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Improvement of access to available agricultural technologies: did it cause land-use changes and poverty reduction in the North-western upland of Vietnam?

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Abstract

Before the economic reform, or "*Doi moi*", the north-western uplands of Vietnam, which are characterized by a complicated terrain and a high cultural diversity, were affected by high illiteracy rates, severe environmental degradation, and poor infrastructural facilities. The livelihoods of the rural upland communities were maintained through a combination of hillside swidden agriculture with low land productivity, forest product exploitation and meager wet rice production. Access to available agricultural technologies was extremely limited. Poverty was widespread in the region. However, development in this region has gained some remarkable achievements since 1990, and one potential explanation is the introduction and application of improved agricultural technologies.

This paper examines to what extent the improvement of access to agricultural technologies and the adoption rate contributed to changing land-use and to reduced poverty in 75 communes of Son La province in the time period from 1989 to 2000. Aerial photographs and satellite images taken in 1989, 1994 and 2000 were interpreted to detect land-use changes. Poverty was proxied by the number of assets controlled by the poor, which were collected at the commune level by means of a survey with a structured questionnaire. All data were geo-referenced and spatially analyzed by using Geographical Information System (GIS) techniques and statistical procedures.

The research findings show that the absence of suitable technologies such as improved breeds of crops and livestock and new farming techniques and lacking access to agricultural extension services left the agricultural potential of the region untapped in many locations. Local farmers pursued land-extensive farming approaches at the cost of a reduced forest cover. Vast areas of forest were converted into agricultural cultivation from 1989 to 1994, whilst the incidence of poverty still remained at high levels. Due to the improvement of access to modern agricultural inputs and extension services, subsistence production has been replaced by high-yielding and more profitable varieties since mid-1990s. Agricultural output soared. Living standards of local inhabitants improved considerably as a result of rising agricultural profits and, in the same period, deforestation decreased. However, the rates of technological adoption, land-use changes and poverty reduction do not show the same patterns across the research area. To better target the activities of agricultural extension services to the rural poor, this paper provides some recommendations to enhance the effectiveness of current agricultural extension services.

1. Introduction

Improved agricultural technologies such as improved crop varieties, irrigation chemical fertilizers and pesticides have been important policy tools to improve livelihoods and foster economic growth in rural areas. The contribution of agricultural technology to alleviate poverty has been proved by a significant number of studies (e.g. Hossain *et al.*, 2003; Kerr and Kolavalli, 1999). However, it is still an open research issue whether improvement of access to and adoption of agricultural technologies help to reduce the pressure on forests and to conserve watershed functions and biodiversity in tropical rural upland regions. The findings of a growing number of studies give a mixed picture. On the one hand, several empirical studies have validated the assumption that that irrigation development can reduce forest clearing (e.g. Deininger and Minten, 1996; Zeller *et al.*, 2000). On the other hand, some studies have shown that the application of advanced agricultural inputs such as improved seeds and chemical fertilizer can lead to agricultural expansion and deforestation (e.g. Mertens *et al.*, 2000; Angelsen *et al.*, 1999).

Before the economic reform, or "*Doi moi*", the north-western uplands were the poorest region of Vietnam. They are characterized by a complicated terrain and cultural diversity suffered from high illiteracy rates, severe deforestation rates, and poor infrastructure facilities. The rural communities in the region maintained their livelihoods through a combination of hillside swidden agriculture with low land productivity, forest product exploitation and limited wet rice production. Access to available, new agricultural technology was extremely limited because of both poor roads and unsuitable agricultural policies. Poverty was widespread in the region. However, development in this region has gained some remarkable achievements since 1990 and one possible explanation is the contribution of agricultural technology.

The key features of innovation in Vietnam that affect the access to and adoption of agricultural technology are: (1) de-collectivization of agricultural co-operatives and recognition of the farm household as the principal unit of agricultural production, (2) market liberalization that enabled farmers to freely purchase inputs and sell their outputs, and (3) the privatization of land use rights.

This paper examines role of agricultural technologies and its contribution to protect natural resources and to alleviate poverty in 75 communes of Son La province, Northwest Vietnam, in the period from 1989 to 2000. In particular, the paper investigates to what extent the improvement of access to and adoption of technology influenced forest cover. The paper begins with a description of natural and socio-economic conditions of the research area and sketches the agricultural technology progress. The methodology is described in the following section. The fourth section discusses the research results. The paper ends with conclusions and policy recommendations.

