 years in Hoa Binh province. The policies encouraged privatization of agriculture and forestlands resulting in increased land use conversion. Deforestation and forest degradation have increased over time after agrarian reforms that created threats to sustainable agricultural production. Crop systems have changed from subsistence to commercial oriented production, hence, paddy and upland rice cultivation, major crops in the area, were replaced with corn, sugarcane, and orange for the aim to increase household income.

Other reasons influencing the decision of land use included land quality, as responded by 11.18% households, influences of neighboring areas (9.13%), labor shortage (5.28%), transitional practices (6.41%), and the other factors including distance to the field and roads, basic farmer needs, and guidance from officers (3.00%).

Regarding crop production, most areas in Hoa Binh are dominated by agro-forestry activities. Among the agricultural crops, the major land use types are rice cultivation, corn, cassava, and sugarcane. In the study areas, the observed average yield of crops varied: 4.8 ton ha^{-1} in case of rice; 3.3 ton ha^{-1} (corn); 8.2 ton ha^{-1} (cassava); and 63.4 ton ha^{-1} (sugarcane).

Table 5. Education level

Education level	Da Bac	Cao Phong	Ky Son	Total
	(60)	(60)	(60)	(180)
Illiterate	25.0	17.0	14.0	19.0
Primary school	36.0	32.0	29.0	32.0
Secondary school	23.0	25.0	30.0	26.0
High school	12.0	19.0	18.0	16.0
College/university	4.0	7.0	9.0	7.0
Total	100.0	100.0	100.0	100.0

Source: Field survey, 2011

Table 6. Household income

Income sources	Da Bac	Cao Phong	Ky Son	Total
	(60)	(60)	(60)	(180)
Agro-Forestry-Fishery	85.0	75.0	71.0	77.0
Industry	12.0	15.0	18.0	15.0
Services	3.0	10.0	11.0	8.0
Total	100.0	100.0	100.0	100.0

