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Maize boom in the uplands of northern Vietnam: economic importance and environmental implications

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Abstract
In Vietnam, the demand for meat products has grown dramatically due to economic growth and urbanisation and will likely continue to increase. Being the primary source of livestock and poultry feed, maize has become the second most important crop after rice. While this maize boom has the potential to reduce rural poverty, its area expansion promotes deforestation and soil degradation, especially in the uplands. Using empirical evidence from mountainous Yen Chau district in north-western Vietnam, the main objective of this paper is to investigate the determinants of area allocation to maize at the household level in order to derive research and policy recommendations.
Maize is the dominant crop in Yen Chau, covering most of the uplands and generating the lion's share of households' cash income. Although farmers are aware of soil erosion, effective soil conservation measures are rarely practiced. Maize is attractive to farmers from all social strata, notably the poor, and through marketing arrangements with traders its cultivation is also not constrained by adverse infrastructural conditions. Access to low-interest credit should be enhanced to mitigate farmers' risk of being caught in a poverty trap when maize revenues plummet, and research is needed on soil conservation options that are economically attractive.

Key words: Maize area expansion, environmental sustainability, Tobit regression

1. Introduction
Since the 1990s, rapid economic growth and urbanisation in Vietnam have led to a diversification of diets and, hence, to an increased demand for meat, eggs, and dairy products. Rising from 16 to 30 kg, annual per capita meat consumption almost doubled between 1990 and 2003 (FAOSTAT 2008). Maize (*Zea mays* L.) is the primary source of feed for Vietnam's livestock and poultry industry. Therefore, the demand for maize has grown dramatically and is expected to further increase in the future (Dao *et al.* 2002; Thanh Ha *et al.* 2004). Consequently, its production has increased sharply, and maize has become the second most important crop after rice (Thanh Ha *et al.* 2004). While this development has the potential to reduce rural poverty by offering attractive income opportunities to smallholder farmers (Delgado *et al.* 1999), it promotes the expansion of agricultural cultivation into fragile agro-ecological zones, often leading to deforestation, soil erosion, and subsequent soil degradation, especially in the uplands (Dao *et al.* 2002; Wezel *et al.* 2002).
Using empirical evidence from a random sample of 300 households in Yen Chau district in the Northern Mountain Region of Vietnam, the main objective of this paper is to identify

determinants of farmers' area allocation to maize in order to derive policy and research recommendations.

2. Description of the research area

The area expansion and intensification of maize production has been particularly pronounced in the uplands of north-western Vietnam. Maize production almost quadrupled between 1990 and 2000, growing from 53,600 to 211,800 metric tons (Dao *et al.* 2002) while at the national scale it 'only' tripled during the same period. Yen Chau is a mountainous district in this region where farmers nowadays mainly cultivate rice in the lowlands and maize in the uplands as a cash crop. The area allocated to maize has more than tripled over the past 20 years, and, due to high population growth rates, even steep slopes have been taken into cultivation for maize production. Together with intensive ploughing and shortened fallow periods this has led to massive erosion and declining soil fertility (Wezel *et al.* 2002). While substantial efforts have been made since the mid 1990s to promote soil conservation technologies in the area (van der Poel 1996; UNDP 2000), adoption rates have remained extremely low (Friederichsen 1999; Wezel *et al.* 2002).

3. Research methodology

The regression model employed

We measure the extent to which a farm household engages in maize production as the share of cultivated area allocated to maize in the main cropping season of 2007. This share is bound between 0 and 100%, and both limit values are observed in nine and eight cases, respectively (approx. 3% of observations each). Hence, because of the censored nature of the dependent variable, we employ a model proposed by Tobin (1958) which accounts for the qualitative difference between limit and non-limit observations.

Determinants of the extent of maize cultivation

We hypothesize the area share allocated to maize to be determined by households' resource endowment, including access to services and relevant infrastructure. Drawing on the sustainable livelihoods framework (Scoones 1998), we sub-divide the relevant components of a household's asset base into natural, human, economic and financial, as well as infrastructural capital. *Upland share* measures the share of land that is officially classified as 'upland' within the total cultivable area (variable *Farm size*), i.e., it consists of non-irrigated and mostly sloping land on which maize is typically grown. According to the Vietnamese land classification, apart from upland plots and paddy land (variable *Paddy share*), *Farm size* can encompass home gardens, perennial crop land, and fish ponds. Since the official end of collective farming in Vietnam in 1988, a series of land reforms have been implemented (cf. Do and Iyer 2008). While land is still owned by the state, farmers have received certificates (so-called Red Books) granting them a use right for specific plots. We account for tenure security through the variable *Red Book share*, which measures the share of *Farm size* for which the farmer holds a formal land use certificate.