2. Regional background

The research region consists of seventy-five communes of Phu Yen, Bac Yen, Moc Chau an Yen Chau Districts, Son La province *(Figure 1: Location of the Research Region)* covering an area of approximately 4,700 km^2. The communes are located on both sides of the Black River (also called *Da River*) and differ in their agro-ecological and socio-economic characteristics. 78 % of the natural area are classified as hills and mountains and are verged by dense forests with rich biodiversity. Paddy fields are mainly situated in the Quang Huy

Valley of Phu Yen and some communes of Yen Chau. The other communes do not have considerable areas of wet rice. The agricultural production depends on dry-farming crops such as swidden rice, maize, cassava. Some communes are situated along the national road No. 6 and have fertile soil suitable for fruits and industrial crops such as Longan, Litchi, Plum, tea, coffee and mulberry. The agricultural sector accounts for 92 % of total employment and for 87 % of the gross domestic product (GDP) of these districts (DARD, 2000). The livelihoods of the local inhabitants in most communes of the research area depend upon cultivation on sloping land, forest exploitation and, only to a limited extent, on irrigated rice production.

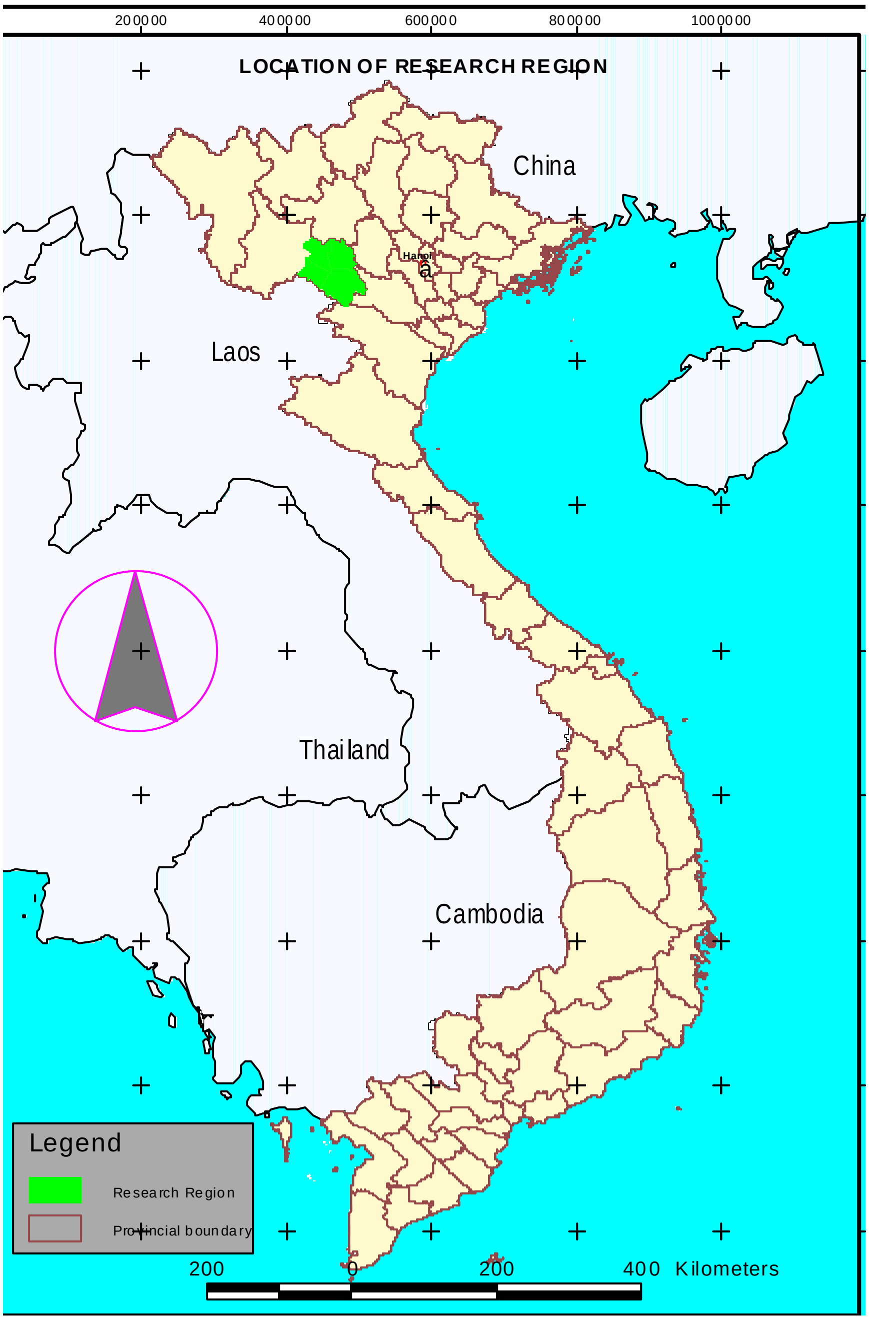


Figure 1: Location of research region

There are thirteen ethnic groups living in the research region. Most of the ethnic groups possess their own language, rules, and agro-economic system (Poffenberger and Phon 1998), produce for their subsistence needs and have diverse agricultural systems (Jamieson *et al*.1998). Particularly, the H'Mong people usually live in remote mountainous areas; they practice shifting cultivation whether or not it involves shifting their places of residence (Pandey and Minh 1998, De Konnick 1999). In contrary, the Thai, Muong and Kinh (Vietnamese) people mainly settle in townships, along main roads, and in flat and fertile land. Annual population growth in the research area is one of the highest in Vietnam, especially in the mountains (2.8% - 3.0 % per year in 2000). High population growth and limited opportunities for off-farm employment lead to a underemployment in the research region. The rate of redundant labor was approximately 10 percent in 2000 (DARD, 2000). Moreover, the illiteracy rate of the ethnic minorities has a particularly high level. According to data of the Ministry of Education, the illiteracy of people from 16 – 40 years of the H'mong is 67.7% and of the Dzao 64.4%. The percentage of primary school participation is very low. For instance, among the H'mong, it is 5.6%, the Dzao 6.5% and the Kho Mu 4.8% (MARD, 1996). Poverty is very severe in the region. The head-count poverty index is over 40% in many communes. The Gross Domestic Product (GDP) per capita is $US 130 per year, but it is less than $US 50 in most mountainous communes (DARD, 2000).

