Population pressure, market access and food security in the uplands of northern Vietnam: a micro-economic analysis

Sushil Pandey
Social Sciences Division
International Rice Research Institute
MCPO Box 3127, Makati City 1271
Philippines
Email: sushil.pandey@cgiar.org

And

Nguyen Tri Khiem
Can Tho University
Can Tho, Vietnam

Key words: uplands, food security, commercialization, Vietnam

---

Full Abstract

Upland areas in Vietnam account for two-thirds of its natural area and one-third of its population. These uplands are characterized by heterogeneous and fragile ecosystems, a high incidence of poverty, severe deforestation and soil degradation. Rice is an important staple which is grown in the upland fields using shifting cultivation and in intensive lowland fields. The predominantly subsistence-oriented agricultural production system of these upland areas is undergoing intensification due to rapidly increasing population pressure. Changes in government policies regarding uplands and improvements in access to markets have led to the evolution of market-oriented production systems in some areas. In addition, rapid improvement in the productivity of lowland rice following decollectivization has also affected the use of upland areas.

The paper examines the effect of population pressure and market access on cropping patterns, cropping intensity, the extent of commercialization of production systems, land and labor productivity, household food supply and the overall level of poverty. The analysis is based on a cross-sectional survey of 980 farm households from 33 communes of six provinces during the crop year 1997-98. It is hypothesized that (a) the cropping intensity is positively related to the population density and is negatively related to market access, (b) labor productivity in agriculture is higher in areas with better access to market, (c) upland rice occupies proportionately smaller area of upland as the size of the lowland holding increases, and (d) the extent of food shortage depends on land and labor endowments as well as the access to markets. Reduced-form models were used to investigate these hypotheses.

Cropping intensity was found to be higher in communes with a higher population density supporting the Boserupian hypothesis. Market access, which was specified as a dummy variable (low access and high access), affected labor productivity and cash income positively. Despite these positive effects, the agricultural production system was found to be predominantly subsistence-oriented with farmers striving to achieve food self-sufficiency even in areas where a lot of cash crop is grown. The proportionate area under upland rice was found to be related negatively with the size of the lowland holding indicating that an improvement in lowland productivity can help reduce the intensification pressure in the upland. Farmers with better access to market and with larger farms were found to have a lower incidence of food shortage than farmers with limited access to markets and with smaller farms.

A simulation model was developed to project the likely effect of continued increase in population pressure on food production, labor absorption in agriculture, calorie consumption per capita and the extent of poverty. A simple life table was used to project the population by sex and age group for the next 20 years. The effect of rising population pressure on food production was simulated assuming that the current agricultural productivity of different land/labor quartiles applies to the households as they move across the quartile groups. The static projection indicated that while the labor force will increase by 75% in 20 years, labor use in crop production will increase by only 9%, thus showing the need to expand labor absorption in the non-crop sector. With the existing technology, crop production will increase by only 5% of its current value leading to a dramatic decline in per capita food supply. The growth in rice yield (both upland and lowland) of at least 2% per annum is needed to maintain the current per capita calorie intake. An improvement in the upland rice yield was found to be an important strategy in reducing the poverty of the low-income quartile group that depends mostly on upland rice. Given the size of the population growth, the overall reduction in poverty will require an expansion of employment in the non-crop and non-farm sectors.

The paper concludes with recommendations that include (a) further expansion of market access and development of more effective marketing institutions, (b) a regionally differentiated approach to agricultural diversification that recognizes the environmental diversity, (c) improvements in food production technology, (d) expansion of income-generating activities such as agro-processing and (e) more effective population control programs.

Population pressure, market access and food security in the uplands of northern Vietnam: a micro-economic analysis

Introduction

Two thirds of the natural area of Vietnam is classified as uplands where 25 million people or one third of the country's population are living. Uplands in Vietnam are characterized by heterogeneous and fragile ecosystem, high incidence of poverty and severe deforestation and soil degradation. The increased population pressure due to natural growth as well as migration of lowlanders has compounded the problem.

