Keynote 1: Agrarian transition and farming system dynamics in the uplands of South-East Asia

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Abstract

In recent decades, agrarian landscapes and livelihoods in the uplands of South-East Asia have undergone dramatic changes. Farming households have had to adapt to the mounting influence of global drivers of change in an increasingly connected world (e.g. market integration, economic policies, environmental regulations, climate change). As a result, agrarian societies -with agriculture as the main occupation, the most important economic activity and the dominant ideology for rural development- have shifted to societies increasingly based on industrial production and services. These rapid and profound societal and environmental transformations constitute the 'agrarian transition'.

In South-East Asia, the agrarian transition has been influenced by megatrends such as the commoditisation of agriculture, the increasing divide between different forms of agriculture (e.g. agribusinesses versus smallholders) and the diversification and de-agrarianisation of livelihoods. These trends are driven by a combination of factors, such as demographic changes, market forces and government policies that differentially affect local land uses depending on the stage they have reached in the agrarian transition. From a bottom-up perspective, the agrarian transition can be described as the rapid accumulation and convergence of multiple local land use trajectories. From there, local trajectories of change can be classified into a limited number of evolutionary pathways.

Locations (villages, districts) that evolve along the same pathways but at a different pace or with a time-lag can learn from each other (e.g. avoid repeating the same mistakes). This can facilitate decision-making in times of uncertainty if institutional mechanisms are in place to support exchanges across scales and sectors. Furthermore, the identification of windows of opportunities for conservation agriculture will facilitate the design of appropriate technologies and spatially differentiated policies.

Key words

Land use transitions, commoditisation of agriculture, livelihood vulnerability, de-agrarianisation

I. Land use trajectories and the agrarian transition in South-East Asia

1) The origins of South-East Asian agriculture: rice civilisations and commercial plantations

Three main types of agriculture can be distinguished in South-East Asia: swidden agriculture, lowland paddies and commercial crops (De Koninck 2005).

Swidden agriculture has existed for thousands of years in all tropical forests. It covers a wide range of cultivation practices (van Vliet et al. 2012) and is still the dominant form of agriculture in many rural upland areas in South-East Asia (Mertz et al. 2009). It is given multiple designations according to authors: shifting cultivation (Watters 1960; Conklin 1961; Spencer 1966; Fox et al. 2000), swidden cultivation (Conklin 1954) and slash-and-burn agriculture (Kleinman et al. 1995; Brady 1996; Fujisaka et al. 1996). All these terms refer to the alternation of cropping and fallow phases. This form of agriculture does not generate large surpluses and is therefore associated with low population densities. Mazoyer and Roudart (1997) estimate that swidden agriculture makes it possible to feed a maximum of 10 to 35 inhabitants per square kilometre, depending on the duration of fallow and the annual basic needs per person. Indeed, with low population densities this practice does not cause deforestation, since the cropping phase is short (1–3 years) and the fallow duration is long (10–20 years). Return on labour is high, but return on land is low, because one must take into account the whole area (crop + fallow) that allows the swidden system to maintain itself. Swidden agriculture can maximise return on labour when land resources are relatively abundant: the forest landscape is converted temporarily and then left to regrow. Swidden systems usually require some mobility from the communities who practise them, although rotation or displacement of the fields does not always imply habitat displacement. Often associated with other forms of forest exploitation such as hunting-gathering, swidden agriculture has its main purpose in food production and self-subsistence. It used to be and is still practised today by ethnic minority groups in the mountains of mainland South-East Asia and by the Dayak of Borneo.

In South-East Asia, the historical process of agricultural colonisation of forest areas was also driven by a sociotechnical model of agricultural production characterised by rice intensification in terraced lowlands thanks to improved water control and management. Irrigated rice cultivation is based on a strongly hierarchical system of labour and land control, as opposed to the more individualistic management of forested land practised by swiddeners. Initially, the technical choices (i.e. paddies v. swiddens) probably lay at the origin of the differentiated social rules. But later, the societal achievements appear decisive in the permanence of the lowland model of agriculture. Irrigated lowland agriculture is inseparable from the feudal societies such as Javanese and Balinese Indonesia, the Kinh in the deltas of Vietnam or the Tay/Thai in the mountains of mainland South-East Asia.