Right after the break-up of the cooperative farms in the late 1980s, the agricultural land has been allocated to the farmers and they could select freely agricultural inputs and sell their products. However, in the upland region, it was very different from the low land areas: The agricultural production in this region remained constraint. Possible reasons include physically difficult access to the agricultural modern inputs (improved seeds, chemical fertilizers and pesticides), and to markets for agricultural products, and the absence of extension services (Quan, 2000). Wet rice expansion required extremely high investment costs on building large scale irrigation systems and it was out of the reach of the local farmers. In this situation, local farmers had no choice other than planting "traditional or local" varieties, which required long growing periods and led to a low land productivity. The "Digging holes by wooden stick then sowing seeds" approach has been practiced by some ethnic tribes (e.g. H'Mong and Dzao). Knifes, axes, hoes and wooden sticks are their major productive materials. Hardly any chemical fertilizers and insecticides were applied in the northern uplands (Jamieson *et al*.1998). The lack of a modern and suitable input technology hindered agricultural potentials and forced the upland farmers to follow extensive farming approaches at the expense of forests and other natural resources (Sikor and Truong 2000, and Rutherford 1992). Moreover, food shortages were unavoidable.

However, the situation considerable improved in the nineties. Modern inputs have been introduced to the region. Particularly, farmers started to cultivate a large number of hybrid varieties of wet rice, maize, soybean, and cassava with short growing periods, drought tolerance and high yields on upland farms[1]. Besides, irrigation investment from both the Government and the farmers led to a significant increase of wet rice in both areas and in the number of harvests per year (Sikor 2000). The application of chemical fertilizers and pesticides remained, however, limited in the region. In contrast to the wide application of highly yielding varieties, mechanic equipments such as tractors and water pumps are still absent from agricultural cultivation, restricted by small land holdings, terraced fields, steep slopes and high investment costs. Furthermore, animal production seemed not to have changed much although the region has comparative advantages to develop this activity. The farmers still grow local breeds and most of the production is used for home consumption,

[1] Application of high yielding rice varieties increased yield of wet rice from 6 tons/ha/year in 1995 to 8 tons/ha/year in 2000 (UB-BC 2001)

weddings and funerals. Veterinary services are until today very weak and mainly exist in districts capitals and communes situated along the paved roads.

The Department of Agriculture and Forestry Extension (DAFE) was established in 1993 under the management of the Ministry of Agriculture and Rural Development (MARD). In Son La, the Center for Agricultural and Forestry Extension (CAFE) was founded in 1996 and under the administration of the provincial Department of Agriculture and Rural Development (DARD) (Kaiser 1997). At the district level, the official directive to establish the extension service, the district Agriculture and Forestry Extension Station (AFES), was implemented some time after the issuance of the document to set up the province level extension service. The main tasks of these offices are the transfer of technologies, training of extension workers, skills, assistance in economic management, and the evaluation of extension programs within its administrative area. Since 2001, most of the mountainous communes with difficult access have one officer of AFES to work there regularly.

