

Montane paddy rice: the cornerstone of agricultural production systems in *Bac Kan* Province, Viet Nam

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Abstract

In the mountains of northern *Viet Nam*, paddy rice plays a major role in most households' food security. A survey of 300 households in *Bac Kan* Province revealed the importance of montane paddy rice in recent agrarian changes. Households' production strategies were found to develop according to two key factors: access to paddy fields (montane valleys and terraces), and each household's rice self-sufficiency level. A multivariate statistical analysis helped to explain the production relationships among montane paddy rice, crop-livestock systems on the hillsides, and off-farm activities. When households lack paddy rice, they turn to rainfed rice on the hillsides, cattle and pig raising, and off-farm activities to sustain their livelihoods. Households that have met their paddy rice needs begin to diversify their production systems with cash crops and buffalo raising. The analysis of production systems that have resulted from differing levels of rice self-sufficiency led to the development of a farming system differentiation model. An understanding of the various strategies in the studied regions makes it possible to target more precisely development interventions and technical and economic advice to farmers.

Keywords: montane paddy rice, farming systems, household typology, mountain agriculture, *Bac Kan, Viet Nam*

1. Introduction

From the lowland deltas to the mountain terraces of the mountains, paddy rice has long been the essential component of agriculture in *Viet Nam* (Dumont, 1935; Gourou, 1936). Today, rice continues to represent 90% of national food production, and rice production occupies the time of 70% of the active population (Dogot et al., 1997; Barbier et al., 1997). Whether managed by cooperatives or individuals, rice production and rice-field access have been at the heart of the

many agricultural changes that have taken place in recent decades. *Viet Nam* as a nation began to produce rice surpluses in 1989 and in recent years has become the world's second largest rice exporter, even while subsistence agriculture continues to dominate the mountainous regions. As in the delta regions, in the mountainous regions paddy rice is the priority for farmers and the primary means by which households achieve food security (Le Trong Cuc, 1995; Pandey and Dang Van Minh, 1998).

Although rainfed rice can be grown on slopes, "paddy" rice production requires flat land. Paddy soil is prepared by saturating and puddling. During crop development, the paddy field is kept flooded, usually by irrigation. Since the cooperative period, development models have sought to assist mountain populations attain rice self-sufficiency by raising the productivity of paddy rice fields. Having met with success in the lowland Red River Delta region, paddy intensification techniques were applied to the mountainous regions. Collective agriculture focused people's energies on maximizing the high potential for production of paddy ricefields (Sadoulet et al., 2002). Today, paddy intensification remains a strong focus of rural development, and almost all research on agriculture in the mountainous regions continues to focus on the montane flatlands (Kerkvliet and Porter, 1995). In contrast, the montane hillsides are considered to be marginal in terms of potential for food production, and more appropriate for forestry (Castella et al., 2002).

However, mountain populations have long relied on shifting cultivation in the uplands, either as a complement to or substitute for montane paddy land production. During the cooperative period, paddy rice shortages forced many families to cultivate the uplands to achieve rice self-sufficiency. Paddy land allocations to individual households, as early as 1982, and the dismantling of the cooperatives beginning in the late 1980s, created incentives for investment in the montane paddy areas. Nonetheless, the comparative productivity advantage of upland fields led to an uncontrolled increase in slash-and-burn cultivation. Disappearing forests and new policies in the 1990s motivated those farmers who could to concentrate their energies again on the paddylands. But the allocation process had left some households with little or no paddylands, offering them little choice but to continue to cultivate the hillsides.

In recent years, the focus of policy in the mountainous regions has moved from livelihood to environmental issues, even while many farmers cannot yet provide for their families (Dao The Tuan, 2000). Often blamed for deforestation and increased erosion and flooding, sloping land crops are still a key component of many households' livelihood systems. While the food situation of almost all households has improved in recent years, slash-and-burn rice and maize systems continue to exist, often as the only means of nourishment for those who were left out of the post-decollectivization land allocations (Courtois et al., 1997; Godon et al., 1997; Bal et al., 1997; Husson et al., 2001). The combination of unavailable

paddy lands, unsustainable upland production systems, and high population pressure has marginalized the poorest of farmers (Chu Huu Quy, 1995; Jamieson et al., 1998).

The *doi moi* transition from collective agriculture to a private-household, market-based economy has been accompanied by rapid household differentiation and the burgeoning of a diversity of new production strategies. The diversity is further complicated by the intricate socioeconomic and ecological mosaic that now characterizes the agro-sylvo-pastoral systems of the mountains. In this context, the traditional technique of applying a single development model to a wide region is not possible (Castella et al., 1999a). Instead, the practitioners of development need to take into account the wide diversity of the mountainous regions and understand the processes that have created it. In this chapter, based on several monographic studies, we will draw regionally-applicable lessons on the diversity of mountainous agricultural production systems (Castella et al., 1999).

We have investigated local agrarian histories from the end of the colonial period to the present in several communes of *Bac Kan* Province, the research site for the Mountain Agrarian Systems Program (SAM, French acronym). The reconstruction of these histories enabled us to understand the source and context of the current diversity of the region's farming systems (Alther et al., 2002; Castella et al., 2002a and 2002b; Fatoux et al., 2002; Sadoulet et al., 2002). Our research indicated that the present-day diversity is based not on ethnicity but on land access, and in particular, differences in household access to montane paddy lands. Our underlying hypothesis was that the key to understanding the current diversity is to understand rice-based strategies once households have secured access to paddyland.

Our objective was to demonstrate that in *Bac Kan* Province, (i) the diverse production strategies associated with paddy rice are different paths toward a common objective: food security; (ii) household rice-sufficiency levels determine the interactions between lowland and upland systems; and (iii) paddy rice production is the key factor for differentiating farm households.