A major factor that is affecting the upland systems of Vietnam in recent years is a shift in the outlook of the government towards these areas based on the recognition that upland systems are an important component of the overall economy. As a result, the government is undertaking additional investments to build rural infrastructures. In addition, policy and institutional reforms are being undertaken to improve the welfare of people in these uplands. For example, new kinds of property rights institutions such as stewardship contracts are being promoted to encourage more sustainable use of land at the forest margin. Institutions to discourage shifting cultivation and clearing of forest-land for upland rice cultivation (MARD, 1998) are being introduced. These efforts have improved the market access in the uplands, encouraged a diversification of upland production systems and led to increasing commercialization of agriculture.

The process of commercialization and diversification of the upland systems has also been facilitated by a rapid increase in productivity of lowland rice. In late 80s, Vietnam began a process of decollectivization, market reform, and trade liberalization in combination with investment in water control and promotion of short-duration high-yielding varieties of rice. These reforms stimulated rapid expansion in rice production over the period 1986-89 and Vietnam has now become the third largest rice exporting country (Khiem and Pingali 1995, Minot and Goletti, 1998).

These changes in the rice economy and the impact of new policy and institutional initiatives being undertaken to develop upland areas may increase or reduce the pressure for intensification of upland use. It is not possible to predict a-priori the nature of adjustments

in upland systems these changes might trigger. Some studies have indicated that policy changes have led to an increase in crop yields and reforestation of formerly barren hills (Donovan et al. 1997, Tachibana et al. 1998). An increase in lowland productivity can lead to reduce the pressure for food production in uplands (Coxhead and Jayasurira 1994, Tachibana et al. 1998). But it may also increase the land use intensity by encouraging cash crop production and may lead to further exploitation of marginal lands (Barbier and Bergson 1998). There are evidences that as farmers in Vietnam have substituted high-yielding maize for upland rice in more favorable areas, upland rice production has been pushed to the more marginal land. In addition, in areas where marketing institutions are not well developed, a shift to non-food crops can increase the vulnerability of small farmers due to the uncertainty associated with the price of cash crops (Dewey 1981). On the other hand, commercial production can increase the total household income and trigger further multiplier effects by encouraging the adoption improved technologies (Von Braun and Kennedy 1994).

The manner in which the upland households respond to improvements in market access and to changes in economic opportunities is a critical factor in determining the merits of agricultural policies. The present study aims at examining the impact of the changes in market access and population pressure on food supply at the household level, on the cropping intensity in uplands, and the productivity of labor. The analysis is based on a survey of 980 households from 33 communes of 6 provinces in the northern mountainous highlands during the crop years 1997-98 and 1998-99.

Conceptual Framework

Population pressure has been considered to be a major factor leading to intensification of agriculture (Boserup 1981). While the initial response to population increase may be to expand the area, the closure of land frontier ultimately will force more intensive use of land as households attempt to satisfy their food needs from the shrinking land base per capita. This type of intensification will reduce the labor productivity as fallow periods are reduced and more and more labor is applied to a given land holding. This situation leads to a downward spiral of population growth-intensification-poverty unless technological change

can arrest further decline in labor productivity or a massive emigration reduces the population pressure.

Intensification may also result from expansion of marketing opportunities. The additional demand created by marketing opportunities initially provides incentives for an expansion of area and ultimately for more intensified land use. Labor supply is less likely to be a constraining factor as improved access to markets reduces the cost of labor-substituting technologies such as tractors and herbicides. Better access to inputs such as fertilizers also improves the returns to land and labor thus further reinforcing the intensification process. The downward spiral resulting from population-driven intensification can be avoided when intensification is market-driven.

The effects of commercialization and policy measures on rural household income and consumption are mediated through complex relationships. An expected increase of income and production capacity will motivate households to enter exchange economy and become more commercialized. The most important exogenous determinants of commercialization are population change, the availability of improved technologies, investment in infrastructures, macroeconomic policies that alter incentives to agricultural production. The endogenous consequences of commercialization are household decisions on resource allocation i.e. mainly family labor, adoption of technologies reflected in land use patterns and expenditures on food and non-food products.