3. Conceptual framework, research hypotheses and methods

3.1 Conceptual framework

The conceptual framework for this research is based on the theory of induced innovation (Boserup, 1965; Ruthenberg, 1980; Ruttan and Hayami, 1984). We divide the impacts of agricultural technology on land use changes into two main processes: (1) agricultural intensification on already cultivated areas, and (2) agricultural expansion into previously uncultivated land. Intensification includes the substitution of land by labor or by capital-intensive technologies such as irrigation, high yielding varieties (HYV), chemical fertilizers, and pesticides. Expansion of agricultural areas usually takes place at extensive and low technological levels (Mueller and Zeller, 2002) and redundant labor forces or degraded cultivation plots.

3.2 Research hypotheses

The main research hypotheses are:
1) Better access to agricultural technologies promotes agricultural intensification.
2) High profits of cultivating improved maize leads to agricultural expansion and, therefore, deforestation in short run.
3) Higher rates of adoption of agricultural technologies reduce poverty in the research region.

3.3 Data collection and analysis

The land use maps with twenty different land-use types of 1989, 1994 and 2000 are derived from the interpretation of aerial photographs and SPOT satellite images taken in 1989, 1994 and 2000 at an average scale of 1:25 000 at the Remote Sensing and GIS Division, Forest Inventory and Planning Institute, Vietnam. Historical land use maps, relevant documents and intensive ground checks were used to enhance the accuracy of the land use mapping.

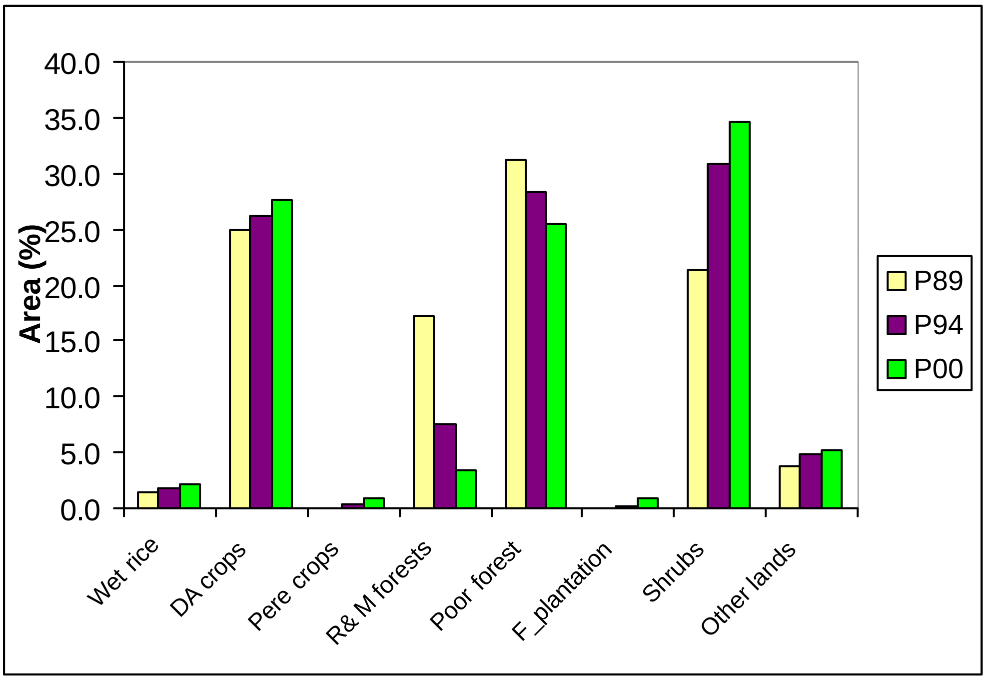
Poverty has usually been conceptualized as a state of lacking income in a way that leads to the inability to provide an adequate level of basic necessities (Ambler, 1999). In the framework of this research, poverty is proxied by monthly income and the assets indicated by poor housing conditions, and lacking ownership of consumer durables)[2]. Poverty rates, technological adoption rates and other relevant data are collected by a structured questionnaire[3]. All data are geo-referenced and analyzed by using the Geographical Information System (GIS) and statistical procedures.

4. Results and discussion

4.1 Impact of agricultural technology on land use changes: a broad view

As discussed in the previous section, the adoption of improved varieties and the development of irrigation systems were the main types of agricultural-related technological progress in the research area. Findings of the research suggest that these applications have contributed to the land use dynamics observed, as partly described in figure 3.

Figure 3 shows that the percentage of wet rice areas compared to total natural lands increased from 1.4% (1989) to 1.8% (1994) and reached 2.1% in 2000. The expansion of paddy fields is assumed to result from the high productivity of improved wet rice, which switched the preference of farmers from rice swiddening to paddy cultivation.



