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Water for Forest: Potential impact of alternative land set-aside programs at village and farm levels in the mountainous areas of Vietnam

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Abstract

The uplands of Northern Vietnam, often having low agricultural productivity, are home to the poorest of the rural poor. The ecosystem services such as food production for marginalized populations, biodiversity reservoirs, and watershed regulating functions have been under increasing pressure due to decollectivisation and the following redistribution of the land, liberalization of the markets and a rapid population growth. To partly reverse these major changes we analyzed the impact of alternative schemes on farm revenues that would set aside cultivated land for forest natural re-growth. Instead of farmers receiving individual financial rewards, we explored the impact of improving collective infrastructures so that more water is made available for irrigation. Using mathematical programming a farm model was developed, in which we investigated scenarios where some land in the sloping area of the catchment is set aside for forest natural re-growth (which aims at restoration of watershed functions), while additional land is made irrigable in the lowland compartment of the farms. The impacts on land use, individual farm revenues, per head revenues and village revenues were analyzed. This led us to conclude that a reduction of cropped area in the sloping compartment, associated with a small increase in irrigable land in the lower compartment, had little impact on the aggregate village revenues. Moreover, under most scenarios, revenues were more equally distributed among households of a community. In fact, careful distribution of small quantities of irrigable land could be very beneficial to irrigation-poor farmers, while the revenues of the more well-off ones are almost not affected. However, this would require some coordination at village or commune levels, and a deliberate choice to help the poorly endowed households.

Introduction

Over the past decades, life has changed dramatically for the people of Northern mountainous areas of Vietnam. The two main drivers of change were the shift from collectivism towards a market system and the rapid population growth. These led to a return to slash-and-burn cultivation in the uplands with increasingly short fallow periods, which in turn caused increased deforestation (Castella et al., 2005). These practices pose a threat to the important ecosystem services available in the region; besides food production for marginalized populations, the ecosystems also provide important functions as biodiversity reservoirs and watershed regulation. If current practices continue, the ecosystems will most likely deteriorate, which will pose large dangers on the existence of all living beings and the food supply of future generations in the areas (Castella and Dang, 2002).

To protect or restore forest resources, local authorities have proposed farmers to set-aside some of their cultivated land in sloping areas to re-establish natural or productive forests. For example, as part of national policies, the authorities of Giang Cay village in Van Chan district have successfully prohibited the cultivation of upland rice by better-off farmers. The implementation of these policies has however been faced by mixed success. At least in the short run, setting-aside sloping land is costly for the farm households involved, as they get even less access to already scarce land. In the long run; however, more forests in the upper part of the catchment could directly benefit the households, because they may result in increased availability of irrigation water for the lowlands. Moreover, the improvement of ecosystem services to the region justifies supporting policies to compensate some of the costs. A suitable policy could be the improvement of collective irrigation infrastructure for the lowlands.

Before deciding on possible set-aside regulations and compensation policies, policymakers need to gain ex-ante knowledge on their costs and benefits at the household level, as these will greatly affect acceptance and compliance. Our main objective is therefore to analyze the household and village-level impact of alternative schemes for setting-aside cultivated land for forest natural re-growth in combination with different options for improved irrigation. We distinguish various possible distributions of set-aside requirements and improved water availability over farmers of different types in order to gain insight in the potential distributions of costs and benefits.

Smallholder farmers in developing countries are not simple profit maximizers. As they face multiple market imperfections, they have to balance factors such as availability of land and family labor, food consumption requirements, and market access. In such a setting, a change in resource availability will affect the entire farming system, and its consequences can not be assessed using cost benefit analysis. We therefore use a farm household modeling (FHM) approach. This approach explicitly models the objectives, resources, possible activities and the socio-economic environment of the farm household and has been used extensively over the past decades to assess the effects of policy measures on farm households (e.g., Holden and Shiferaw, 2004; Kruseman and Bade, 1998; Laborte *et al.*, 2009; Van den Berg *et al*., 2007).

This paper contributes to the existing literature on farm household modeling, but does not only assess the effects of a policy-induced land set-aside scheme but also introduces possible compensation schemes for its adoption. The modelisation allows for an *ex ante* analysis of land set-aside and water addition schemes under the assumption that farm households are rational units which behave in an income-maximizing way. Obviously, all decisions made by the farm household are taken within the constraints (land, labor, credit etc.) and opportunities of cropping activities and off-farm work that the households face. The solutions of the model will show and compare the loss of possible land set-aside schemes and gain of water-addition schemes per type of farm household group in comparison to a base situation, which represents the current situation of farming practices in the area. In order to do this, we will first provide a short overview of the study area and its socio-economic conditions, followed by a description of an already existing typology, which is used in our analysis and application of the farm household model. The farm household model is first applied to the base run scenario and thereafter to the different land set-aside and water addition schemes, followed by a discussion on the impact of these different schemes.

Study area

The study was carried out in Van Chan district, which is part of the mountainous province of Yen Bai, situated in the North-West of Vietnam (figure 1). The province is situated 150 km North-East of Hanoi, has a total area of 6900 km² and a population of around 750,000 inhabitants. The highest altitude in the province is 2500 meters and the main crops cultivated are irrigated and rain fed rice, maize and tea. Van Chan district has a total surface of 1205 km² and its 31 communes form a total population of around 140,000 (GSO, 2008). The majority of the people living in this area belong to one of the ethnic minorities of the Thai, Tay, Dao or H'mong and a village is mostly composed of one ethnic group.

Within the district of Van Chan, four villages in different communes have been selected to gather data on household characteristics, crop production and other activities of farmers. This selection has been based upon the different availability in types of agro-ecological zones, the different ethnicities living in these areas, the different crops grown and the different access to markets.

*Figure 1: Map of research area (*Jourdain *et al.*, 2009).