Survey design and data

A stratified sampling design was used to select farm household to generate data set covering a wide range of population density, market access, ethnicity, relative proportion of upland and lowland areas, and the extent of crop diversification. In total, 980 households in 33 communes were included in the survey. In pooling household data for comparative analysis, communes were classified as having good or poor market access by considering degrees of market access in terms of physical distance to market centers and the main transport routes across districts.

Tables 1 presents a summary of general characteristics of households in areas with poor and good market access. Average farm size is 1.26 and 0.88 hectares for the two groups of households, respectively. Households in locations with good market access are generally

found in lower altitude, cultivate land with lower slope and have slightly more lowland area. In market accessible areas, the major cash crops are improved maize and horticultural crops. For example, 10% of upland area is planted to cash crops (such as fruit trees, beans, peanuts) in locations with good market access compared with only 3% in locations with poor access to markets.

Despite a lower farm size, the total household income is 23% higher and the cash income is 45% higher in areas with good access to market. When expressed in per capita terms, these gaps are even greater as the household size is bigger in areas with poor access to markets. All of this difference can not be attributed to the differential market access in a cross sectional study like this one as other factors such as soil fertility, rainfall and climate also vary from location to location. However, without the differential access to markets, the effect of these natural variations on household income would probably have been much lower. This is indicated by the near equality of the non-cash component of the income in these two locations. The difference in the total household income between the two locations is driven mainly by the differences in cash income.

In terms of land use, lowland fields are almost invariably planted to rice. Rice is planted twice in fields that have access to irrigation. Other crops are rarely grown in these lowland fields. Upland rice, maize and fruits/vegetables are the major crops grown in the uplands. The relative proportion of rice and maize to the total upland area are similar irrespective of the market access. The main difference is in the area under orchard/home garden which is higher in areas with better access to markets. The fallow area is correspondingly lower. Thus, in percentage terms, land use intensity in areas with better access to markets is higher than in locations with poorer access to markets. Farmers in locations with poorer access to markets, are however, much more dependent on upland rice for food needs as indicated by their higher share of upland rice in total rice output relative to locations with better access to markets.

Hypotheses and Model specification

The first model examines the effect of population density on land use intensity in the uplands. A simple measure of land use intensity is the length of the fallow period. The longer the fallow period, the lower will be the intensity of land use. Information on the length of the last fallow period for each upland parcel was obtained from the survey. The explanatory variables used are the population density, field slope and the travel time from the house to the field. The effect of population density on the length of the fallow period is expected to be negative. Field slope is a proxy for land quality, and hence, its effect is expected to be positive implying that fields with greater slope (or poorer quality) are less intensively cultivated, with other things remaining the same. Parcels nearer to the homestead are expected to be more intensively cultivated as less labor is required in travelling time. In addition, the policy of sedenterization of shifting cultivators and granting more secure land tenure is expected to encourage farmers to intensify the use of parcels closer to their homesteads.

The second model attempts to explain the variations in the importance of upland rice across households. The importance of upland rice is measured by the ratio of upland rice area to total upland area. Explanatory variables specified are lowland area, field slope, travelling time from the field to the homestead and market access. For household consumption purposes, rice from lowland and uplands are almost perfect substitutes. Thus households who have more lowland fields are expected to reduce the area under upland rice. The effect of field slope is expected to be positive as upland rice is the main crop grown in steeper fields while maize and other crops provide alternatives for less steep fields. Fields that are closer to the homestead can be closely monitored and are, hence, likely to be planted to cash crops. This behavior may relegate fields further away to upland rice thus generating a positive effect of distance on the upland rice area. Market access is expected to have a negative effect on allocation of area to upland rice.