2. Methods

Our analysis of production strategies in *Bac Kan* Province draws on a series of monographic studies undertaken in 1999 and 2000 (Alther et al., 2002; Castella et al., 2002a and 2002b; Fatoux et al., 2002; Sadoulet et al., 2002). The research sites for those studies were selected to cover the range of market integration and agro-ecological diversity present in the province (Castella et al., 1999a). The studies all followed a similar methodology. First, the agrarian histories of the studied districts and representative communes were traced through interviews with local stakeholders, farmers and officials, who were witnesses to the recent

events of the regions. Landscapes and landscape changes were studied through field observation and analysis of a chronological series of aerial photographs. Finally, individual household strategies were identified through interviews with a sample of 300 farmers selected to best represent the diversity of agricultural systems in their communes and districts. Across the research sites associated with the SAM Program, we studied twenty-one villages, six communes, and five out of the six districts of *Bac Kan* Province (Figure 1).

A comparative analysis of the five monographic studies resulted in a conceptual model that explained the production logic of household farms in terms of their different access to resources. The data collected at the various research sites were combined with official statistics on the entire districts, helping us to generalize our commune-based results to the entire *Bac Kan* Province.

The starting point of our analysis was the hypothesis that a household's paddy rice sufficiency level is a key determinant of its production strategy. We defined sufficiency as a threshold corresponding to the commonly accepted value of 250 kg of hulled rice/person/year for the mountainous areas (National Committee of Food Security, 1998). We identified a stepwise decision-making process that farmers followed in search of food security, beginning with the montane paddylands, then moving to uplands and private gardens and continuing to

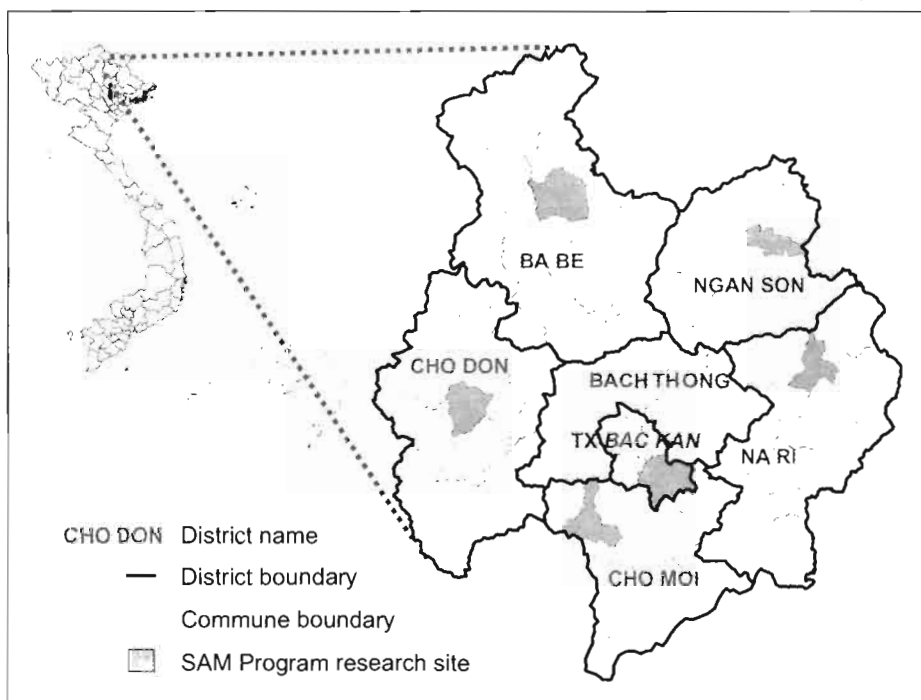


Figure 1: Map of Bac Kan Province showing the communes used as research sites for monographic studies

diversify until the food needs of the household were met. An analysis of farmers' iterative strategy-building process helped us to define the relationships between paddyland and upland uses, as well as relationships between cropping and livestock systems.

Our examination of production strategies in terms of varying levels of rice self-sufficiency demonstrates the continuing dominant role played by paddy rice. By identifying and separating the different production strategies in the studied areas (diversification of activities, intensification, and specialization), we developed a farming-system differentiation model that is applicable at the provincial scale.

3. Land use changes, rice self-sufficiency, and household subsistence strategies

In the context of subsistence agriculture, the primary objective of each household is to meet its food needs. The monographic studies showed that rice self-sufficiency is the key factor in understanding the region's variety of production strategies. In *Bac Kan* Province, more than 92% of families consume their entire rice production, whether paddy or upland. On average, of the 1.3 tons of rice produced per household in the province, 1.2 tons are consumed by the producer. Given that montane paddy rice productivity (with two crops a year) is about eight times greater than upland rice productivity, paddy rice is the most important food crop, and the crop with the highest rate of producer consumption, in the province (Figure 2).

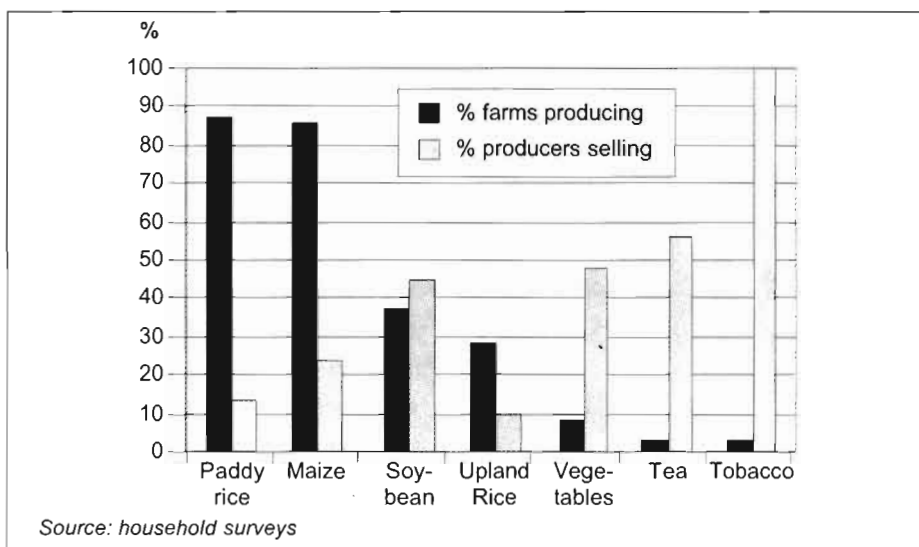


Figure 2: Proportion of farms cultivating surveyed crops in Bac Kan Province, and proportion of those producers who sell part or all of their production