The first village selected is Pang Cang in the commune of Suoi Giang. This village is chosen for its low amount of irrigated lowland. To compensate for this shortage in irrigated lowland, farmers tend to intensively cultivate the uplands. As for the perennial crops, Suoi Giang is famous for its special variety of tea. The people of this village belong to the ethnic minority group of the H'mong. Earlier research showed that land degradation in the uplands is high in this village, mainly due to the cultivation methods of farmers (Do *et al*., 2007).
The second village is Giang Cay in the commune Nam Lanh, where the people belong to the ethnic minority of the Dao. This village is much differentiated in the amount of irrigated lowland that they have available. The village authorities prohibited the cultivation of upland rice as part of a project to preserve the hillsides. After the price drop in tea, the crop has not been cultivated for sale in this village anymore. Two other cash crops that are cultivated here are ginger and cinnamon.
The third village is Ban Tun in the commune Tu Lé, which is characterized by its relatively large amount of irrigated lowland during the dry and wet season available. The ethnic minority Tai living here do not specialize in any cash crops except for a special variety of sticky rice.
Lastly, the village Nam Chau in the commune Nam Bung has been investigated because of its relatively large amount of newly constructed terraces. Access to water is however low here, which is at least part of the reason that people only cultivate one cycle of irrigated rice per year. The inhabitants of this village also belong to the ethnic minority of Dao and cultivate cardamom as an important perennial crop.

Despite the fact that the Doi Moi or economic reforms were initiated in the late '80s (Castella, Dang, 2002), the four villages investigated still face some major market constraints. Opportunities to engage in off-farm work are often restricted to certain periods of the year, depending on the village and the type of farm household. Where market access for some farm households may be better than for others, none of the households could decide to fully engage in off-farm work and give up on cropping activities. This could be partly due to the fact that a full establishment of markets takes time, but also because the position of the villages of this study is isolated from outside labor markets. Moreover, the inhabitants of these areas are almost all of ethnic minorities, which does not seem to help them in finding off-farm work and hence, may increase transactions costs of doing so.

Market restrictions are however not limited to the labor market; for all crops besides the main staple crop rice, markets are not fully established. A good example of this is the market for ginger, which is quickly satiated. Because it is often not directly clear how much of the crop is exactly cultivated within the village, prices fluctuate highly from year to year. This would lead a risk-averse farmer to only spend a very limited amount of his resources to the cultivation of ginger, since he would probably only be able to sell a very limited amount for a reasonable price. Moreover, there is no official credit market to which farmers have access. If farmers face food constraints during certain time periods of the year, the most common way of solving these is by borrowing rice from friends and relatives. However, for more chronic food and cash shortages, lending from traders can be a possibility for farmers. Lastly, a land market does not exist in the area; hence, transactions in terms of sale or renting do not occur.

For the cultivation of the main staple crop in the lowlands, irrigated rice, there are two distinct seasons: a dry (December till May) and a wet season (June till October). Upland crops are generally cultivated between March and November and can have two cropping seasons. The upland crops cultivated in this region are upland rice, maize, peanuts, cassava, soybean, sweet potato and ginger. Apart from those, there are three perennial crops grown, namely tea, cardamom and cinnamon. The exact crops cultivated and their periods of cultivation differ somewhat between communes, but the sequence of activities and practices was the same between different communities. This allowed us to establish a general cropping calendar, as can be seen in figure two.

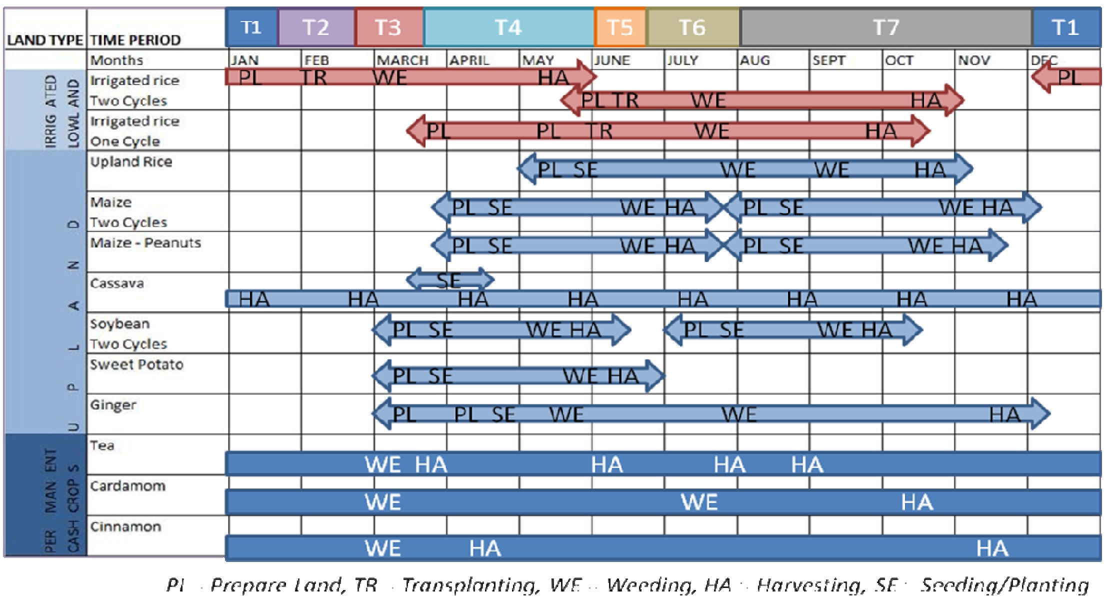

Figure 2: General cropping calendar

The local governments in Yen Bai province aim for a more sustainable management of the ecosystems. In line with this aim is the closing down of the uplands for the cultivation of upland rice in Giang Cay. Food self-sufficiency in order to meet food requirements is one of the main strategies of the farmers in the province. Possible ways to sustain the ecosystems while at the same time trying to sustain food self-sufficiency have been extensively investigated in the area with the help of conservation agriculture such as mulch-based cropping systems (Affholder *et al*., 2010). However, this research led to the conclusion that cropping systems based on mulching techniques still need quite a number of improvements in order to be adopted by farmers. Therefore, if we would want to coincide the objective of maintenance of the eco-systems with meeting the food requirements of farmers, we have to come up with some kind of compensation system in order for farmers to meet their principal strategy.