In the third model, labor productivity in agriculture is specified to depend on farm size (a proxy for population density), household capital and labor endowments, and the access to market. Following the Boserupian argument, an increase in population pressure (or a

reduction in the farm size) is expected to reduce labor productivity, ceteris paribus. Thus the expected sign of the coefficient of farm size, which can be considered to be a proxy for population pressure, is positive. Household capital endowment is also expected to have a positive effect on labor productivity. Improved market access is similarly expected to have a positive effect by encouraging a switch to high value crops.

The factors determining the extent of rice shortage is diagnosed in the fourth model. The number of months of rice shortage during the survey year is defined as the dependent variable. This information was elicited from farmers during the survey. The explanatory variables specified are the area of lowland and upland fields, household size, population density and market access.

The expected effects different explanatory variables on the dependent variables of these models are shown in Table 2.

In addition to the estimation of these reduced-form models, the consequences of continued population growth on food balance were projected using a static projection. A simple life table was used to project the population by considering the major demographic parameters applicable to northern mountainous regions of Vietnam. For brevity, the net migration was assumed to be zero. The existing cropping pattern and land productivity of the different land-person quartile groups were used as the basis for predicting the effect of population growth on food production and labor absorption in agriculture. This assumption implies that no change in agricultural technology or non-farm employment opportunities will occur in the future. Obviously, this is a very restrictive assumption but this assumption is used to generate a "benchmark" scenario. Alternative assumptions on the technological improvement in upland and lowland rice production are subsequently specified to assess the impact of various technological interventions on food balance and poverty of different income quartiles.

Model results and discussions

The regression results are presented in Table 3. In the first model, the population density has a statistically significant negative effect on the length of the fallow period indicating that the cross sectional data analyzed provides support to the Boserupian hypothesis. The communes where the population density is higher have a shorter fallow period, with the average fallow period for the whole sample being 4.4 years. The regression does not pick up the effects of land-specific factors on the length of the fallow period.

In the second model, the statistically significant negative effect of lowland area supports the hypothesis that an improvement in the productivity of lowland paddy will reduce pressure to produce rice in the uplands. In doing so, it will free up upland for other crops which may be cash crops. Whether such a switch will have a positive environmental effect is uncertain since it will depend on a number of other factors such as the types cash crops chosen and the institutional arrangements for growing such crops. If upland rice is substituted by more erosive annual cash crops, the environmental effect could in fact be more detrimental. In fact this seems to the case in some parts of Vietnam where upland rice is being replaced by maize. As farmers plow the fields more intensively for maize than for upland rice, soil erosion problem in the maize fields which also has poorer canopy cover may have increased.
The results also indicate that improvements in the access to markets can reduce the pressure to grow upland rice through income enhancement.

The third model indicates that the labor productivity in the upland agriculture is positively related to the farm size (which is inversely related to the population pressure). The parameter estimates suggest that an increase in population pressure (i.e., a reduction in farm size) by 1% will reduce the labor productivity by 0.22 percent. Thus, at the current rate of population growth of about 3% per year in the uplands of Vietnam, labor productivity will decline by 0.66% per year. Productivity improvement of 0.66% per year is needed just to maintain the labor productivity. The positive effect of market access indicates that the negative effect of population pressure on labor productivity can be counteracted to a certain extent through an improvement in market access.

Finally, the fourth regression equation shows that both land endowment and market access work favorably to reduce the extent of rice shortage. Improvements in market access could hence be an important strategy for reducing the extent of food shortage. However, the cost of developing road infrastructure in the highly dissected mountainous terrain of northern Vietnam could be quite high, at least in the short to medium run. As the frequency of food shortage is positively associated with the population density, efforts to increase yield of rice and other major food crops are needed to ensure that food shortages do not increase with population growth.

The simulated effect of continued population growth on per capita food availability and calorie intake under various scenario are presented in Table 4. While the labor force will increase by 76% of the baseline value, labor input in crop production under constant technology will increase merely by 9%. Thus, even if labor-absorbing technologies are developed, food production alone is unlikely to be able to absorb the surplus labor force of this magnitude. There is a clear need to expand employment opportunities in the non-food sector. Under Scenario 1, which represents the status quo, food production will increase by 5% only but the per capita caloric intake will decline to 65% of the baseline value. Clearly, these are undesirable consequences.