Source: Aerial photo interpretation and own calculation

Figure 3: Changes of major land use categories in three years 1989, 1994 and 2000

In addition, investments in irrigation systems from both individual farmers and villages as well as from the government have contributed to an increase in the wet rice area. Subsidized by the Government in the early 1990s, perennial crops such as Mango in Yen Chau and Tea, Apricot and Plum in the Moc Chau plateau yield high profits and were introduced into the

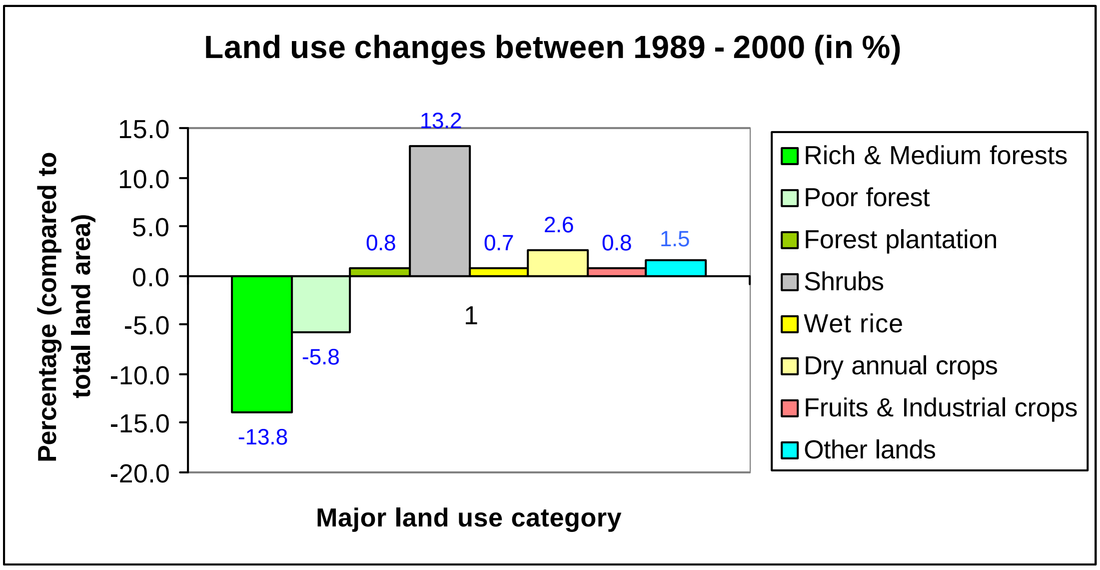
[2] We used the poverty criterion that released by Vietnamese Ministry of Labor, Invalid and Social Affairs (MOLISA) applied before 2001. This poverty line is defined in terms of monthly per capita income in kind: less than 15 kg for rural mountainous and island regions.

[3] The questionnaire was applied at both commune and village level. However, only commune data are used in this paper.

region. However, growing industrial crops and fruits was not attractive for the farmers because of the severe food shortage, difficult access to output markets and risk aversion. Consequently, the area of perennials only increased from 0.1% in 1989 to 0.4% 1994.

Nevertheless, increasing profits of planting fruits and industrial trees eventually motivated villagers to expand these activities (plum planting started in 1995 and tea in 1998) especially in Tan Lap, To Mua, Phieng Luong and Van Ho of Moc Chau district. The area of fruit trees also expanded in the communes of Phu Yen district and some communes along national road No. 6 of Yen Chau. Typically, the area of tea plantations in To Mua commune, Moc Chau district, increased by 150 hectares within 2 years (1998-2000). The expansion of industrial crops and fruits in the region is also a result of extension activities of in the form of financial support and technical training of so-called SFDP, 327 and 747 Projects.

High productivity of improved maize, cassava and soybean seemed to have contributed to the surge of these annual dry crops from 24.9% (1989) to 26.1% (1994) and 27.5% (2000). The fallow cycles were shortened from three years to one year or even replaced by planting cassava. At the same time, shrub and grass land increased from 21.4% (1989) to 34.6% (2000). Consequently, the forest cover was reduced from 48% (1989) to 36% (1994). This is equivalent to a deforestation rate of 2.6% per year. Rich and medium forests dropped from 17.2% in 1989 to 3.4% in 2000. Much of the forests were converted into agricultural areas. This is quite clearly observed in many communes, especially in communes far from district centers and the main roads. The application of improved crops in these communes also was more recent and occurred at lower rates. It appears that technological progress in agriculture played a certain role in reducing deforestation from 1994 – 2000, when the rate of forest loss decreased to 1.3% per year. In the same period, afforestation (*natural forest regeneration*) and reforestation (*man-made forest plantation*) were conducted in some communes. Most of these communes have been supported by foreign-aided and governmental projects, such as the SFDP, FARM, 747, 327 and 661 projects. As mentioned above, it is estimated that approximately 10 % of the agricultural labor force in the region is unemployed, which also motivated these projects. Therefore, reforestation might not be the result of only agricultural technology progress, but also of specific policy measures aimed at increasing the forest cover. Land use changes from 1989 to 2000 are depicted in figure 5.