Farm household typology

During the transition from collectivism to a market economy, lowland fields were redistributed among members of cooperatives. These changes in land tenure policy caused a very unequal distribution of lowland among different ethnicities (Erout, Castella, 2004; Castella *et al*., 2005; Jourdain *et al*., 2010; Sikor, Doa, 2000) and different households in the region. Moreover, the transmission of land between generations, induced by gender differences and the informal rule that prohibits the construction of new terraces upstream of existing terraces without the approval of potentially affected persons, has contributed to an increasing differentiation in landholdings among farm households.

In order to measure the differences in endowments between farm households, a typology of different types of households was constructed in an earlier study (Jourdain *et al*., 2010). For this typology, the two communes of Nam Bung and Suoi Giang were selected based on their contrasting access to markets. Within these two communes, two catchments were selected, based on their differences in lowland area available; Sai Luong in Nam Bung and Pang Cang in Suoi Giang with respectively a large and small amount of lowland available. Within each of the catchments, 60 households were randomly selected using a semi-closed questionnaire aimed at collecting data on household characteristics such as the number of adults and children, production factors such as land and capital endowments, participation in labor and product markets and the access to water and level of control of households in irrigation water. With the help of a Principal Component Analysis (PCA) on all variables, the most discriminating combinations of variables were selected. Thereafter, a hierarchical ascending classification (with Ward links) on centered and reduced retained variables using the procedure hcluster of software package R was conducted (Everitt, 2005). Six contrasted typological household groups with different endowments and related strategies were selected:

Group 1: Water and Land Scarce is characterized by a small landholding, no irrigation water and a low human capital (lowest adult education index of all groups). They could be considered as the most vulnerable group; their landholding is very small, with almost all their land situated in the sloping areas. In order to meet their food requirements, they cultivate almost all their land with staple crops, which is likely to decrease soil fertility. Because these households are generally also the ones with a very restrictive access to markets, their opportunities to work off-farm are limited as well.

Group 2: Water Scarce, Land Rich. This group is faced with a very limited access to water, but does have large areas of sloping land and tea available. Contrary to the previous group, they are connected to the market and are therefore able to sell a large amount of their products, which they mainly seem to do in order to offset their lack of access to water.
Group 3: Off-Farm Work represent a small group of households that have been established for a long time, are endowed with a large workforce and therefore a low amount of irrigated lowland per head. Therefore, they have largely turned towards off-farm work.
Group 4: Terraces and Uplanders are large households, which have been established for a long time. They have a large area of terraces in their possession, but these areas generally do not get a lot of water during the spring season and the household is faced with a large amount of mouths to feed, which leaves them with a rice production per head of the household that is close to self-sufficiency.
Group 5: Terraces and Perennials. This group has a large share of terraces available with good access to water. The slopes are mainly cultivated with staple crops, but they also have a large amount of perennial crops available.
Group 6: Paddy Rich. This group has a large area of paddy land available, which receives a lot of water during the spring season. Staple and perennial crops are cultivated on the slopes.

The differentiation in endowments of farm households, based on the different agro-ecological zones, distribution of land and access to the markets, will lead different farm households to react differently on policy-induced changes such as the land set-aside and water improvement schemes analyzed in this study. In order to get more detailed data of the farmers living in the four villages of our study area, we interviewed 45 households with the help of a semi-structured questionnaire. This concerned an in-depth analysis on their household characteristics, livestock, crops cultivated on each plot of land, the activities and inputs that those crops require and the yield they obtained during the calendar year 2008-2009 on the specific plots, the off-farm and non-farm activities, assets possessed and a food balance on whether or not self-sufficiency in rice and other staple crops was obtained. To cover all these aspects, three rounds of questionnaires with each farm household were conducted, which also gave us the chance to check data that appeared unclear or incorrect. A representative member of each household was interviewed, where we tried to get a sample of male and female respondents, but for traditional and cultural reasons in Vietnam, this was often the head of the household, who, in almost all cases, was male. The households have been selected via a stratified random sample in which we focused on whether the household was classified as a poor household or not and on their amount of paddy and terrace land available, since we assumed that this latter criteria is highly correlated with the well-being of the household.

The data collected were then grouped according to the six types of farm households identified in the typology. Within each typology group, one representative farm household was selected for the farm household model. Their main characteristics are shown in table one below.

Table 1: Farm Household's main characteristics

Farm type	Water and Land Scarce	Water Scarce, Land Rich	Off-Farm Work	Terraces and Uplanders	Terraces and Perennials	Paddy Rich
Household size (pers.)	4	5	7	6	8	6
Family labour force (man-year)	2	2	5	3.5	5	3.5
Land available in each zone (m2)						
Paddy (spring and summer irrigation)	0	0	200	100	200	1500
Paddy (summer irrigation)	0	0	1500	250	250	3000
Terraces (spring and summer irrigation)	0	0	0	1000	300	0
Terraces (summer irrigation)	200	500	800	3000	2100	0
Sloping land	6500	14000	7800	16000	8000	15000
Perennials	600	6000	200	5000	9000	4500
Total Area (m2)	7 300	20 500	10 500	25 350	19 850	24 000

Farm household model

The whole-farm model is built using mathematical programming (Hazell Norton, 1986) and developed on a GAMS-platform (Rosenthal, 2007) of which a mathematical description can be found in the annex. This model was designed in order to reproduce the behavior of farm households that have to select a set of crop and off-farm activities under constraints with respect to available production factors, technical opportunities and food consumption requirements; and how these would change with changing endowments in sloping land and a changing access to water. Therefore, we developed optimization models that incorporate essential characteristics of each representative farmer per type of farm household grouped according to the typology above.