An increase in the yield of both upland rice and lowland rice by 2% per year is needed to keep the per capita caloric intake to approximately the same level as in the baseline scenario. Given that the historical growth in upland rice yield has been less than 1% per year, this is a major challenge indeed. However, even under the optimistic scenario of 2% growth in yield, it is very unlikely that all of the increase in labor force will obtain gainful employment in food production.

How will various interventions impact on poverty? The simulated impact by income quartile groups is shown in Table 5. For the baseline year, the overall poverty headcount ratio for the northern mountainous region of Vietnam is 59%. This estimate is very close to the one derived by Glewwe (undated) using the consumption survey data (Vietnam Living Standards Survey) for 1997-98. The estimated poverty ratio for the lowest quartile group is 88% indicating a very high degree of poverty. A doubling of lowland rice yield will bring the overall poverty ratio down to 40%, but it will mostly affect the higher income quartiles. An

increase in upland rice yield is seen to produce a slightly more favorable impact on the lower income groups who are more reliant on upland rice production for their food needs. However, the simulation results indicate that even an ambitious program of increase upland and lowland rice yield and non-farm income by 50% will still not make a big dent on the poverty of the lowest quartile groups. These results indicate that, while a higher priority may be accorded to efforts to increase upland rice productivity so that the lowest income groups benefit the most, more fundamental changes in the economic structure are needed to make a significant dent on the poverty.

Concluding remarks and implications

The results of the study indicate the important role the access to market can play in arresting and reversing the Boserupian decline in labor productivity as population-driven intensification of land use occurs. The labor productivity was found to be higher in areas with better access to market, with the improvement in productivity and income resulting mostly from an expansion in cash crop production. Improvements in the access to markets also reduced the need to intensify food production in the uplands. These factors may have also generated positive environmental benefits.

These positive effects based on market access, however, probably would not have materialized unless the productivity of lowland increased to improve the food security of farmers. Unlike in other countries, Vietnamese upland farmers also have some lowland fields. A rapid improvement in the productivity of lowland fields as a result of policy changes during the mid-80s was instrumental in relaxing food supply constraint to diversification of land use in the uplands. In fact, the upland rice area, which had expanded rapidly during the 70s when the lowland rice productivity was low, started to decline after the mid-80s. Improvement in market access alone without the changes in the productivity of rice in the lowland would most likely not have resulted in more commercial production in the uplands.

The results also show that upland rice is an important component of household food security in the mountainous region of northern Vietnam. Due to the remoteness of these areas and the high cost of transporting foodgrains from the productive deltas, the northern mountainous

region has benefitted little from the rapid growth in rice production in Vietnam. Farmers in this area still rely on upland rice even though a part of their food needs is met through an intensive cultivation of small areas of lowland. The farmers who do not have access to even these small areas of lowlands are the most food-insecure.

Vietnam thus represents an interesting case of rice surplus at the national level that co-exists with a chronic food deficit and hunger among the vulnerable groups inhabiting the upland environment. To deal with the increasing supplies and falling price at the national level, the government of Vietnam is encouraging diversification from rice to other high value crops that are increasingly being demanded in the urban centers. This policy of diversification is being promoted even in the uplands in the belief that higher income from non-rice crops will allow farmers purchase lowland rice. However, low opportunity cost of labor, lack of income earning opportunities, poor access to markets and costly transportation of food all point towards the need for in-situ food production. An improvement in household food security through increased productivity of upland rice could be an important strategy to release land and labor required for transition to commercially-oriented systems.

The results from simulation study show that improvement in the crop sector alone will not be adequate to deal with the chronic poverty situation of the uplands. Growth in population will continue to reduce labor productivity and earnings in agriculture unless employment opportunities are generated elsewhere. The biophysical and socio-economic diversity of the upland system also means that a single recipe for development of upland areas is clearly inappropriate. While the overall policy may be to encourage diversification of income sources, the exact nature of economic activity will differ across locations. It is important that policy makers and researchers recognize this diversity and build adequate flexibility in interventions to allow for location-specificity. It is also essential that institutions that build and strengthen local food security networks are fostered through a further decentralization of planning process at the local level. In addition to these reforms, more effective population control programs are needed to reduce the continuing pressure on the fragile ecosystems of the mountainous region.