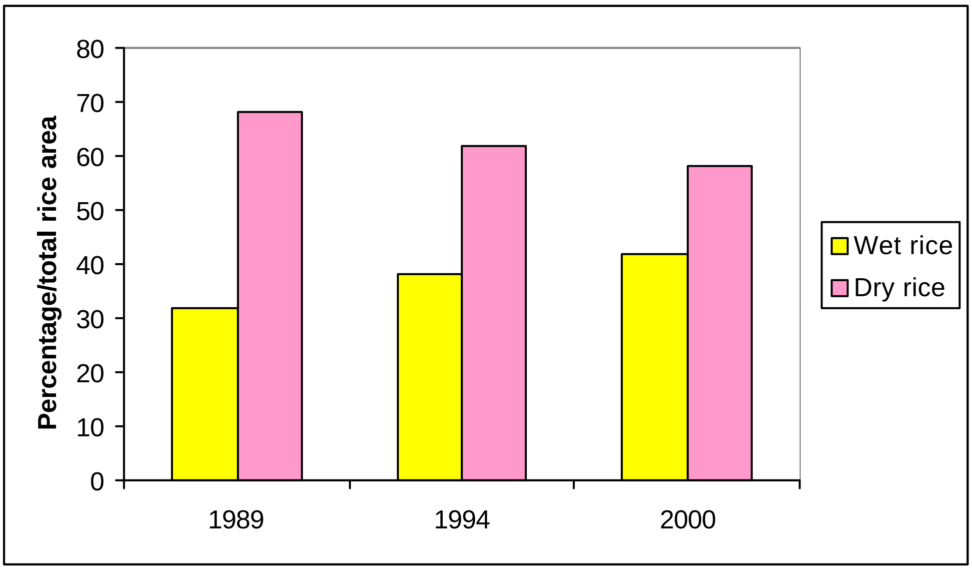
Source: Aerial photo interpretation and own calculation

Figure 4: Changes of major land use categories from 1989 – 2000

4.2 Impact of agricultural technology on land use changes: a closer view

The shift in rice cultivation area

Irrigation expansion and highly yielding varieties of wet rice played an important role in changing rice production in the research region. Figure 5 indicates a shift from dry rice to wet rice cultivation.



Source: Commune survey and own calculation

Figure 5: Change in percentage of area of wet rice versus dry rice

In the late 1980s, rice production in the region consisted of extensive rice swiddening or dry rice and limited wet rice cultivation. Most of the local farmers used local or "*traditional*" wet rice varieties, which produced one crop per year (*Mua or Summer crop*) with a productivity of 1.5 – 2 metric tons per hectares (Quan, 2000). Low productivity of wet rice cultivation and the modest adoption rate of other upland crops led to a high percentage of swidden rice in the total area of cultivated rice in 1989. Change in macro-policies (e.g., rural road development, subsidized of seeds and micro-credit), enabled upland farmers to access high yielding wet rice cultivars, which were available in the low land. The average productivity of paddy increased from 2.5 - 3 tons/ha in 1990 to 5 – 6 tons/ha in 1993. In addition, decollectivization, the privatization of land use rights and market liberalization provided incentives for farmers to invest in the expansion of wet rice by (1) building more terraced fields, (2) constructing small irrigation systems with earth canals and bamboo water pipelines. Besides, the Government also financed new irrigation dams and consolidated old ones. However, physical and financial constraints of many farmers caused low adoption rates of improved wet rice. In 1995, new wet rice varieties were only planted in the communes located near the district capitals and along the asphalt-paved road, and accounted for 5.1% of the total paddy area (Quan, 2000). The percentage of wet rice area increased from 32% (1989) to 38% (1994).