In this study, we analyzed the impact of land set-aside and water addition schemes on different types of farm households by focusing on two aspects. The main objective in the farm household model is income maximization. With this objective, it is assumed that farmers can reach their highest possible welfare. We formulated a cash balance that is composed of incomes coming from the sale of crop products and wages of off-farm activities and expenses that arise from minimum cash living expenses, the purchase of staple food crops, inputs for crops cultivated and wages paid for labor that is hired into the farm. In order to allow for negative cash balances during the season, we included the possibility of borrowing between different time periods. Taking the energy requirements and in the restricted access to markets that farmers face into account, food self-sufficiency in order to meet food requirements is also a main strategy of the modeled farmers. Therefore, we will also look at the impacts that the different scenarios have on the objective of farmers to reach food self-sufficiency.

The objective of income maximization results from the outputs generated by the model, which are the farm income and farm operational plan, i.e. capital, land and labor allocation to each possible activity. A different initial endowment of capital was appointed to each type of farm household. Furthermore, farmland was classified in six land use types based on topography and surface irrigation. Surface irrigation only occurred on paddy or terrace land and can be available either during the spring and summer season or only during the summer season. Next to that, we identified sloping land and land that belongs to perennial crops.

The simulation horizon over which farmers based their decisions on crop cultivation and off-farm activities to undertake was the cropping year 2008-2009. Livestock activities were not included in the model as an income generating activity, since it was not a main activity in any of the surveyed farm types and is unlikely to have a large effect on the results of our simulations. Depending on the type of land, we identified 28 feasible cropping systems, all with a set of data on output and required labor and external inputs. The 28 cropping systems included in the model were composed of 11 crops: 14 single-crop systems, 10 double-crop systems of which four are not rice-based and four specified rotation systems for crops that cannot be grown continuously. The composition of these crops is shown in table two. The rotation systems are composed of several years but modeled according to their average yields and requirements per year. The crops produced by the farmers can either be sold or consumed. Moreover, if food requirements are not met by crop cultivation, crops can also be bought. This led to the establishment of a product balance, in which the household buys, sells or consumes the products that are available.

Table 2: Composition of Cropping Systems

Name	Cropping System	Cropping Type	Land Type
Cassava	Cassava	Single-Crop	Sloping
Ginger	Ginger	Single-Crop	Sloping
Maize (low)	Maize (low inputs)	Single-Crop	Sloping
Maize (high)	Maize (high inputs)	Single-Crop	Sloping
Peanuts	Peanuts	Single-Crop	Sloping
Soybean spring	Soybean (spring season)	Single-Crop	Sloping
Soybean summer	Soybean (summer season)	Single-Crop	Sloping
Sweet Potato	Sweet Potato	Single-Crop	Sloping
Cardamom	Cardamom	Single-Crop	Perennial
Cinnamon	Cinnamon	Single-Crop	Perennial
Tea	Tea	Single-Crop	Perennial
Irrigated Rice (low)	Irrigated Rice (low inputs)	Single-Crop	Terraces/Paddy
Irrigated Rice (med)	Irrigated Rice (medium inputs)	Single-Crop	Terraces/Paddy
Irrigated Rice (high)	Irrigated Rice (high inputs)	Single-Crop	Terraces/Paddy
Maize-Maize (low)	Maize-Maize (low inputs)	Double-Crop	Sloping
Maize-Maize (high)	Maize-Maize (high inputs)	Double-Crop	Sloping
Soybean-Soybean	Soybean-Soybean	Double-Crop	Sloping
Maize-Peanuts	Maize-Peanuts	Double-Crop	Sloping
Rice-Rice (low)	Irrigated Rice-Irrigated Rice (low inputs)	Double-Crop	Terraces/Paddy
Rice-Rice (med)	Irrigated Rice-Irrigated Rice (medium inputs)	Double-Crop	Terraces/Paddy
Rice-Rice (high)	Irrigated Rice-Irrigated Rice (high)	Double-Crop	Terraces/Paddy
Soybean-Rice (low)	Soybean-Irrigated Rice (low inputs)	Double-Crop	Terraces/Paddy
Soybean-Rice (med)	Soybean-Irrigated Rice (medium inputs)	Double-Crop	Terraces/Paddy
Soybean-Rice (high)	Soybean-Irrigated Rice (high inputs)	Double-Crop	Terraces/Paddy
Maize-Cassava	3 years Maize-3 years Cassava	Rotation	Sloping
Upland Rice-Fallow	1 year Upland Rice-2 years Fallow	Rotation	Sloping
Upland Rice-Maize-Cassava-Fallow	2 years Upland Rice-2 years Maize-2 years Cassava-3 years Fallow	Rotation	Sloping
Upland Rice-Cassava-Fallow	2 years Upland Rice-2 years Cassava-2 years Fallow	Rotation	Sloping

Regarding the cultivation of these crops, all farm households face some major labor constraints at certain time periods. Therefore, we divided the year into seven time periods corresponding to the main labor patterns in crop cultivation identified by the surveyed farmers, which can be found in figure two above. In each time period, the household allocates its available time between different cropping activities and off-farm opportunities. If family labor is not sufficient to fulfill all tasks needed on the farm, additional labor can be contracted; however, wage employment in both the farm and the non-farm sector is limited. Because land transactions in terms of sale or renting were not observed during the surveys, they were not included as possible options for the modeled farmers.