References

Barbier Bruno and Gilles Bergeron. 1998. Natural resource management in the hillsides of Honduras: Bioeconomic modeling at the micro-watershed level. Environment and Production Technology Division discussion paper No. 32. IFPRI. Washington.

Boserup, Ester. 1981. Population and technology. Oxford: Blackwell.

Coxhead, Ian and Sisira Jayasuriya, 1994. Technical change in agricultue and land degradation in developing countries. Land Economics 70(1994).

Dewey, K.G., 1981. Nutritional consequences of the transformation from subsistence to commercial agriculture in Tabasco, Mexico. Human Ecology 9: 151-87.

Donovan, D, A. T. Rambo, J. Fox, L.T. Cuc and T.D. Vien, (eds) 1997. Development trends in Vietnam's northern mountain region. East-West Center. Center for Natural Resources and Environmental Studies. Hanoi.

Glewwe, P, Gragnolati, M. and Zaman, H. (undated). Who gained from Vietnam's boom in the 1990's? an analysis of poverty and inequality trends. Development Research Group, the World Bank (Mimeo).

Khiem, N. T., and P. L. Pingali 1995. Supply response of rice and three foodcrops in Vietnam. In Denning, G. and Xuan, V.T. (eds.) Vietnam and IRRI: a Partnership in Rice Research. International Rice Research Institute.

MARD 1998. Ministry of Agriculture and Rural Development Report on Development Plan for Northern Mountain Region 2000-2010. Hanoi.

Minot N. and F. Goletti 1998. Export liberalization and household welfare: the case of rice in Vietnam. Amer. J. Agr. Econ. 80: 738-749.

Tachibana, Towa, Nguyen Manh Trung and Keijiro Otsuka. 1998. From deforestation to reforestation through tenure reforms: the case of the Northern Hill region of Vietnam. Hokkaido University, Tokyo Metropolitan University and International Food Policy Research Institute.

Von Braun, J. and Kennedy, E., 1994. Agricultural Commercialization, Economic Development and Nutrition. Johns Hopkins Press, Baltimore.

Table 1. Household characteristics of low and high market access communes areas.

	Poor market access		Good market access	
Number of sampled households	605		375	
Average household size	7.7	(0.14)	6.9	(0.15)
Annual production per household (kg)				
Lowland rice	769	(39)	1134	(49)
Upland rice	606	(23)	320	(21)
Maize	531	(25)	511	(38)
Average area per household (ha)				
Lowland	0.235	(0.02)	0.291	(0.01)
Upland	1.030	(0.04)	0.590	(0.02)
Upland rice	0.436	(0.02)	0.239	(0.01)
Upland maize	0.327	(0.01)	0.234	(0.02)
Home garden/Orchard	0.031	(0.01)	0.058	(0.01)
Annual total income ($US)	559	(89)	686	(55)
Cash income	213	(12)	310	(20)
Sales of crop products	34.6	(2.5)	37.8	(3.6)
Sales of livestock	85.6	(4.5)	134.7	(13)
Sales of forest products	11.2	(2.7)	4.4	(0.5)
Sales of home garden products	6.8	(1.4)	52.6	(8.5)
Non-farm income	75.0	(10.8)	81.2	(6.9)
Non-cash income	344	(11)	374	(13)
Share of cash income (%)	34.7		40.0	
Per capita income ($US)	78	(2.8)	103	(3.5)
Lowland rice area / lowland area	1.09		1.40	
Upland rice output / total rice output	0.44		0.22	
Fallow cycle of upland fields (years)	5.0	(0.10)	4.5	(0.08)

Note: Figures in parentheses are standard errors.

Table 2. Expected effects of major explanatory variables on the dependent variable.