Sampling procedure and data collection

Data were collected in a survey of 300 randomly selected households in Yen Chau district in July 2007. A cluster sampling procedure was applied where in a first step 20 villages were randomly selected using the Probability Proportionate to Size (PPS) method and in a second step 15 households were randomly selected per selected village. This procedure results in a self-weighing sample (Carletto 1999).

4. Results

Maize production in Yen Chau district

In the main cropping season of 2007, 97% of our sample households grew maize on 1.16 ha on the average (median 0.97 ha), representing 71% of the total farmed area. In general, 97% of the

maize growers sell their maize, which accounts for 65% of total household cash income and 76% of agricultural cash income, on the average. Recall data on the main cropping season 2006[1], show that considerable amounts of mineral fertilizer are applied to maize (370 kg ha^{-1} of NPK and 171 kg ha^{-1} of urea, on the average). At an average of 6.17 Mg ha^{-1} (median 6.00) the yield level is comparatively high, and at 1,059 US$ ha^{-1} (median 1,020) the average gross margin attained is highly attractive relative to alternative crops.

Soil conservation practices in Yen Chau district
Maize is mainly grown on sloping upland plots, and farmers are well aware of soil erosion on these plots: on a scale from 0 (= no erosion) to 10 (= severe erosion) they assigned a severity score of 4.4 to soil erosion on their maize plots, on the average[2]. Three-quarters of the sample farmers know at least one soil conservation technique (SCT), and 53% currently practice at least one technique to reduce soil loss, especially the digging of small ditches to channel run-off water off the plot. Other particularly effective SCTs, such as the establishment of vegetative strips along the contour lines, the use of cover crops or mulch to protect the soil against erosive rainfall, or the building of terraces are virtually not practiced at all. Apart from a lack of labor for the establishment of terraces or the application of mulch, major reasons stated for not practicing SCTs are adverse effects on maize production through competition for land, nutrients, and sunlight.

Determinants of the extent of maize cultivation
The results of our regression analysis on determinants of the area share that farmers allocate to maize are provided in Table 1. Moreover, the Variance Inflation Factors (VIFs) are listed which attain a maximum value of 2.83, indicating that there is no cause for concern regarding multicollinearity among the explanatory variables (Myers 1990). Since the Breusch-Pagan test (Breusch and Pagan 1979) rejects the null-hypothesis of homoskedastic errors, heteroskedasticity-consistent standard errors are used that also account for the cluster sampling procedure.

5. Discussion

As expected, farmers' endowment with natural capital, both 'upland' and paddy area, has a highly significant influence on their area allocation to maize. The highly significant negative coefficient on *Paddy share* shows that, although maize has become a very profitable cash crop, farmers continue to have a clear priority to use irrigable land for the cultivation of rice, which is mostly home-consumed. This suggests that farmers view it as too risky to rely on local, national, and global rice markets for the acquisition of their major food crop and are willing to pay a considerable risk premium in terms of foregone gross margin on the more lucrative crop maize for ensuring food security. No influence of the degree of tenure security (variable *Red Book share*) is supported by the data. This is not surprising since even without a formal land title tenure security will be given for at least one cropping season, so that farmers can be sure to reap the economic benefits from their maize crop.
Concerning human capital, the characteristics of the household head have important implications on the extent of maize production. Contrary to our expectation, illiterate household heads allocate six percentage points more land to maize than literate household heads. However, qualitative research in the uplands of northern Vietnam indicates that there are significant deficiencies in farmers' knowledge on proper maize management (Thanh Ha *et al.* 2004). Surprisingly, the area share devoted to maize is almost 15 percentage points higher in female-headed relative to male-headed households. This can be explained by differences in land endowment between the two

[1] At the time of the survey the maize of the growing season 2007 had not yet been harvested.

[2] N = 294. Household-level values are means of plot-specific ratings weighted according to the plot size.

household types: first, the total cultivable area available to female-headed households is significantly smaller than that of male-headed households (0.97 versus 1.63 ha, Mann-Whitney test significant at $P < 0.01$) leading to a lower area share being fallowed. Second, female-headed households are less endowed with paddy land (269 versus 382 m^2 per person, Mann-Whitney test significant at $P < 0.1$). Therefore, the need to allocate land to a profitable cash crop is particularly pronounced to generate income for the satisfaction of food needs. The differences found between ethnic groups are likely to be related to differences in market access and consumption preferences. The sign of the regression coefficient on *Dependency ratio* is negative, probably because of reduced labor availability and/or a preference for food crops with an increasing number of dependent household members.