Lastly, there are several market imperfections that we took into account in the model; A price band between the farm-gate price and the consumer (retail) price of the crops produced represents the shallow market opportunities and will force farm households to produce for home consumption and try to reach food self-sufficiency (De Janvry et al., 1991). The opportunities to sell cash crops are often restricted, such as for the example of ginger mentioned in the introduction. Therefore, we only allowed a restricted percentage of land per farm household type to be cultivated with these crops. Furthermore, a 10% transaction cost for hiring-in and hiring-out labor was also included. These costs represent the expenses of finding off-farm work and making the transition to the job and back beyond the actual salary that the farmer either receives or has to pay. Because of this, it could be likely that farmers with a high labor/land ratio, such as the group Off-Farm Work will face a shadow price of labor that may be below the market wage rate.

Base run results

The modelisation results in terms of cropping systems used in the base run scenario, in which current farmers endowments are included, can be found in figure 3 below.

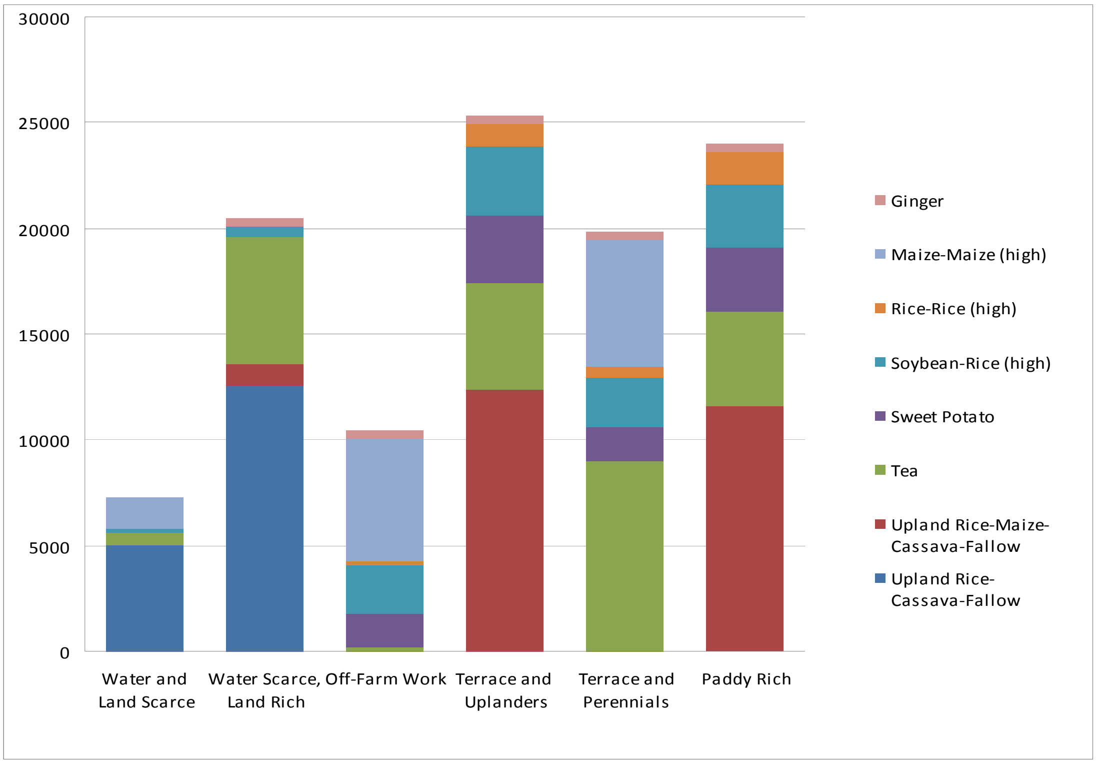

Figure 3: Cropping systems' results of the base run scenario

Under current endowments, all modeled types of farm households spent all their irrigated land available to soybean-irrigated rice with high inputs if water is only available during the summer season and two cycles of irrigated rice with high inputs if water is also available during the spring season. This suggests that these technologies are not likely to be rejected because of cash and labor constraints. Sensitivity analysis does however show that an increase of off-farm activities could lead to a substantial decrease in the interest of farmers who can reach self sufficiency in rice of cultivating the crop, but does not show such an effect for those farm-households who are not self sufficient in rice. Soybean-Irrigated Rice is the only cropping system that is cultivated according to the model but is not very common in reality. There are three main reasons underlying this; Firstly, soybean cultivation on irrigated rice fields is a new cropping system that is being promoted by most of the local authorities. Risk averse farmers may be reluctant in adopting new cropping systems; the absence of risk considerations in the model may not take this into account. Secondly, there is not yet a market chain developed for alternative crops as there is one for rice. Thirdly, adopting spring crops in irrigated areas is something that farm households commonly have to do because of the livestock which is allowed to walk freely in these areas during the spring season. Simple measurements such as fencing could however prevent this. For now, cultivation in the lowlands does not seem to diminish cultivation in the uplands, since the labor constraint of most farmers in the area is, due to the very high land constraints, not high.

The two poorest groups of farm households are forced to mainly use the short rotation of Upland Rice-Cassava-Fallow on the slopes because of their insufficiency in rice. Only farm households with sufficient area of paddies seem to relieve pressure on the sloping areas, but this is mainly due to the labor shortages that they face during critical periods of upland crop cultivation (establishment of summer crops in the sloping compartment). From table 3 below it can be seen that cash and total revenues per farm household type in the base run are very unevenly distributed.