Source: Field survey, 2011

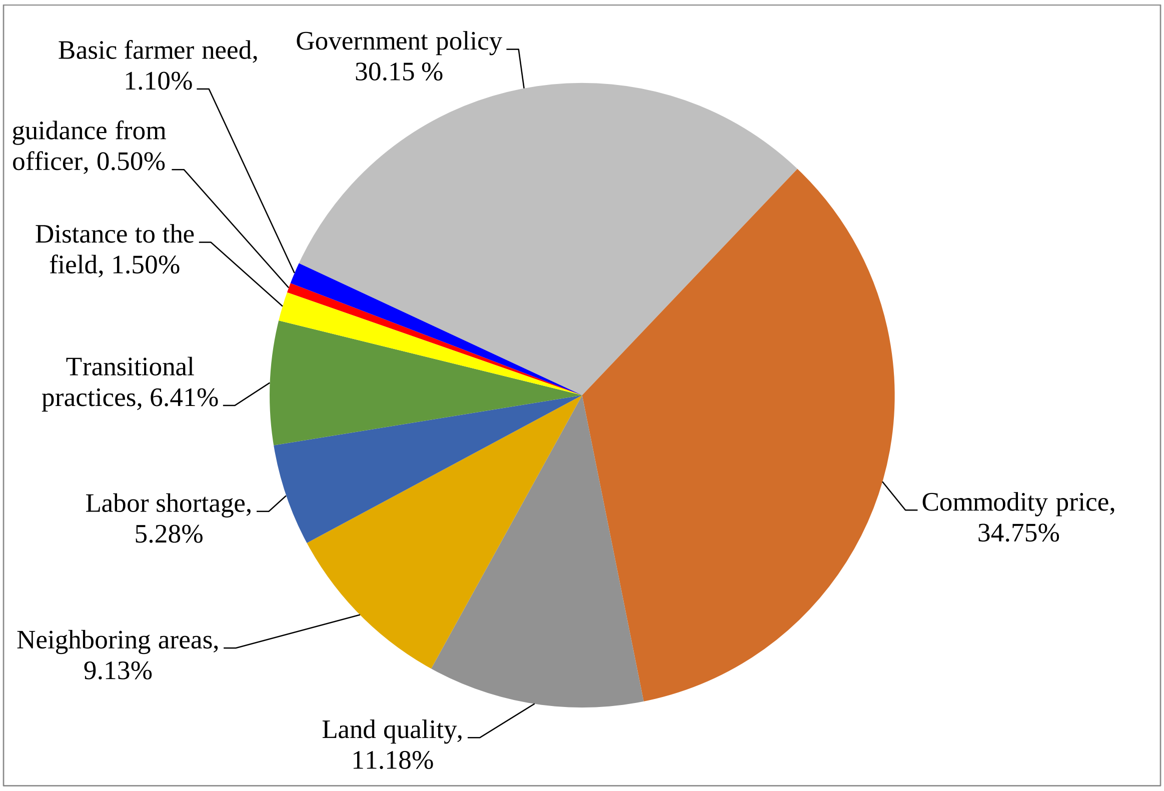

Figure 2. Factors affecting land use decision

3.4. Interactions on land use, soil erosion and water resources

Soil and water resources are greatly influenced by agricultural activities. According to heads of Cao Phong, Ky Son, and Da Bac districts, the conversion of forest to agricultural land in both upland and lowland areas influenced soil infiltration and increased overland flow, all of which was contributing to soil erosion, nutrient loss, and crop productivity declines in the upland areas. On the other hand, the lowlands could have positive benefits because the movement of nutrients from the uplands to the lowlands is used for agricultural crops, particular paddy rice cultivation. However, during heavy rain events, deposition of sediment yield or nutrients in the lowlands may affect the paddy rice fields and also crop productivity. The effect on the hydrological processes and crop production mainly depend on the change in land cover/use type in an area. Land use decisions, in many cases, could have positive or negative impacts on the ecosystems, hence, hydrological processes determine supply of water not only for crop production but also other uses for livelihood.

During the household survey, data on soil characteristics (structure, texture, and fertility), soil loss, water quantity and quality, vegetation cover, and crop yield were obtained. This information is required to further explain and understand the perception of the local people on land, soil erosion, and water related impacts. The opinions of the respondents were collected in the three periods of time 5 years ago, 10 years ago, and 15 years ago.

The results indicated that the perception of households on water quantity and quality was divided by the three periods of time. Table 7 describes a water shortage; water quantity and quality decreased over the years after being positive 15 years ago, indicating a decrease in the quality of environmental characteristics over the last 5 - 10 years. As explained in the previous section, the decrease in water yield implies that surveyed households in the last 5 and 10 years tended to use the water from deep wells mainly for drinking purposes instead of using open sources (spring, rivers, lakes, and ponds). Open water sources are only used for non-drinking domestic purposes such as bathing and washing clothes, irrigation, animal husbandry, and fishery. The largest amount of consumed water was used to irrigate paddy fields, hence, unequal distribution of the irrigation water is one of the main challenges of local people in this area.

Similarly, soil fertility has decreased over the last 15 years as shown by the IPC values of 0.08 (1995), 0.06 (2005), and 0.03 (2010). The majority of respondents could distinguish the decreasing soil fertility by changes in color and texture. The fertile and degraded soils were recognized by the change in soil color. According to respondents, black topsoil indicates fertile soil because most of the land area was covered by forest and very few areas were covered by cultivation or upland fields at that time. When the soil color turns into brown and red-yellowish after 10 to 15 years due to intensification and expansion of cultivation on the slopping lands, that means the soil is degraded. As forests were disturbed and cultivation was expanded on the slopping land, the overland flow and soil losses were more visible; hence, farmers could easily recognize the color shift from back to brown and yellowish.