Farmers in *Bac Kan* Province have developed their subsistence systems through intensification in the paddylands. Rising population has led to a progressive per capita decline in paddyfield area. Between 1991 and 2000, this area dropped almost 20% from 680 to 560 m² / person. Per capita rice production has increased in spite of lower area per person because of increasing yields (Figure 3). Yields have increased over the last decade for at least three reasons: (i) increases in the amount of labor poured into the ricefields since the end of the cooperative period; (ii) the introduction of new rice varieties (*Bao Thai*, 203, Ai32, etc.); and (iii) the improvement of chemical input distribution networks (Castella et al., 2002b; Sadoulet et al., 2002). However, by far the main reason for production increases has been the addition of a second cycle of rice (spring season) on a growing proportion of paddy fields (Figure 4). Even as more and more farmers plant spring rice, the progressive improvement of techniques associated with this crop is resulting in an even greater increase in production (Figure 5). Very few households are willing to substitute another food for rice as the basis of their diet. Only a small number of *H'mong* and *Dao* ethnic villages consume maize, and that only in times of shortage (Pandey and Minh, 1998). Upland rice is thus the primary alternative for those households who do not have

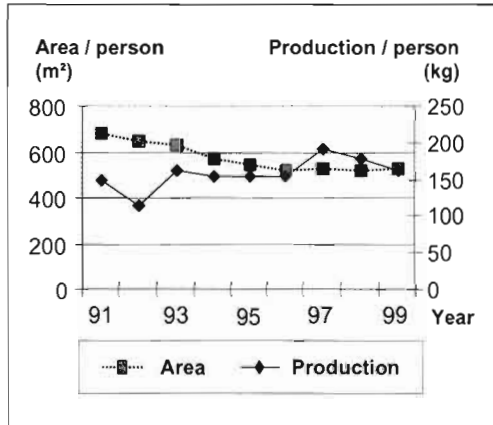


Figure 3: Surface area and production per person of summer rice in Bac Kan Province

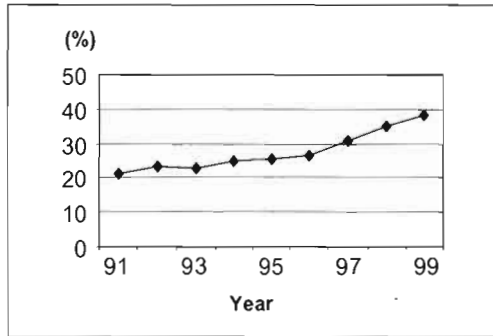


Figure 4: Percentage of double-cropped ricefields in Bac Kan Province

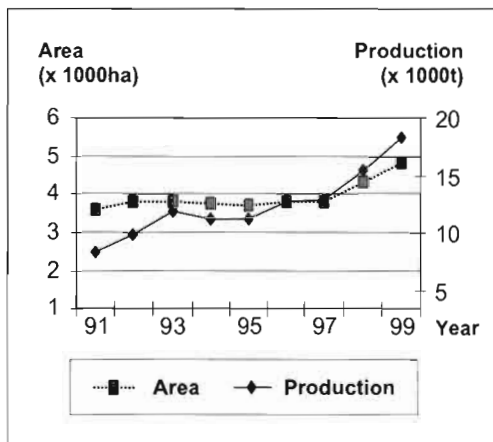


Figure 5: Surface area and production of spring rice in Bac Kan Province

access to paddy fields (about 12% of households; Figure 2). The substantial increase in the productivity of irrigated rice, combined with the ban on slash-and-burn cultivation, have brought about a major decrease in upland rice cultivation across the province. But in spite of progressively declining upland yields due to shortening fallow periods (Husson et al., 2001), and in spite of the increased competition for upland spaces that is putting shifting cultivators in crisis, upland rice remains the primary food production strategy for a substantial number of households. Formerly shifting cultivators of upland rice have been sedentarized since the recent forestland allocations from 1994-present (Castella et al., 2002). Confined to a fixed area, with their cultivation systems slowly exhausting the land, these farmers are now experimenting with many kinds of innovations and small-scale trials in a desperate attempt to find alternatives to upland rice (Castella et al., 2002).

Of the various cultivation systems practiced by the surveyed households, maize cultivation on the hillsides is as common as rice in the paddylands. Close to 86% of farms (Figure 2) cultivate maize, sometimes intercropped with perennial plants, usually fruit or timber trees (Castella et al., 2002b; Sadoulet et al., 2002). Maize grain, in combination with cassava and rice bran, makes up the bulk of feed for pigs and fowl. Of the surveyed households, 96% raised at least two pigs per year. Pig raising makes use of the residues of paddy rice cultivation and allows upland maize and cassava production to be used directly rather than sold (Castella et al., 2002a; Sadoulet et al., 2002). Producers, however, do not think of pig raising as a substitute for paddy rice. There is no correlation between rice sufficiency levels and pig production. Thus, researchers cannot use pig raising to define distinct farming systems.

Households with high levels of market integration (i.e. good access to market place and information) have the option of growing cash crops (soybean, tobacco, vegetables, fruit trees, etc.); raising animals; or pursuing off-farm activities. Farmers who are not rice self-sufficient engage in such activities to generate revenue that can then be used to purchase rice (Castella et al., 2002a and 2002b; Fatoux et al., 2002; Sadoulet et al., 2002). Farmers who already have attained rice self-sufficiency often pursue the same kinds of activities in pursuit of capital accumulation.

Non-agricultural activities engaged in by one or more family members can be a stable source of income, allowing investment in production tools. Thus, families with such external revenue often are both better equipped and sooner able to foot the cost of perennial plantations and their deferred revenues. A large proportion of surveyed households benefit from non-agricultural activities. Close to 40% of households gain at least 20% of their household income from off-farm activities such as forest products gathering, non-farm rural wages, self-employment (e.g., motorcycle-taxi service), or salaried employment in a local administration.