Table 3: Simulated revenues per farm type

	Water and Land Scarce	Water Scarce, Land Rich	Off-Farm Work	Terrace and Perennials	Terrace and Uplanders	Paddy Rich
Ranking in revenue per head	1	2	4	3	6	5
Cash Revenue (PPP/day/head)	0.91	1.63	2.43	2.41	3.18	3.13
Total Revenue (incl. auto-consumption) (PPP/head/day)	1.59	2.24	2.79	2.77	3.54	3.49
1 PPP = 6100 VND (International Monetary Fund)						

Alternative scenarios

In the different simulations, where some sloping land is set aside for re-forestation projects in order to restore the watershed function, land available for upland farming is reduced. In parallel, we assumed that water access for irrigation was improved in the lower part of the catchment. Different alternative scenarios on how land could be set aside (from whom and what share of set-aside land for each farm type) and how the additional available water would be shared were developed. With these different simulations, we aimed to provide more insight in the trade-offs involved in the resource use between different parts of the catchment for different groups of farmers. In order to restore the watershed functions, land available for upland farming is reduced, which meant that the ‘sloping’ area for each modeled farm was scaled down. There are two reasons behind making more water available: Firstly, an increased area of forest in the upper compartment of the catchment would change the water flows which would make more water available for irrigation in the lower compartments. Secondly, some new infrastructure works can be built that increase the amount of water available for the community. This latter argument could be interpreted as a compensation for the land set-aside in order to restore watershed ecosystem functions and as an incentive from policies for farmers to do so. Depending on the watershed configuration and institutions, different scenarios of water increasing availability can be thought of.

In order to fully measure the trade-offs, we modeled a hypothetical village of 112 households, in which the six types of households are in strict proportion to the data gathered in the typology. We simulated that 10 hectare or 8% of sloping land is to be set aside for forest re-growth, based on the assumption that this would be the maximum amount of sloping land that farm household’s would be able to set aside. In table 4 three mechanisms to set-aside this 10 ha of land among different types are calculated: first by converting 8% of each household’s sloping land; secondly, by converting 870 m^2 of sloping land from each farm household; lastly, by setting-aside 1650 m^2 of sloping land only from farm households belonging to the two richest types. With these three different set-aside schemes, we aim to measure the losses in terms of revenues and food self-sufficiency that different types of farm households have to overcome and what the impacts in terms of revenue of these losses would be for the village as a whole.

At the same time, we analyze the benefits of additional water access for different types of households and the village as a whole caused by the set-aside of land by investigating four exclusive scenarios’s based on how much water can be made available and how this is used. In the first case, we do not built new terraces, but assume that the 10 ha of sloping land that is set aside will make additional water in 2 hectare of lowland available, which is allocated by converting 12% of each farm household’s existing endowment in paddy/terrace land with only summer irrigation to spring and summer irrigation. In the following three scenario’s, we increase the amount of terraces with water available during the summer. In the first scenario, we allocated 180m^2 of terrace land with summer irrigation to each household. Secondly, we allocated 150m^2 of terrace land with spring and summer irrigation to each household. The difference in size between these two scenarios’s follows from the reasoning that it is more difficult to fetch water during the spring season than during the summer season. Lastly, we assigned 300m^2 of terraces with spring and summer irrigation to the households belonging to the two poorest types. These scenarios are represented in table 4 below.

Table 4: Different trade-off scenarios

Zone	Water and Land Scarce	Water scarce, Land Rich	Off-Farm Work	Terrace and Perennials	Terrace and Uplanders	Paddy Rich	**Total (ha)**
No. Farmers	37	16	7	14	16	22	112
Sloping area (m2)	6500	14000	7800	8000	16000	15000	122
Set aside of sloping land (m^2)							
Equal proportion (8% each)	520	1120	624	640	1280	1200	10
Equal area	866	866	866	866	866	866	10
Equal area (richest)	0	0	1645	1645	1645	1645	10
Additional water in the lowland (m^2)							
Convert 12% of terraces with summer irrigation to spring and summer irrigation	24	60		252	360		1.1
Convert 12% of paddy with summer irrigation to spring and summer irrigation			180			360	0.9
							Total Converted: 2
Add equal area terraces with summer irrigation	180	180	180	180	180	180	2
Add equal area paddy with spring and summer irrigation	150	150	150	150	150	150	1.6
Add equal area terraces with spring and summer irrigation to poorest	300	300	0	0	0	0	1.6

These three types of sloping land set-aside, and four types of allocation of the newly developed irrigable land lead us to 12 alternative scenarios as represented in table 5.

Table 5: Overview of 12 alternative scenarios

Additional water in lowlands	***Set aside 8% from all***	***Set aside 870 m2 from all***	***Set Aside 1650 m2 from rich***
Convert 12% paddy/terraces with summer irrigation into spring and summer irrigation to all	S01	S05	S09
Add 180m2 terraces with summer irrigation to all	S02	S06	S10
Add 150m2 paddy with spring and summer irrigation to all	S03	S07	S11
Add 300m2 terraces with spring and summer irrigation to poorest	S04	S08	S12

Land set-aside and more water in the bottom valleys

Table 6 below shows the impact of total revenues for each of the trade-off schemes on the individual farmer (weighting the impact on households by the number of persons in the household), the different types of farm households and the village as a whole (weighted sum of the impact on each household type). As can be seen from the table, it is not likely that any of the trade-off schemes will have a large impact on the aggregate village revenues, ranging between a negative relative change of 3.8% and a positive relative change of 1.8%. Moreover, poor households seem to be affected worst; with the lowest amount of land endowments, a change in land allocation is likely to have the highest impact on this type of farm households. Therefore, positive and negative impacts will change most for this type of households, ranging between a negative impact of 21% and a positive impact of 19.2%.

The largest revenue losses for the village as a whole can be found under scenario S01 and S05. Here, additional production in irrigable land clearly does not compensate for the loss of land in the sloping compartment. This shows that, especially for the poorest group of farmers, insufficient compensation for the set-aside of land can have some dramatic effects in terms of revenues and over time also in terms of land fertility. The highest overall revenues of the two poorest groups of farmers can be found under S11 and S12, which would also largely reduce the insufficiency in rice shortages among these groups of farmers.