Explanatory variables	Model 1	Model 2	Model 3	Model 4
Population density	-			+
Field slope	+	+		
Travel time	-	+		
Farm size			+	
Lowland area		-		-
Upland area				-
Market access		-	+	-
Value of capital stock			+	
Household size				+

Note: Dependent variables
       Model 1: Length of the fallow period in years
       Model 2: Area of upland rice/Total upland area
       Model 3: Natural logarithm of labor productivity in agriculture
       Model 4: Number of months of rice shortage

Table 3. Estimated parameters of reduced-form models.

Explanatory variables	Model 1	Model 2	Model 3	Model 4
Constant	5.51	38.5	2.64	1.70
Population density	-0.01*			0.01*
Field slope	0.01	0.69*	-0.21	
Travel time	-0.004	0.10*		
Farm size			0.22*	
Lowland area		-12.54*		-1.0*
Upland area				-0.27*
Market access		-12.15*	0.24*	-0.67*
Value of capital stock			0.24*	
Household size		0.91		0.05*
Education			0.13*	
Log likelihood ratio		257		86.2
R²-adjusted	0.17		0.27	
Degrees of freedom	2418	5	804	5

Models 1 and 3 estimated by OLS and Models 2 and 4 estimated by Tobit regression. Farm size and value of capital stock in Model 3 specified as natural logarithm.

Variable definitions:
Dependent variables: As defined in Table 2.
Independent variables:

Population density:	Number of people in a commune divided by the total natural area of the commune.
Field slope:	Slope of the field measured in degrees.
Travel time:	Time in minutes required to travel from homestead to the field in question.
Farm size:	Farm size of the household in ha.
Lowland area:	Lowland area of the household in ha.
Upland area:	Upland area of the household in ha.
Market access	= 1 if good access
	= 0 if poor access.
Value of capital stock:	Value of livestock of the household.
Household size:	The number of adult members in the household.
Education:	Number of years of schooling of the household head.

Table 4 Simulation of growth in labor force, production of major food crops and per capita caloric intake.

Item	Baseline 1999	2009[a]	2019[a]
	(Index: 1999 = 100)		
Population	100	125	161
Labor force	100	135	176
Consumer unit equivalent	100	130	165
Labor input in crop production	100	104	109
Food crop production			
Scenario 1[b]	100	103	105
Scenario 2[c]	100	110	121
Scenario 3[d]	100	118	141
Scenario 4[e]	100	125	157
Per capita caloric intake			
Scenario 1[b]	100	80	65
Scenario 2[c]	100	90	82
Scenario 3[d]	100	90	82
Scenario 4[e]	100	99	98

[a] Projection based on agricultural population growth of 2.38 percent per year.
[b] Assuming yields of lowland and upland food crops remain unchanged.
[c] Assuming the yield of lowland rice increases at 2 % per annum but yields of upland crops remain unchanged.
[d] Assuming yields of upland food crops increase at 2 % per annum but the yield of lowland rice remains unchanged.
[e] Assuming yields of lowland rice and upland food crops increase at 2 % per annum.

Table 5. Simulated effect of various interventions on poverty (percentage of households below the poverty line)

Item	Income group (quartile)				
	Lowest	Second	Third	Highest	All
Benchmark value (1999)	88	71	53	23	59
50% increase in upland rice yield	78	62	42	16	50
50% increase in lowland rice yield	81	62	35	8	46
100% increase in upland rice yield	75	50	27	13	40
100% increase in lowland rice yield	75	56	25	4	40
50% increase in non-crop income	85	65	45	13	52
50% increase in non-crop income and upland and lowland rice production	67	38	19	4	32

Poverty ratio for Vietnam defined as the per capita expenditure needed to consume basic food and non-food necessities in Vietnam – equivalent to $US128 or 1790 thousand Dong in January 1998. Since household expenditure data were not available from the survey, this study uses income data to assess the poverty of the sample households. As income data underestimate the expenditure data, the estimated poverty ratio can be considered to be an upper bound.