In terms of vegetation cover, it is easier for local people to distinguish changes in vegetation cover by observing the density of big trees. According to the land use planning report (2010), a decline in vegetation cover was observed over the last 15 years. However, respondents still have difficulty in distinguishing changes in vegetation cover as indicated by a large percentage of the ‘no change’ responses.

3.5. Soil and Water conservation

3.5.1. Environmental impacts and conservation practices implementation

Soil and water conservation plays a vital role to stable farming systems and long-term sustainability. The importance of conserving these natural resources was realized by 90.0% respondents (Table 8); however, only 41.3% implemented soil and water conservation in their farms (Table 9). Most of the soil conservation practices implemented in the lowlands and hilly areas, such as strip grass barriers, the contour hedgerow system, and crop residue, could be used to explain both the decrease in overland flow and soil loss. Among the study districts, Cao Phong had the highest percentage of households (45.0%) implementing soil and water conservation practices. The requirement of water for paddy rice and upland crop were different because rice was grown in the lowland area, hence, requires a large amount of water, whereas the upland crop is only grown based on rainfall. There were very few soil and water conservation practices implemented in the upland areas like Da Bac (36%).

The types of soil and water conservation practices implemented in the study area by the local farmers were both biological and mechanical techniques such as strip grass barriers, crop residue, contour hedgerows, mulching, and ridges and furrows.

Table 7. Perception of household on soil and water consequences under land use changes

Categories		Soil fertility	Soil degradation	Drought	Flood	Water quantity	Water quality	Vegetation cover
5 years ago	Increase	34	31	43	52	15	21	25
	Decrease	29	35	37	49	20	25	38
	Not change	117	114	100	79	145	134	117
	IPC	**0.03**	**-0.02**	**0.04**	**0.02**	**-0.03**	**-0.02**	**-0.07**
10 years ago	Increase	28	40	56	45	21	24	28
	Decrease	17	24	32	27	41	31	54
	Not change	135	116	92	108	138	125	98
	IPC	**0.06**	**0.09**	**0.13**	**0.01**	**-0.11**	**-0.04**	**-0.14**
15 years ago	Increase	26	10	15	10	26	9	30
	Decrease	11	8	14	10	23	4	30
	Not change	143	162	151	160	131	167	120
	IPC	**0.08**	**0.01**	**0.01**	**0**	**0.02**	**0.03**	**0**

Source:Field survey, 2011

Table 8. Importance of soil and water conservation

Category	Da Bac	Cao Phong	Ky Son	Total
	(60)	(60)	(60)	(180)
Important	87.0	92.0	91.0	90.0
Not Important	13.0	8.0	9.0	10.0
Total	100.0	100.0	100.0	100.0

Source: Field survey, 2011

Table 9. Perception on implementation of soil conservation practices

Category	Da Bac	Cao Phong	Ky Son	Total
	(60)	(60)	(60)	(180)
Conservation practices implemented	36.0	45.0	43.0	41.3
Conservation practices not implemented	64.0	55.0	57.0	58.7
Total	100.0	100.0	100.0	100.0

Source: Field survey, 2011

Table 10. Types of implemented soil and water conservation practices

Category	Da Bac	Cao Phong	Ky Son	Total
	(%)	(%)	(%)	(%)
Strip grass barrier	5.0	18.0	10.0	11.0
Contour hedgerow	5.0	-	3.0	2.7
Mulching	4.0	8.0	15.0	9.0
Crop residue	25.0	17.0	12.0	18.0
Ridge and Furrow	2.0	2.0	3.0	2.3

Source: Field survey, 2011

Table 11 Perception of respondents on the role of conservation practices on soil and water quality

Category	Da Bac	Cao Phong	Ky Son	Total
	(60)	(60)	(60)	(180)
Improve	90.0	95.0	94.0	93.0
Not improve	10.0	5.0	6.0	7.0
Total	100.0	100.0	100.0	100.0

Source: Field survey, 2011

Crop residue and strip grass barriers were predominantly implemented by 18.0% and 11.0%, respectively. Followed by mulching (9.0%), contour hedgerows (2.7%), and ridges and furrows (2.3%) (Table 10).