Overall, individual financial rewards for setting aside some sloping land will only be viable for the richest group of households because of their lower opportunity cost of land. These results are complementary to earlier simulations made on poor farmers with very low access to markets (Jourdain, 2009). The analysis leads us to conclude that the allocation of new irrigable land reinforces the existing inequalities in terms of land and water allocation between different types of farmers and is therefore not attractive from a social and private point of view. The most attractive scenario's for the majority of the village are those that lead to a large increase of farm revenue for the poorest households, and a small decrease for the richest households, such as S03, S04, S07, S08 and to a larger extend scenario S11 and S12.

Table 6: Total revenues impact

Total Revenue Change Per Farm Household Group (%)	**S01**	**S02**	**S03**	**S04**	**S05**	**S06**	**S07**	**S08**	**S09**	**S10**	**S11**	**S12**
Water and land Scarce	-17	11.6	12.5	15.6	-21	8.9	10	13.1	5	15.6	16.2	19.2
Water Scarce, Land Rich	-2	-0.8	3.5	7.9	-1.6	0.1	4.3	8.5	-0.2	3.1	7.3	10.4
Off-Farm Work	-1	-0.6	-0.3	-1.5	-1.6	-1.1	-0.9	-2.1	-3.4	-3	-2.7	-3.9
Terraces and Perennials	-0.7	-0.6	-0.3	-1.3	-1.2	-1	-0.8	-1.8	-3.1	-2.9	-2.6	-3.7
Terraces and Uplanders	-1.2	-1.4	-1.1	-2	-0.5	-0.7	-0.5	-1.4	-1.8	-2	-1.7	-2.6
Paddy Rich	-1.2	-1.3	-1.1	-2	-0.6	-0.8	-0.5	-1.5	-1.9	-2.1	-1.9	-2.8
Total Revenue Changes For the Village (%)												
Village	-3.4	0.7	1.5	1.8	-3.8	0.6	1.5	1.7	-1.1	0.8	1.6	1.6
Average Revenue Changes Per Head (%)	-5	2	3	3.7	-5.8	1.6	2.6	3.2	-0.4	2.6	3.5	4
Gini coefficient of revenues (0.24 under base run)	0.24	0.23	0.22	0.21	0.27	0.23	0.23	0.22	0.23	0.22	0.21	0.21
Gini change (%)	-2	-7	-8	-11	11	-5	-7	-10	-4	-11	-12	-15

Discussion and conclusions

Farmers in the upper-catchments of Northern Vietnam have undergone some major changes over the past decades. This led them to make more and more land from forests available for cultivation, while increasingly use the land on the hillsides available with a decreasing amount of fallow periods between cultivation. In order to better understand the strategies and livelihoods of farmers in these areas, we examined the effects of different trade-off schemes in which forest re-growth was compensated by making more water available in the lowlands. A farm household modeling approach was used in this study to develop twelve scenarios where some land in the sloping compartment is set-aside for forest natural re-growth, while additional land is made irrigable in the lowland compartment of the farms. These scenarios varied by the way land is set-aside and irrigable land is divided among farmers of a village.

The base run results showed that currently farmers use all the irrigated land that they have available for cultivation and that the cropping systems of soybean in the spring and irrigated rice in the summer where no spring-water is available or two cycles of irrigated rice are very likely to be adopted by all types of farm households. The fact that risk is not yet adopted in this model may however give a slightly biased view on the adoption of soybean in the spring. Based on the base run, we can say that in general, the higher the self-insufficiencies in rice from the lowlands that farm households face and the more restrictive the possibilities to engage in off-farm work are, the more likely they are to practice intensive cultivation on the sloping land. This means that especially the poorest groups of farm households practice intensive crop cultivation on the slopes with short rotations and few fallow periods.

The analysis of the twelve alternative scenario's led us to conclude that a reduction of cropped area, associated with small increases in irrigable land in the lower compartment, has some potential beneficial effects in terms of restoration of watershed functions and in terms of distribution of revenues among households of a community, without having a major impact on the aggregate village revenues. In some scenarios, this can lead to an improvement in the revenues of poor farmers, while not affecting much of the revenues of better endowed farmers. Impacts on revenues do however seem to be small, especially for the farm households which are poorly endowed in land. Moreover, increased lowland productivity does not seem to have a large impact on activities conducted in the sloping areas.

This type of scheme, where sloping land is set-aside and small quantities of irrigable land are being distributed is likely to be more efficient and equitable than a pure financial reward for setting aside some sloping land. Coordination at the village or commune level and a deliberative choice to help the poorly endowed households is however essential in order to achieve a distribution that has the support of and is beneficial to most of the households in the village and the poorly endowed households in particular. This is especially of large importance in the light of the re-allocation of land after the transition from the collective to the market system, which showed that a very uneven distribution of land could emerge from village decisions. The methodology and results presented here could be of large value in coordination and deliberation at the level of local authorities and can contribute to *ex ante* assessments of policies targeted at ecosystem restoration by farmers.

Annex 1: Mathematical Description of the Model

The farm household model represents an average household for each farm household group as described in the typology. Table 1.1 and 1.2 below give a description of the indices and variables used in the equations below.

Crop Production

Production equation:

$$\mathbf{PROD(p,t) = \Sigma_{c,z} X(c,z) * Yield(c,p,z,t)}$$

The quantities of products that are produced in each period.

Product balance per product, per time period:

$$\mathbf{BAL(p,t) + PROD(p,t) + BUY(p,t) – CONS(p,t) – SALE(p,t) = QEND(p,t)}$$

A balance of what the household produces, buys, consumes and sells per time period.

Transition of balances between periods:

$$\mathbf{BEG(p,t+1) = QEND(p,t)}$$

The starting balance of one period corresponds to the ending balance of the previous period

Labor Allocation

Labor balance (for each period t):

$$\mathbf{\Sigma_{c,z} X(c,z) * Lab(c,z,t) + LIN(t) \leq FamLab(t) + LOUT(t)}$$

The labor that is devoted to different cropping activities or off-farm activities. Labor can also be sold outside or into the farm.