High population pressure in *Bac Kan* Province has eliminated the possibility of extending the area of cultivated land: all usable land is already cultivated. The remaining possibilities for sustaining and improving livelihood systems are intensification, diversification, specialization, and non-farm activities.

4. Paddyland rice - upland rice: two settings for rice strategies

4.1. Historical land access and ethnicity

Almost exclusively used for irrigated rice, paddylands have been targeted by many successive land policies: (a) progressive colonization and private exploitation (pre-independence through 1960); (b) agrarian reforms and collectivization (1960-1980); and (c) cooperative dismantling and re-claiming of ancestral lowlands by descendants (1980-present; Sadoulet et al., 2002). During the post-cooperative period, land purchases also have played an important role in the resumption of private ricefield use.

Ethnicity has often been cited as a key factor in both historic and present-day diversity in production systems (Le Trong Cuc, 1995). Traditionally, people of the *H'mong* and *Dao* ethnicities in *Bac Kan* have occupied the uplands, while the *Tày* have settled the lowlands (Bal et al., 1997; Sadoulet et al., 2002). This tiered settlement of the ecosystem is linked to the order in which successive ethnic groups arrived in the region (Mellac, 2000; Castella et al., 2002c). However, this geographic division according to ethnicity is not as apparent today as it was in the past. The many different land policies and redistributions, in combination with recent sales and purchases, have made it nearly impossible to associate specific production systems exclusively with specific ethnic groups.

Today, it is primarily resource access that determines families' abilities to meet their rice needs. Unquestionably, ethnicity played a role in the results of the land allocations (Mellac, 2000; Castella et al., 2002; Sadoulet et al., 2002), but diverse households within each ethnic group now face diverse situations. Our analysis of the diversity of production strategies suggests that there is no unique *Tày* production system that stands in contrast to a *Dao*, *Kinh*, or *H'mong* system. Rather, within all groups, household production strategies are determined primarily by access to land resources.

Household access to paddy fields varies widely, ranging from 0 to 1.2 hectares per household, with yields as high as 7 tons/household (Figure 6). Annual production per unit area can vary by a factor of three, depending on yield and (especially) on proportion of double-cropped area. Households growing 1-cycle rice averaged only 4 tons/ha/year (symbolized by circles in Figure 6), whereas households growing 2-cycle rice averaged 8.5 tons/ha/year (symbolized by diamonds).

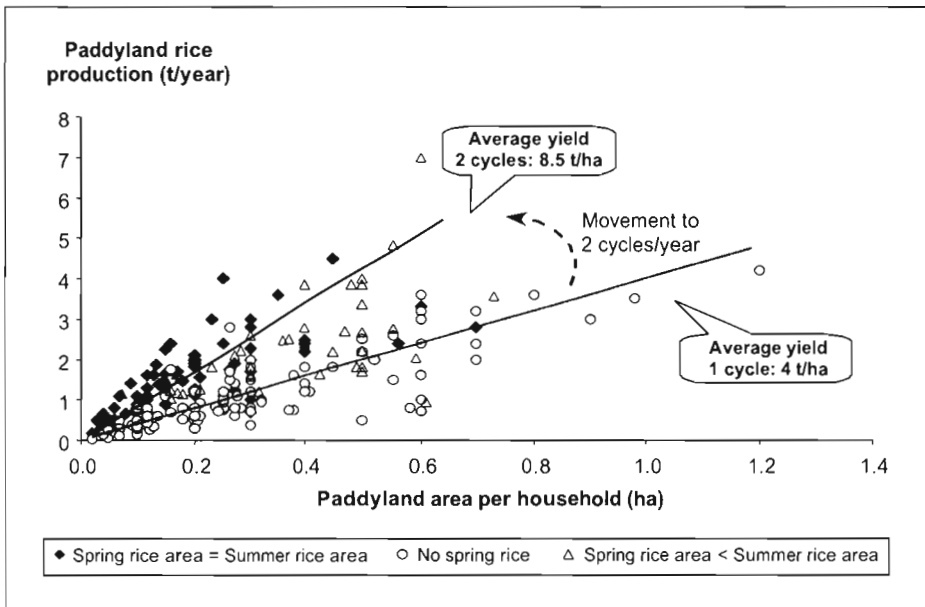


Figure 6: Relationships between area of cultivated paddyland and production of surveyed households in Bac Kan Province.

N.B.: Separate regression lines were calculated for households with one rice harvest per year (circles) and two rice harvests per year (triangles and diamonds). Average yield for each category of household corresponds approximately to the slope of the respective regression line.

Paddyfield yields were relatively homogeneous among the surveyed households, particularly when compared to the extreme variability of upland yields (Husson et al., 2001).

4.2. A paddy rice-based farming system typology

By classifying households according to their ability to meet their rice needs in the montane paddylands, we identified three different household strategies (Figure 7). Access to irrigation water during January and February determines the area of paddyfield that *can* be double-cropped, whereas the quantity of rice needed to feed the household (mouths to feed) determines the area of paddyfield that needs to be double-cropped. At the time of our study, more than 50% of surveyed households who could not attain rice self-sufficiency with one-cycle rice (summer season) were able to make up the deficit with a second cycle during spring season (Figure 7, zone B). Spring rice offers these households the potential to double their production; in 60% of households classified into type B, the entire paddyland area was double-cropped. These households have a minimum of 300 m² paddyland per laborer, and generate yields exceeding 3.6 t/ha/cycle.

Households who can attain rice self-sufficiency with a single summer crop per year (Figure 7, zone C) are relatively rare, making up only 12% of the surveyed households. Their paddyland area per laborer is in excess of 500 m², with yields of about 3 t/ha. Among these households, a small number grow a second spring cycle of rice, which generates yields in excess of 4 t/ha/cycle.

A substantial number of farmers are in the third category: those who cannot achieve rice self-sufficiency with either one or two crops per year (Figure 7, zone A), usually because of insufficient paddyland area. Farmers in this group need to turn to other activities to feed their households. Upland rice, merely a complementary crop for household types B and C, is the most important crop in the systems of type A households.