Comparison among districts indicated that local famers in upland and highland areas preferred applying crop residue for soil and water conservation than the fellow farmers of the lowland area as showed by 25.0% of households using crop residues in Da Bac, 17.0% in Cao Phong, and 12.0% in Ky Son. On the other hand, strip grass mulching was predominantly adopted in Cao Phong by 18.0% households and Ky Son (10.0%) compared to Da Bac (5.0%).

3.5.2. Roles of conservation practice on soil and water quality

A large number of respondents (93%) agreed that the positive effects of conservation practices were improved soil fertility, and water availability and quality. The conservation practices would help reduce surface runoff, soil loss, and improve water quality.

3.6. Livelihood assessment and perception of local people on land use change

Table 12 shows the calculated score for each indicator under each livelihood asset. The overall livelihood index was 0.514 indicating that the livelihood of the households in the study area is at or above average. The combined indices for Da Bac, Cao Phong, and Ky Son were 0.468, 0.550, and 0.525, respectively, indicating a lower level of livelihood in general for Da Bac in comparison to Cao Phong and Ky Son districts.

For the study area, the highest index value among the five livelihood assets was the social asset index at 0.639. This was followed by financial (0.536), physical (0.493), natural (0.479), and human (0.577) assets.

With regard to individual assets for each group, Cao Phong had the higher index for natural, financial, social, and physical assets. This indicates that Cao Phong has relatively better livelihoods compared with the other two groups.

The human asset was significantly different among Da Bac (0.367), Cao Phong (0.434), and Ky Son (0.475). At an individual indicator level, only education was significantly different among the groups 0.283 (Da Bac), 0.375 (Cao Phong), and 0.442 (Ky Son), whereas household size was almost the same.

The land availability index of Da Bac (0.475) was significantly smaller ($p<0.05$) than of the households in Cao Phong (0.633) and Ky Son (0.525) because Da Bac farmers usually grow upland rice, corn, and cassava. In contrast, farmers in Cao Phong and Ky Son grow paddy rice, oranges, sugarcane, and rubber, hence, they have relatively larger land holdings in comparison to the farmers in Da Bac. Land availability is an indicator of a natural asset, which is one of the important livelihood assets.

The financial asset index was found to be significantly different from Da Bac (0.492) in comparison with Cao Phong (0.579) and Ky Son (0.538). One indicator, income from crop production, was found significantly different from the groups (Da Bac -0.392, Cao Phong - 0.550, and Ky Son -0.508). In general, the calculated indicators for the three groups show that the level of income of Da Bac households was low because upland rice and upland crops (corn and cassava) had the lowest value among all the crops. The other indicators, including credit and loans, were not different across the groups.

The social asset index showed that all the groups have a high social asset, however no significant differences were found between the groups. The physical asset showed that there was also no significant difference across the groups.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusions

Land use change in the research area was dominated by converting forests (DTFR & UDFR) to field crops. From 1995 to 2005, the proportional extent of change of FCRP, PDDY, and URBN, was from 5.36% to 11.89%, 10.91 to 15.66, and 5.98 to 8.48%, respectively. On the other hand, the proportion of DTFR and UDFR dramatically decreased from 22.92% to 14.32% and 30.61% to 24.43%, respectively. From 2005 to 2010, the proportion of the extent of land use was changed due to the decrease in BRNL, FCRP, and PDDY and the increase in DTFR, and UDFR land uses.