Table 1. Tobit estimates of influencing factors of the farm area share allocated to maize production in Yen Chau district, Northern Vietnam (N = 294)

Capital type	Variable	Mean	Coefficient[a]	t-value[b]	VIF[c]
Natural	Farm size (ha)	1.59	1.1410	1.47	1.39
	Upland share (%)	77.50	0.4635	8.33***	1.68
	Paddy share (%)	12.28	- 0.3396	- 2.92***	1.50
	Red Book share (%)	72.97	- 3.5648	- 1.40	1.32
Human	Age of household (HH) head	43.22	- 0.0630	- 0.63	1.58
	Literacy HH head (%)	0.77	- 6.3590	- 3.42***	1.52
	Sex HH head (Dummy, 1 = female)	0.08	14.8777	3.58***	1.23
	H'mong (Dummy, 1 = H'mong)	0.15	- 16.2758	- 4.90***	2.79
	Kinh (Dummy, 1 = Kinh)	0.08	12.1237	2.14**	1.39
	Dependency ratio (<18 and > 60 depend.)	0.41	- 14.6329	- 2.13**	1.53
Econ./ financial	Wealth index[d]	0.59	- 23.6084	- 2.37**	2.83
	Off-farm income (% of total HH income)	15.83	- 0.1239	- 1.49	1.30
	Credit limit ('000 VND[e])	42,666.61	3.6138	3.17***	1.47
Infra-structure	Maize price received in 2006 (VND kg^{-1})	2,100.30	0.0060	1.26	1.47
	Extension access[f]	3.10	0.6182	0.78	1.08
	Distance to fertilizer outlet (km)	0.71	- 0.3448	- 0.92	1.16
	Distance to paved road (walking min.)	16.00	0.2635	7.33***	1.84
	Constant		14.8856	0.82	
F-value = 223.6***					
Log likelihood = - 1175.3					
Pseudo R^2 = 0.079					
% censored obs. at 0 = 3.1					
% censored obs. at 100 = 2.7					

*(**)[***] Statistically significant at the 10% (5%) [1%] level of error probability.

[a] Dependent variable: Maize share. Coefficients are marginal effects on the latent (uncensored) dependent variable based on a Tobit regression.

[b] Standard errors are heteroskedasticity-consistent (White 1980) and account for the cluster sampling procedure applied in selecting the farm households.

[c] Variance Inflation Factor.

[d] Relative wealth index constructed from a number of wealth indicators via Principal Component Analysis.

[e] Vietnamese Dong. 1 US$ = 16,000 VND (June 2007).

[f] Farmers' perception on a scale from 1 = very poor to 5 = very good.

Contrary to our expectation, the coefficient on *Wealth index* is negative, implying that poorer households devote a larger share of their cultivable area to maize than wealthier households, although this typically entails considerable cash input, especially in terms of fertilizer. As expected, the variable measuring credit access, applying the methodology developed by Diagne *et*

al. (2000), yields a positive regression coefficient. Since this variable enters the model in its logged form, we conclude that a one *percent* increase in credit access leads to an expansion of the maize area share by 3.6 percentage points. This is a rather large effect which emphasizes the importance of rural credit to finance agricultural inputs.

With regard to the infrastructural environment that farmers operate in, an influence of the maize price received in the cropping season 2006 on the area share devoted to the crop in 2007 is not supported by our household-level data, although they exhibit a considerable degree of variation, ranging from 1,150 to 3,000 VND kg^{-1}. This can be explained by the lack of alternative cash crops that are able to compete with maize, even if the price received in a particular location and under a specific marketing arrangement (see below) may be comparatively low. Furthermore, neither an influence of access to agricultural extension nor the distance to the closest fertilizer outlet is supported by the data. In contrast to our expectation, the area share devoted to maize increases with increasing distance to the nearest paved road. The explanation of this effect is probably that some villages have established marketing contracts with maize traders who collect the produce at the farm gate. These traders also supply the farmers with the necessary inputs for maize cultivation, hence explaining why neither the physical distance to the closest fertilizer store nor the distance to the nearest paved road discourage farmers from engaging in maize production. These marketing arrangements with maize traders come at a cost, however: in the two most remote research villages that rely on such arrangements the maize price received was 23 and 28% lower than in the remaining, less remote villages in 2006 and 2007, respectively (Mann-Whitney test significant at $P < 0.001$). Moreover, especially the poor receive in-kind credit in the form of seeds and fertilizers from these traders at comparatively high interest rates. The supply with agricultural inputs as in-kind credit is also commonly organized by village-level institutions, whereby the timing of supply and repayment are strongly tied to the cropping cycle of maize. This makes it much more comfortable for farmers to engage in maize production than to choose an alternative, less commonly grown crop.