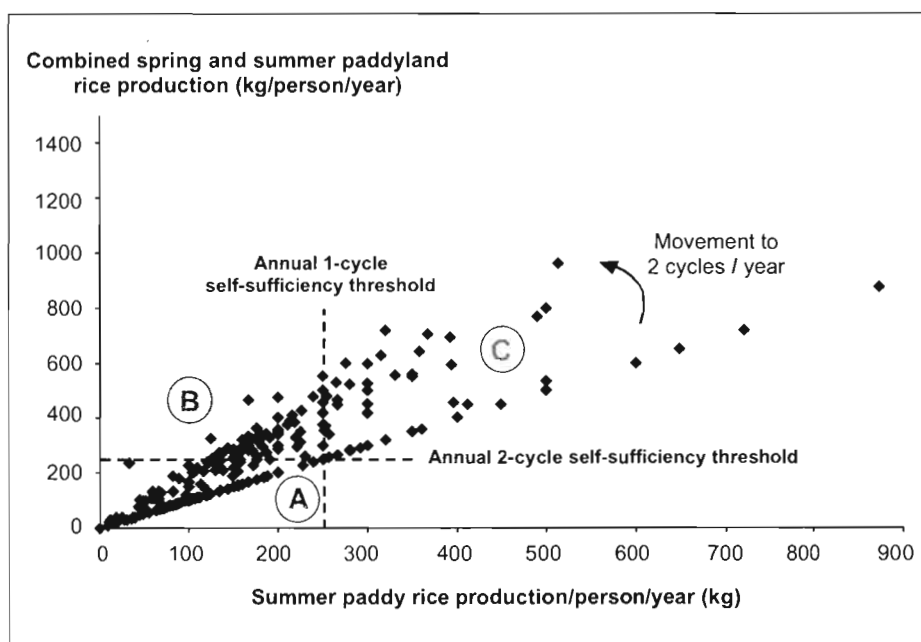


Figure 7: Capability of one-cycle and two-cycle paddy ricefields to meet households' rice needs.

N.B. Households can be classified into three groups according to their levels of rice self-sufficiency and their production strategies

- (A) Not rice sufficient (below the threshold both for summer production and for combined spring-summer production).
- (B) Rice sufficient, but dependent on combined spring-summer production (below the sufficiency threshold for summer production alone).
- (C) Rice sufficient, and not dependent on spring production (above the sufficiency threshold for summer production alone).

The lower limit of combined spring and summer production (vertical axis) is the value of summer production alone.

4.3. Upland rice: an alternative in the absence of adequate paddyland

Figure 8 shows the importance of upland rice for households who cannot meet their food needs with paddyland rice. A substantial proportion of these households cross the rice self-sufficiency threshold once upland rice is added to their systems (triangles). Some households can even attain rice self-sufficiency with upland rice alone (circles). Households producing less than 200 kg of rice per person on paddyland tend to cultivate sloping land with upland rice for household consumption.

However, as mentioned earlier, population pressure and land policy have made slash-and-burn cultivation systems unsustainable. The average yield of upland rice is 1 t/ha, and each year of cultivation requires three years of fallow. Based on an average paddyland rice yield of 4 t/ha/cycle, for each ton of upland rice produced, an equally sized area of one-cycle paddyland could produce 16 tons of rice, or 32 tons if double-cropped. Given these yield differences, it is not surprising that farmers prioritize the paddylands in allocating both manual labor and chemical inputs¹. In *Bac Kan*, there are no more “shifting cultivators at heart,”

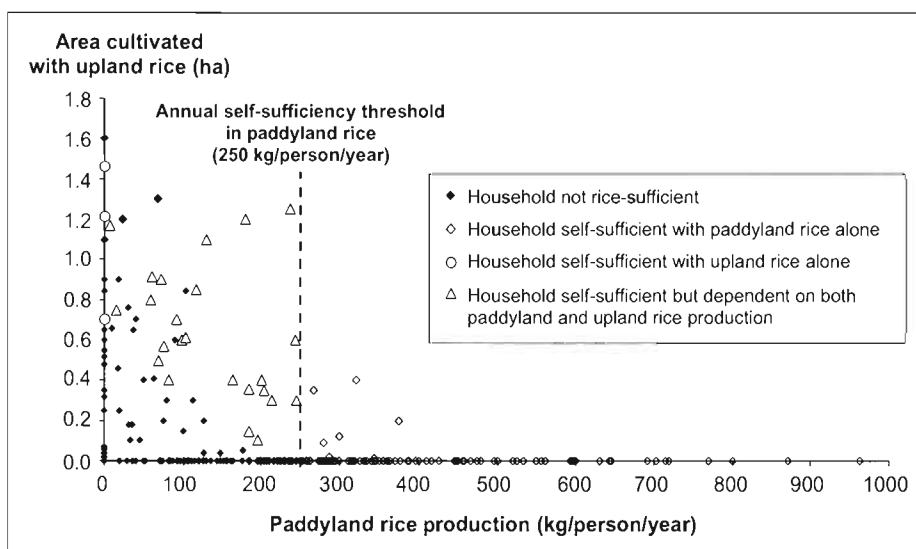


Figure 8: Cultivated upland surface area per household versus annual paddy rice production per person

¹Note that this has not always been the case: in the 1980's, comparative productivities favored upland rice (because of the ill-managed paddyland under the cooperative system and, on the other hand, the relatively pristine forest resources on the hillsides that allowed good upland rice yields). This resulted in wide expansion of slash-and-burn cultivation and extensive, province-wide deforestation (Sadoulet et al., 2002).

but rather farmers who cultivate upland rice because they have no other choice. The first objective of all farmers who do not have sufficient paddyland fields is to acquire them.

Paddyland is at the center of the decision-making processes of *Bac Kan* farmers. Access to paddyland determines the ability of a household to sustain its livelihood, and levels of rice production in both upland and paddyland environments define the range of possibilities available to (or imposed on) each household.