Factors influencing land use decisions and crop systems, according to respondents, were government policies (30.15%) and commodity prices (34.75%). The other factors include land quality (11.18%) neighboring areas (9.13%), labor shortages (5.28%), transitional practices (6.41%), and other factors (3%). Considering soil erosion and water related impacts, expansion of agricultural activities as well as deforestation was a cause of increased surface flow and contributed to soil erosion and nutrient loss. It was shown that most respondents could distinguish the difference between fertile and degraded soil by observing soil color. According to them, when topsoil is black, it indicates fertile soil, whereas when topsoil has turned brown and red-yellowish, it means soil is being degraded. In addition, perception of households on water quality and quantity indicated that the development and quick population growth created a pressure on water resources leading to decreases in water quantity and quality year by year.

Table 12. Livelihood asset indicators

Livelihood asset indicator	Da Bac	Cao Phong	Ky Son	Study area	Significant
	Average	Average	Average	Average	
Human asset					
Household size	0.283	0.375	0.442	0.367	0.010*
Education	0.450	0.492	0.508	0.483	0.502ns
Human asset index	0.367	0.434	0.475	0.425	
Natural asset					
Soil loss	0.350	0.433	0.458	0.414	0.265ns
Land availability	0.475	0.633	0.525	0.544	0.018*
Natural asset index	0.413	0.533	0.492	0.479	
Financial asset					
Income	0.392	0.550	0.508	0.483	0.028*
Credit and loan	0.592	0.608	0.567	0.589	0.833ns
Financial asset index	0.492	0.579	0.538	0.536	
Social asset					
Membership in society	0.575	0.625	0.575	0.592	0.598ns
Neighborhood	0.667	0.717	0.675	0.686	0.543ns
Social asset index	0.621	0.671	0.625	0.639	
Physical asset					
Access to road	0.467	0.592	0.542	0.534	0.079ns
Facilities	0.433	0.475	0.450	0.453	0.815ns
Physical asset index	0.450	0.534	0.496	0.493	

Source: Field Survey,2011

ns = Non-significant at p>0.05, *Significant at p<0.05

Considering soil and water conservation, the importance of conserving soil and water resources was realized by 90.0% respondents; however, only 41.3% implemented conservation practices in their farms. Most soil conservation practices implemented in the lowlands and hilly areas, such as strip grass barriers, contour hedgerow systems, and crop residue could be used to explain both the decrease in overland flow and in soil loss. Among soil and water conservation practices, crop residue and strip grass barriers were predominantly implemented by 18.0% and 11.0% farmers, respectively, followed by mulching (9.0%), contour hedgerows (2.7%), and ridges and furrows (2.3%).

Households in Cao Phong district showed higher overall livelihood indices compared to other household groups. On average, the social asset index had the highest value (0.693) among the five livelihood assets, followed by financial (0.536), physical (0.493), natural (0.479), and human (0.577) assets.

4.2. Recommendations

The increase in crop prices is an interesting incentive for local people and encourages them to convert forests into annual crop land without any cares about conservation practices, which are the main causes of increases in runoff variability and land degradation. Therefore, farmers should be presented with knowledge about the negative environmental impacts and importance of soil and water conservation, which will help them understand the negative effects on soil and related water under inappropriate land use conversion in the long term. It is also important to help farmers enable high profits from sustainable farming activities that will support them to prevent further inappropriate land use conversion in the future. Based on the results, there is a need to enhance the diversification of existing land management practices like contouring, mulching, strip grass barriers, crop residue, crop diversification, and ensure continuous governmental support in the implementation of soil and water conservation.

Furthermore, government policies should be implemented to allow longer land use rights with supporting financial aid programs that create favorable conditions for land use flexibility at the household level, providing accurate information (including forecasts) related to markets and production in a timely fashion to farmers so that farmers can enable themselves to make production choices, and making sure farmer receive the support they demand for improved land management. Besides, the use of multiple policy instruments with a wide range of stakeholder's participation will help to increase participation of local communities in land use, soil, and water conservation in the future. For example, increasing tree planting by establishing tree nurseries in every hamlet and commune, and encourage farmers to plant more trees through education and awareness using local regulations.

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