6. Conclusions and recommendations

Maize is by far the most important cash crop in Yen Chau district, covering most of the uplands and generating the lion's share of households' cash income. Although farmers are well aware of soil erosion on their maize plots, effective soil conservation measures are rarely practiced. The fact that maize is a highly profitable cash crop under the current economic conditions means that the establishment of soil conservation measures incurs high opportunity costs in terms of land lost for maize production. Moreover, the negative effect of erosion on soil fertility may (still) be masked by the high amounts of mineral fertilizer applied. Our analysis shows that, apart from the availability of upland area, farmers' area allocation to maize is mainly determined by the households' endowment with human and financial capital. Infrastructural conditions, such as easy access to paved roads and markets, are found to not play a significant role, which is probably due to marketing and input supply arrangements with maize traders who collect the produce in the village. Maize is attractive to farmers from all social strata, notably the poor and illiterate.

Although formal credit programs do not directly target credit to maize, it is comparatively easy to obtain in-kind credit for maize production from maize traders or via village-level institutions. Although the interest rates charged are typically high, this is an attractive option particularly for the poorest farmers living in remote places who lack adequate access to formal credit at moderate interest rates. We thus conclude that enhancing the access of the poor to formal rural credit would make it easier for them to diversify their crop portfolio and reduce the risk of becoming indebted and caught in a poverty trap. Given the currently extremely high shares of maize in overall production and cash income this can easily happen when revenues plummet due to maize pests or diseases, price fluctuations, or adverse climatic conditions.

In order to address the crucial issue of soil erosion and degradation on the maize-dominated upland areas in and beyond north-western Vietnam, more interdisciplinary research is needed on

land use options that are economically attractive while at the same time serving a soil conservation purpose. Since the livestock sector in Vietnam is rapidly growing, research priority may be given to soil conserving land use options that produce feed and/or are easily combined with the current production of maize.

References

Breusch TS, Pagan AR (1979) A simple test for heteroscedasticity and random coefficient variation. *Econometrica* **47**, 1287-1294.

Carletto C (1999) Constructing samples for characterizing household food security and for monitoring and evaluating food security interventions: Theoretical concerns and practical guidelines. Technical Guide No. 8, International Food Policy Research Institute (IFPRI), Washington, D.C.

Dao DH, Vu TB, Dao TA, Le Coq JF (2002) Maize commodity chain in Northern area of Vietnam. Proceedings of the international conference '2010 Trends of Animal Production in Vietnam', October 24 - 25, 2002. Hanoi, Vietnam.

Delgado C, Rosegrant MW, Steinfeld H, Ehui S, Courbois C (1999) Livestock to 2020: The next food revolution. Food, Agriculture, and the Environment Discussion Paper 28. International Food Policy Research Institute (IFPRI), Food and Agriculture Organization of the United Nations (FAO), and International Livestock Research Institute (ILRI), Washington, Rome, and Nairobi.

Diagne A, Zeller M, Sharma M (2000) Empirical measurements of households' access to credit and credit constraints in developing countries: Methodological issues and evidence. Discussion Paper No. 90. Food Consumption and Nutrition Divison, International Food Policy Research Institute (IFPRI), Washington, D.C.

Do QT, Iyer L (2008) Land titling and rural transition in Vietnam. *Economic Development and Cultural Change* **56**, 531-579.

FAOSTAT (2008) FAO Statistics Division, available at http://faostat.fao.org, accessed 12.09.2008.

Friederichsen RJ (1999) Assessment of erosion control in farming systems in Northwestern Vietnam. Proceedings of the international conference 'Deutscher Tropentag', October 14 - 15, 1999. Berlin, Germany.

Myers R (1990) Classical and modern regression with applications. Second Edition. Duxbury, Boston, MA.

Scoones I (1998) Sustainable rural livelihoods: A Framework for Analysis. IDS Working Paper No. 72. Institute of Development Studies, University of Sussex, Brighton, UK.

Thanh Ha D, Dinh Thao T, Tri Khiem N, Xuan Trieu M, Gerpacio RV, Pingali PL (2004) Maize in Vietnam: Production systems, constraints, and research priorities. CIMMYT, Mexico.

Tobin J (1958) Estimation of relationships for limited dependent variables. *Econometrica* **26**, 24-36.

UNDP (2000) Compendium of rural development assistance in Viet Nam. United Nations Development Programme (UNDP), Hanoi, Vietnam.

van der Poel P (1996) Technology options for upland development in the Song Da watershed. Social Forestry Development Project (SFDP) Working Paper No. 2. Hanoi, Vietnam.

Wezel A, Steinmüller N, Friederichsen JR (2002) Slope position effects on soil fertility and crop productivity and implications for soil conservation in upland northwest Vietnam. *Agriculture, Ecosystems and Environment* **91**, 113-126.

White H (1980) A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. *Econometrica* **48**, 817-838.