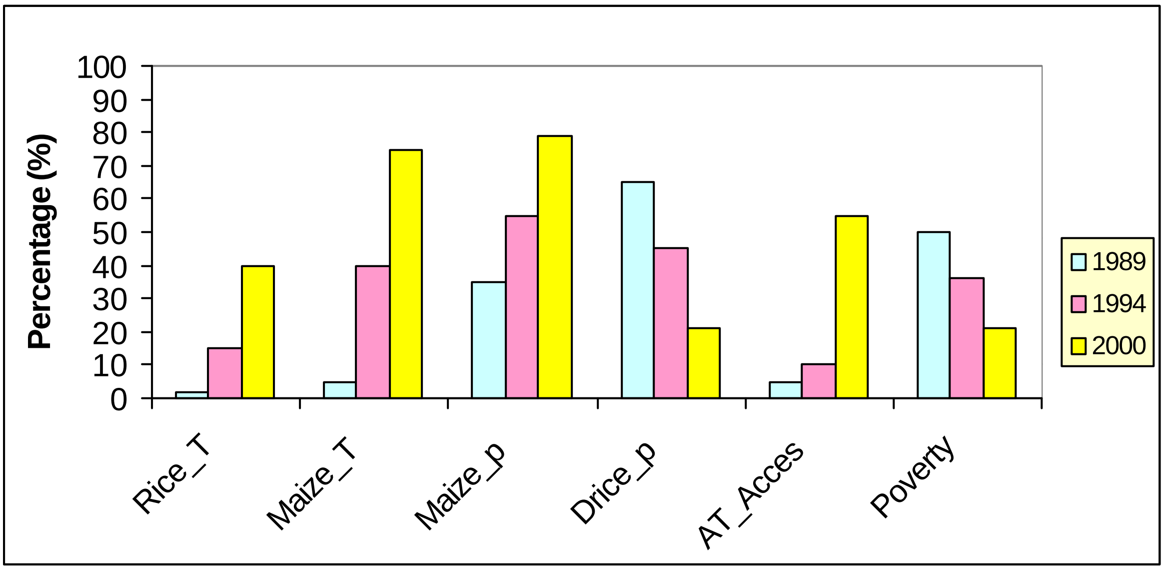
In later years, market and technological factors continued to favor wet rice cultivation (Sikor, 2000). More improved seeds with shorter growing periods were introduced by the farmers. Some varieties produced up to 8 tons/ha in 1997 (Foerster and Nguyen, 1999). These HYVs enabled the farmers to have two or even three harvests per year (*spring and summer crops*) where water was available for irrigation. At the same time, the productivity in dry rice cultivation declined because the shorter fallow cycles did not allow the soil fertility to recover fully, and more time was required for weeding. The search for high yielding dry rice varieties was not a preference of either farmers or local authorities. The SFDP tested a number of new varieties and the average gross margin not particularly attractive. Rice swiddening fell to 58% of the total cultivated rice area in the year 2000, and was mainly practiced in mountainous areas with difficult market access and unsuitable natural conditions for cultivating wet rice. Steep slopes and water shortages, also caused by deforestation, were reasons, which constrained the construction of more irrigation dams to enlarging the paddy area. Consequently, an expansion of wet rice cultivation was not observed in half of the communes, most of which are situated in the high mountains.

Expansion of hybrid maize versus other annual subsistent crops

A large number of improved maize and soybean varieties have been introduced to the farmers (Foerster and Nguyen, 1999). However, the adoption rates were quite low in the early 1990s because of high initial investments for the purchase of seeds (about 25,000 VND/kg), the necessity to repurchase seeds every year and the fluctuation of market prices. Again, the adoption of these improved crops started at communes located near district towns and/or under support of SFDP and FARM projects. Lack of information on new technology and cultivating requirements, and long distances from the markets were major constraints of applying hybrid maize in the remote communes. Some hybrid varieties yielded 3.5 tons/ha, and even up to 7 tons/ha, as compared to 1.5 tons/ha of "*traditional*" maize. Successful trials of improved maize in these areas and the development of extension services have played vital roles in distributing this cash-oriented crop to the entire region. In 1994, 40% of the upland crop area was planted with hybrid maize. In some communes the farmers started to grow two crops of maize per year. Maize cultivation provided much higher profits compared to subsistence dry rice (7-12 million VND/ha/year versus 1.5 million VND/ha/year). Moreover, rice swiddening sometimes produced no harvest due to soil degradation and frequent drought[4]. Planting cassava yields lower profits than maize (3-5 million VND/ha/year) and traditional cassava normally is harvested after three years. The market demand for cassava is not as high as that of maize. Therefore, cassava is now only planted in the upland fields after some harvests of dry rice and/or maize instead of the fallow periods. High yields and a high demand for animal food production from the lowland made maize a predominant upland crop for cash income in the region. Therefore, there is a shift from the production of food crops for subsistence needs (dry rice, cassava) to more market-orientated cash crop production (maize). In 2000, hybrid maize accounted for 70% of the total upland crop area. However, the adoption rate of improved maize varied across the region, and is highest in lower altitudes and near market places. The lowest adoption rates are encountered in remote mountainous areas. The adoption process of different agricultural technologies and the poverty incidence is shown in figure 6 where:

- Rice_T: adoption rate of improved wet rice
- Maize_T: adoption rate of hybrid maize
- Maize_P: Ratio of cultivated hybrid maize to total area of upland crop
- AT_Access: Percentage of HHs accessed to information on new agricultural technology
- Fcover: forest coverage (%)
- Poverty: Head-count poverty index (%)

[4] Maize could give 2 harvests per year while dry rice only produces 1crop/year). If one harvest is lost, the farmers can grow the second one. It means that maize production is safer than dry rice is.