5. From rice strategies to diversified production

5.1. Principal components of diversity

Rice self-sufficiency is the driving force of production strategies. By studying these strategies, we can assess the economic sustainability of the entire household. To explain household production strategies, we chose to retain eleven of the many variables quantified in our household survey. From preliminary analysis we found that these eleven variables were capturing most of the overall diversity of our household sample. A principal component analysis (PCA) allowed us to describe the dependence relationships among these eleven variables (Figure 9), as well as similarities among groups of households (Figure 10). However, principal components analysis requires a complete dataset for each household. This requirement constrained us to analyze only 277 households.

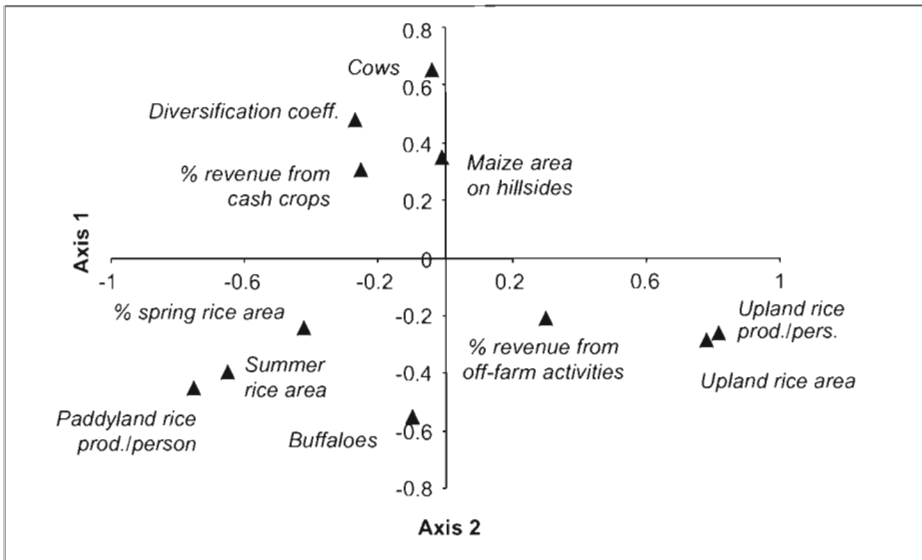


Figure 9: Representation of Axes 1 and 2 of the Principal Component Analysis of variables characteristic of production strategies employed by 277 farms in Bac Kan Province.

The two most significant principal components are represented as axes in Figure 9 and Figure 10. These first two axes explain 53.6% of the total variance.

Axis 1 is largely defined by variables characterizing paddyland and upland rice strategies (contributing 84% of the variance in the first axis). The first axis places the variables 'summer rice surface area' and 'paddyland rice production / person' in opposition to 'upland rice area' and 'upland rice production / person'.

Axis 2 identifies an opposition between production strategies. On the negative side are variables associated with rice specialization and capital accumulation via buffaloes: 'summer rice surface area', 'paddyland rice production / person' and 'buffaloes' (number on farm). On the positive side of Axis 2 are variables characteristic of diversification strategies: 'diversification coefficient' (number of different crops cultivated), 'surface area of maize on hillsides' and 'cows' are all well represented.

Axis 3 (not illustrated) includes variables that are characteristic of paddyland intensification ('% paddyland surface area with spring rice' and '% revenue from cash crop sales') are opposed to those representing strategies of paddyland specialization ('summer rice surface area', 'buffaloes'), as well as extensive hillside systems ('surface area of maize on hillsides', 'cows').

Lastly, Axis 4 (not illustrated) opposes the two means by which farmers can generate additional income: '% revenue from off-farm activities' (negative) against '% revenue from cash crop sales' (positive).

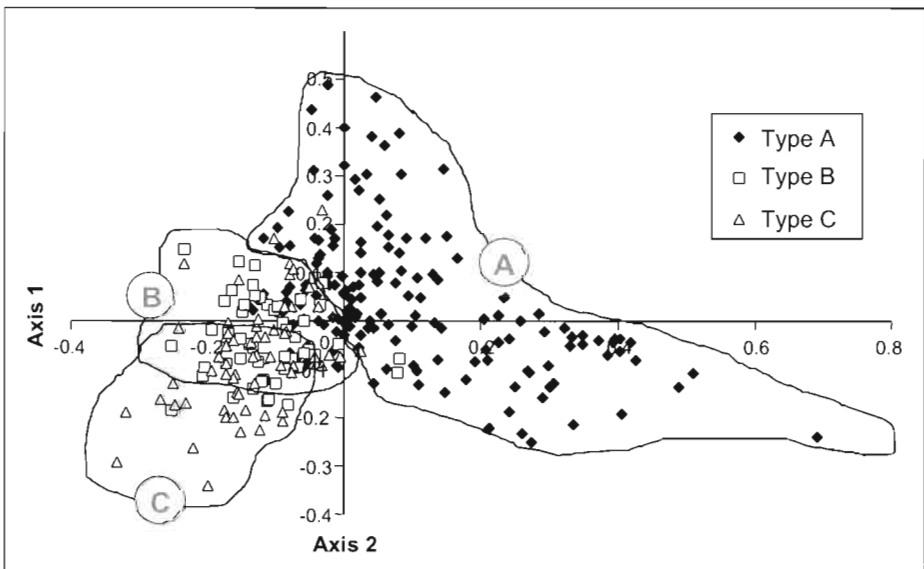


Figure 10: Representation of 277 households on the plan formed by axes 1 and 2 of the Principal Component Analysis, showing classification of individual households into types A, B, and C (defined in Figure 7)

This PCA should be interpreted with caution, because the first two axes explain only 53.6% of the variance. Nonetheless, we can note two major tendencies in Figure 9 and Figure 10. Firstly, there is a marked opposition between two contrasting food production strategies: the paddyland rice growers at the left versus the shifting upland cultivators at the right. Axes 2 and 3 reveal the diverse and concurrent strategies for sustaining livelihood systems and capital accumulation. Specialization in rice allowed by large ricefield areas stands in opposition to diversification of production. Paddyland intensification (double-cropping of rice, non-rice annual crops during winter, or perennial fruit trees near paddyfields) stands in opposition to the development of more extensive systems that rely on the hillsides (particularly maize and cassava for pig raising).