Limitation on off-farm opportunities:

$$\mathbf{LOUT(t) \leq FamLab(f,t) * sLIMLAB(f)}$$

Labor opportunities per farm household depend on the likelihood to find real off-farm opportunities.

Cash Flow

Cash constraint:

$$\mathbf{CASHBEG(t) – LIVEXP(t) – \Sigma\ (BUY(p,t) * BUYPRICE(p)) + \Sigma\ (SALE(p,t) * SALEPRICE(p)) + LOUT(t) * LPRICE * (1\text{-}trc) – LIN(t) * LPRICE * (1 + trc) – \Sigma\ (c,z,t,i)\ (INPUTS\ (c,i,t) * INPP – BORROW(t)*wBORROW = CASHEND(t)}$$

The costs for living expenditures minus the food that has to be bought, the labor that is hired in, the costs for inputs for cropping systems and the interest rate on borrowing, plus the earnings from food that is sold, off-farm work. It is possible to borrow, but this has to be repaid at the end of the period.

Transition of cashflows between periods:

$$\mathbf{CASHGBEG(t+1) = CASHEND(t)}$$

The starting cash flow of one period equalizes the ending of cash flow of the previous period.

Consumption

Consumption requirement of staple crops per time period

$$\mathbf{\Sigma(CONS(p,t) * ENERGYVALUE(sc) * UVALUE(sc)}$$

≥ DAILYNEEDS(g)*FAMCOMP(f)

Based on their daily calorie intake, farm households have to consume a certain amount of the staple crops rice, maize or cassava, for which they have a preference for the consumption of rice, as is identified by the higher utility value for this crop.

Land Constraints

Land constraint equation:

Σ_c **X(c,z) ≤ *area*(z,f)**

In each agro-ecological zone (z), land used by crops is limited by the household's land endowment (area(z,f)).

Restriction on use of ginger:

X(cGI,Sloping) ≤ 0.05 * Area(Sloping,f)

Ginger is normally only cultivated in the gardens of the farmer and due to the fluctuations in price and market access will remain a side activity to farmers.

Objective Function

Objective function of income maximization

Max Y = CASHEND(t) – BORROW(t) * wBORROW

The farm household is assumed to maximize its discretionary income (Y) under the restrictions given above by choosing those activities from crop production and off-farm work that will bring the highest expected values of monetary income after deduction of the essential food requirements and repayment of possible loans. In order to keep production sustainable over time we included an additional loss component for borrowing.

Table 1.1 Description of variables

Variable	Description
Area(z,f)	Area per zone per farm household type
BAL(p,t)	Product balance per product per time period
BEG(p,d)	Stock of crops at the beginning of each period
BORROW(d)	Loan to be paid in period d
BUY(p,d)	Quantity bought per product per time period
BUYPRICE(p)	Consumer price of product p
CASHBEG(d)	Cash balance at the beginning of period d (endogenous)
CASHEND(d)	Cash balance at the end of period d (endogenous)
CONS(p,d)	Quantity consumed per product per time period
DAILYNEEDS(g)	Daily calorie intake necessary per gender/age group
ENTERGYVALUE(sc)	Kilo calories per kg of the staple crop
FAMCOMP	Family composition per farm type
FamLab(f,t)	Family labor available during period t
INPP	Input prices
INPUTS(c,I,t)	Input requirements of input I for crop c during period t (exogenous)
Lab(c,z,t)	Labor requirement of crop c in zone z during period t
LIN(t)	Amount of external labor from outside the farm
LIVEXP(d)	Cash expenses of the household in period d (exogenous)
LOUT(t)	Amount of family labor sold during period t
LPRICE	Daily wages (or other off-farm activities)
PROD(p,t)	Quantity produced per product per time period
QEND(d)	Stock of crops at the end of each period

SALE(p,d)	Quantity sold per product per time period
SALEPRICE(p)	Farm-gate price of product P
Slimlab(f)	Restriction on off-farm labour per farm household type
trc	Transaction costs on the labor market (in % of the average price)
UVALUE(sc)	Utility value per staple crop
w BORROW(d)	Additional loss component for borrowing
X(c,z)	Production of Crop per Zone
YIELD(c,p,z,t)	Production of products from crops per period per zone

Table 1.2 Description of indices

Index	Description	Element	Description
c	Crops to be cultivated	cCM cCA cCI cGI cMA cPE cIR cSB cSP cTE cUR	Cardamom Cassava Cinnamon Ginger Maize Peanuts Irrigated Rice Soybeans Sweet Potato Tea Upland Rice
z	Agro-ecological zone	IRRPAD_SP IRRPAD_SU IRRTER_SP IRRTER_SU SLOPING PERMCASH	Irrigated paddy during spring and summer Irrigated paddy only during summer Irrigated terraces during spring and summer Irrigated terraces during summer Sloping land for the cultivation of upland crops Perennial crops
t	Time period according to cropping calendar	T1 T2 T3 T4 T5 T6 T7	1 Dec - 15 Jan 16 Jan - 20 Feb 21 Feb - 20 Mar 21 Mar - 31 May 01 Jun - 20 Jun 21 Jun - 30 Jul 31 Jul - 30 Nov
p	Product balance		Sum of crops cultivated, bought or sold
i	Inputs	NPK N PEST HERB SEED	Nitrogen(5)- Phosphor(10) - Kalium(3) Nitrogen(46) Pesticides (in different packages) Herbicides (in different packages Seeds (for different crops)
f	Farm Household Type	WSLS WSLR OFFW TERLAB TERUPL PARI	Water short, Labor short Water Short, Land Rich Off-Farm Work Terraces and Perennials Terraces and Uplanders Paddy Rich
sc	Staple Crop	cIR cUR cCA cMA	Irrigated rice Upland rice Cassava Maize
g	Gender	MEN WOMEN CHILD BABY	Male Female Child Baby

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