Source: Commune survey and own calculation

Figure 6: Agriculturally technological progress and poverty alleviation

4.3 Impact of agricultural technology on poverty alleviation

According to statistics from the General Statistical Office of Son La province, market prices of wet rice and maize are increasing over time. Moreover, the improvement of access to markets due to road investment and the growing demand for animal food processing in the lowland raised the price for agricultural outputs in high mountain communes. In that way, agricultural technology contributes significantly to an increase of cash incomes and to a reduction of poverty of local inhabitants. Figure 6 shows the trend of agricultural technology progress and poverty alleviation in the research area. The poverty rate decreased from 50% (1989) to 36% (1994) and 21% (2000). Brick houses were rarely seen in the region in early 1990s. However, accumulation of profits from planting improved crops enabled the farmer to build good houses. Many of them now possess motorbikes, radios and televisions. In 2000, the solid and semi-solid houses accounted for 85 % in the lowland communes. However, it appears that a cycle of severe poverty - low adoption rate of new agricultural technologies and high poverty rate existed in high mountainous communes.

5. Conclusions and recommendations

The research findings allow us to draw a number of conclusions on the relation between technology, deforestation and poverty. Change in the access to and the adoption rate of HYV promoted agricultural intensification both in paddy and upland fields, and changed the crop composition from subsistence crops to a more cash-oriented production, as manifested by more hybrid maize, industrial crops and fruits, and less dry rice. High profits of hybrid maize expanded its cultivation area and seemed to play a certain role in deforestation in most communes. Agricultural technology contributed to poverty reduction in some areas of the research region. However, a certain spatial pattern biased towards lowland areas with a greater agricultural potential seems to exist. Agricultural technological progress, land use changes and poverty reduction varied in the region and depended on large number of factors.

With a view to improving the dissemination of agricultural technologies to farmers and to protect natural resources in the research region, the following recommendation can be derived from our results:

- The adoption rate of new technologies depends substantially on their appropriateness for the prevailing farming system, information dissemination, and the size and effectiveness of agricultural extension services. Most farmers in the mountainous communes noted that they did not have access to information on newly improved seeds and sufficient knowledge to use them. Therefore, extension services should increase the frequency of their visits to the remote communes and place more emphasis on the transfer know-how to the farmers in these regions.
- Commune cadre and village headmen are usually better educated than other inhabitants. They might play an important role in improving local extension services. Organizing "*training for trainers*" targeted to key persons in communes and villages could be a cost-effective approach to better disseminate agricultural technology.
- Agricultural extension should provide information not only on technology but also on markets, consumer demands, and associated environmental and economic risks. This could facilitate farmers to better analyze, test and decide on suitable production technologies.
- Suitable agricultural policies are indispensable for sustainable development in the region. In addition to recent policies concerning tax elimination for using agricultural land and the improvement of agricultural extension, market access (including rural infrastructure, micro-level food processing and market organization) is crucial. Many commune officials and farmers reported that the harvested products could not be transported to the markets because of bad road conditions.
- The use of fertilizers on uplands is currently very limited, because the application of fertilizers would reduce the benefit-cost- ratio. Application of fertilizers focuses on wet rice production, home gardens and industrial crops. Lack of fertilizers and effective soil erosion measures puts pressure on land resources and increases the conversion of forestl for agriculture. Facilitation of applying fertilizers (both organic and chemical types) and soil conservation techniques is essential to enhance crop production and protect natural resources.
- A promotion of animal production should tap the comparative advantages of the natural characteristics of the region and contribute to economic development.
- The land allocation program should be completed in an equitable way to secure long-term land use rights for the farmers.

The descriptive analysis conducted in this study gives only an indication of the correlations between agricultural technology progress, land use changes and poverty reduction. More deductive econometric modeling is required to examine underlying causes. Spatially explicit regressions could further reveal spatial processes and contribute to the analysis of geographical differences in the links between poverty reduction and land use changes. More variables need to be included to capture the effects from the natural potential, demographic and socio-economic differences and external policy influence.

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