Secondly, there is an opposition between buffalo and cow abundance. Buffaloes are associated with paddy fields for their traction power, and are also a means of capitalization. In contrast, cows are a means of saving and diversification for farmers who rely largely on the hillsides.

Plotting individual households on the grid formed by axes 1 and 2 (Figure 10) allowed us to associate the various production strategies defined above with farming system types A, B and C, defined earlier in Figure 7 according to their capacity to meet their rice needs.

5.2. *Type A households*

Type A households occupy a large area on Figure 10, revealing the internal diversity of this type in terms of production strategies. Insufficient paddyland rice production pushes these households to rice-based and non-rice-based strategies in the uplands. Shifting cultivators occupy the rightmost portion of Figure 10. Based on upland rice, their system still persists in areas that both have abundant forest and are located sufficiently distant from villages to escape the growing restrictions on slash-and-burn practices.

Where such areas are unavailable, which is becoming more and more the case throughout the province, type A households must turn to other food crops that can survive in low quality soil (maize, soybean, cassava), which are then consumed, sold, or fed to pigs. When these food production systems can be stabilized on the hillsides through partial terracing or inputs of nutrients (generally manure), these households can begin to generate income through cash crops and cow raising. The diversification of agricultural activities is characteristic of type A households, as they search for alternatives to upland rice on the hillsides. They sell fruits, soybeans, and vegetables grown on sloping land, generating 5 to 40% of household revenue. Non-farm activities play an important role for type A households who cannot generate sufficient income with food and cash crops. Over 30% of households in this group generate more than 50% of their income from non-farm activities (Figure 11).

5.3. Type B households

Type B households are those who are not self-sufficient in summer rice, but have become so with the addition of spring rice. The labor requirements of intensified paddy-land production largely prevent this group from engaging in wide diversification on uplands. Intensification strategies include planting winter crops (mainly maize and vegetables) in paddy fields, and developing cash crops (soybean, tea and/or fruits) in the areas bordering their paddy fields. The tendency toward minimal diversification in upland cash crops is reflected by a low '*diversification coefficient*' accompanied by a high '*% revenue from cash crops*'.

The agricultural activities described above tend to occupy the entire available workforce, limiting non-farm activities to several households who just barely have their rice needs met (Figure 11).

5.4. Type C households

With their food needs largely met by large areas of summer-season paddyland rice, rice specialization is the strategy favored by type C households. They tend to have developed buffalo herds, both for animal traction on their paddy fields and as a kind of living capital. Cash crops provide no more than 20% of household revenue. With annual rice production averaging 450 kilograms per head, the only non-rice agricultural income of most of these households is the sale of maize, either directly or indirectly (through pigs and fowl). In particular, type C households outside the intersection area with type B are those with the largest ricefield areas and adopt only minimal diversification strategies. Other type C households diversify their production systems in three ways. Firstly, some plant fruit trees on the hillsides bordering the paddy fields. Secondly, others produce winter crops (soybean and vegetables) in the paddylands (area on Figure 10 covered by both types B and C). Thirdly, others move to off-farm activities to generate further income.

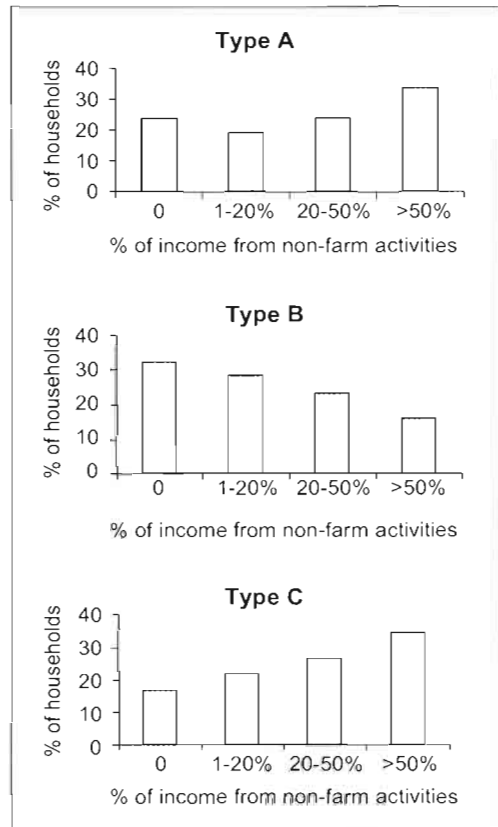
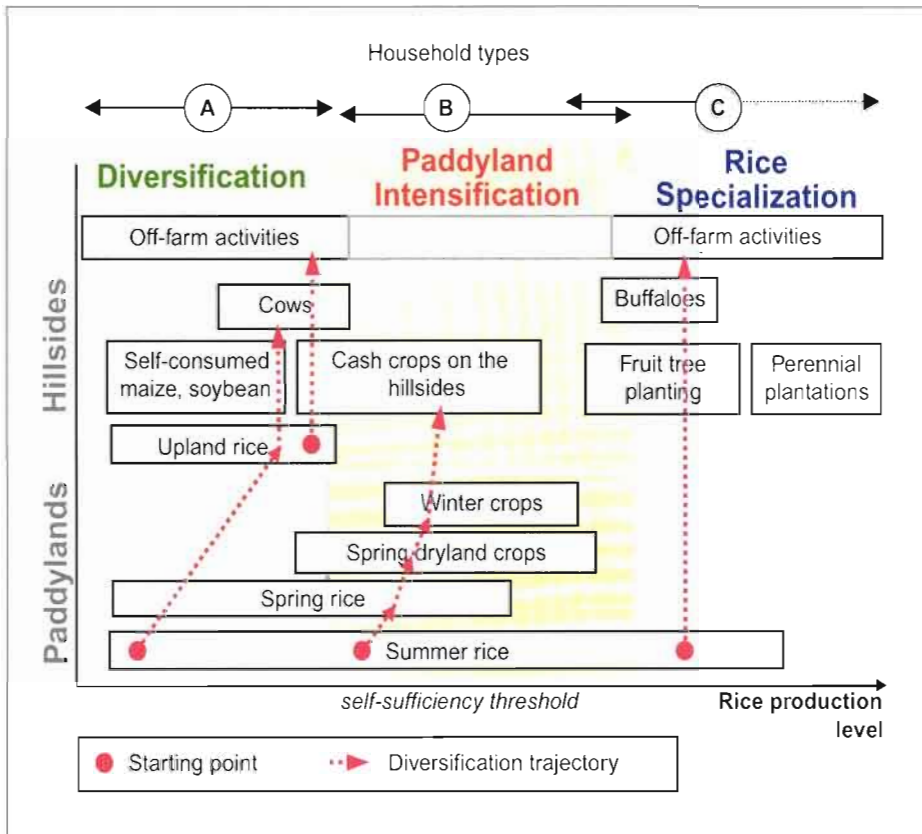


Figure 11: Reliance of household types A, B, and C on off-farm activities

For more than 30% of the households in the type C group, off-farm activities represent more than 50% of annual revenue (Figure 11). As the richest farmers in the community (based on land access), they have the most well-developed social networks, and often hold positions of authority in local administration.

5.5. Paddyland-upland links and sustainability

The definition of these three groups of households according to their distinct production strategies was based on two major factors: (i) access to paddylands and (ii) the level of rice self-sufficiency attained in the paddylands. Based on these factors, households seek food security and accumulation through either diversification (type A), paddyland intensification (type B), or in rarer cases, rice specialization (type C). Figure 12 synthesizes the production relationships described above, showing the connections among paddyland rice production, upland rice cultivation, livestock systems, and off-farm activities.



The economic and ecological viability of the above-described production systems rests on the sometimes complementary, sometimes competitive relationships between the two landscape zones in the mountainous areas: the paddylands and the hillsides. These zones are inherently interdependent, and there are many associations between various upland and paddyland crops and livestock systems. For example, residues from the rice harvest are combined with maize to feed pigs, manure from which can then benefit either the hillsides or the paddylands. Profits from maize and cash crops allow capital accumulation in the form of buffaloes, which can then provide traction in the paddyfields.

But competitions also can arise between the two systems. Certain kinds of land can have multiple functions, and households with diverging interests sometimes find themselves in conflict. For example, free-grazing buffaloes owned by type C households can damage the hillside crops upon which type A households depend. The centrality of paddyland rice in the system is demonstrated by the stronger social control that rules the paddylands: although crop-livestock conflicts in the uplands are considered to be strictly the problem of the cultivators, paddyland rice-based conflicts tend to be blamed on the animal owners. That said, the development of winter paddyland crops by type B households remains constrained by roaming animals (Castella et al., 2002b).

6. Conclusions

All households in *Bac Kan* Province share the common objective of attaining food security through paddyland rice production. Paddyland access and production are thus the defining elements of the region's production strategies. When rice self-sufficiency cannot be attained (because of insufficient water or poor water management, insufficient paddylands, low yields, or inadequate labor force), households develop alternative rice- or non-rice based strategies. In the context of a rapidly-changing agricultural system, paddyland access is the driving force of province-wide transformations. With the noted exception of household type C and its income-generating paddyland surpluses, the majority of households are in the process of acquiring additional paddyland, intensifying production on their paddyland, or both. Paddyland acquisition and intensification are funded by revenues from cash crops, animal husbandry, and off-farm activities. Montane paddyfields already have expanded to their limits in *Bac Kan* Province, and make up the "backbone" of agricultural production.

Upland rice is on the decline, as it is now a low-productivity alternative practiced only by those who cannot meet their rice needs in the paddylands. Since the allocation of forestland use rights to individual households, shifting cultivators have been effectively sedentarized, and their traditional production system is slowly disappearing. Many type A farmers are now confined to fixed locations on

which slash-and-burn cultivation cannot sustain their livelihoods for any length of time. These farmers must now innovate if they are to survive; otherwise, they may be forced to migrate to new frontiers in the South or to urban areas.

The new sedentary production systems of type A households put their food security at risk, but at least have the advantage that these poorest of farmers are now in a place where they can be helped by effective development programs that can accompany them in their search for new hillside cultivation systems (Bal et al., 2000; Husson et al., 2001). It is our hope that this study will help development planners to identify this group more quickly on the regional scale (Castella et al., 2002c).

Our analysis of production strategies allowed us to develop a differentiation model based on the defining role of paddy rice production. Based on only a few criteria, we were able to classify all the farming systems in the region, making it easier to target development interventions and technical and economic advice to the appropriate farmers. For example, paddyland intensification has been identified as a promising possibility to reduce pressure on uplands, but this intensification needs to be achieved via different strategies for different groups (increasing double-cropped areas, introduction of cash crops in spring or winter, etc.). This farming-system classification can now be generalized to the entire province based on statistical data (e.g., number of laborers and mouths to feed, rice self-sufficiency levels) readily available from communes and villages, without the need to repeat the extensive household surveys used to generate the classification.

Paddyfield expansion has reached its limits in *Bac Kan* Province. Slash-and-burn cultivation is no longer a sustainable alternative, although the practice continues to this day. Before farmers can become interested in the long-term sustainability of the upland areas, their basic food needs have to be met. Given locals' prioritization of rice, this will require increased food production in the paddylands to decrease pressure on the uplands. Options are limited to increasing paddyland yields (through improved water management, more manure, labor and chemical inputs) and further ricefield intensification, with spring-season paddy rice if irrigation is available, or if it is not, with aerobic rice (upland rice varieties resistant to temporary flooding that are grown on flatland) or other rainfed spring-season crops.

The interdependence of all cropping and livestock systems in the studied region, both on hillsides and paddyland, calls for a system-wide approach to development. As land use evolves, strategies diversify, and the need for rural off-farm employment intensifies, farmers need to be supported in constructing new rules of social organization that are well adapted to their new production relationships.

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