Long before the colonial era this form of rice cultivation was linked to dominant civilisations, such as those that emerged on the alluvial plains and deltas of the Irrawaddy, Chao Phraya, Red and Mekong rivers. Originally, rice surpluses allowed societies to maintain castes of artisans, nobles and clergy that have gradually structured rice civilisations (Geertz 1954; Hanks 1972; Conklin 1980; Gourou 1984; Diamond 1997). With the development of trade these surpluses could be redistributed or exchanged within the region or exported outside South-East Asia.

Since the colonial period, other areas were cleared for the development of commercial crops such as coffee, rubber and oil palm. The development of cash crops followed the takeover by the colonial powers of the commercial networks in the region with the intention of generating and exporting new agricultural surpluses. In addition to the south of the Indochina peninsula, Java and Sumatra experienced a massive development of cash crops. Rice cultivation dominated in the peninsula, while commercial plantations dominated in the archipelago. Throughout the 20th century, the expansion of these crops continued at the expense of the forest areas inhabited by peoples practising swidden agriculture. The demographic dynamism of the more hierarchical and organised societies led to saturation of the agricultural space. From the beginning of the 20th century, government programs such as transmigration in Indonesia organised the agricultural colonisation of the forest areas of Sumatra and Borneo by Javanese migrants. In mainland South-East Asia, the continuous expansion of the hydraulic societies brought them 'into contact' with swidden rice farmers.

2) The rise of South-East Asian agriculture: agricultural expansion and intensification

Since the 1950s, agricultural expansion has been driven by governmental programs of population resettlement and colonisation of the margins (De Koninck et al. 2003, 2005). Migratory movements associated with the expansion of agricultural pioneer fronts allowed industries to maintain, or even increase, production surpluses, turning the region into a major source of agricultural exports to the world market. The dynamics of agricultural expansion recomposed the rural territories and the relations between lowland and upland areas everywhere. The tremendous growth of the agricultural sector was associated with a widening development gap between the central irrigated basins and the marginal mountainous regions. Taking advantage of the vast areas of natural forest that were still available, agricultural expansion temporarily delayed the Malthusian spectre of a deterioration of the livelihood conditions due to population growth.

The Green Revolution marked a major shift in agricultural development patterns in South-East Asia. While rice yields had changed very little until the 1950s, rice production growth rates then exceeded those of the population growth in almost all countries of the region. The International Rice Research Institute, which was established in the Philippines in 1959, made high-yielding rice cultivars available to farmers. The combined use of improved seeds, fertilisers and pesticides of industrial origin led to a steady growth in rice production.

The adoption of short-cycle, daylength-insensitive rice cultivars helped in turn to generalise the practice of double cropping (i.e. two rice harvests per year), thanks to the development of large-scale irrigation projects (Trébuil and Hossain 2004). In addition, proactive government policies (e.g. improved transportation, storage and marketing infrastructures), economic incentives for agricultural intensification (e.g. improved access to and subsidised prices for inputs and irrigation water, generalisation of credit for agriculture, price regulations for agricultural products, provision of secured market outlets) and massive human and financial investments in agricultural research, extension and training together reduced economic risks for the farmers who adopted the new technologies. Thanks to the Green Revolution, many farmers in Asia experienced a sharp increase in their yields and revenues despite the continuous decline in the real price of cereals on the market. Rice productivity, much like that of maize, doubled or tripled depending on the region between the 1960s and 1990s. In four decades, rice production increased from 260 million to more than 600 million t. The decline in rice price benefited in the first place the poor, who tend to spend a large share of their income on the purchase of food, in both urban and rural areas. The increasing income of rural populations increased the demand for consumer goods, which contributed to the development of the whole economy. The reduction in rice price helped to feed the urban population at a lower cost and therefore to supply a cheap workforce, ensuring greater competitiveness of industrial products. Thus, the impact of the Green Revolution extended beyond the agricultural sector, and was a key driver of economic growth in South-East Asia (Dufumier 2006; De Koninck 2005). The rise of agriculture resulting from the convergence of agricultural expansion and intensification lies at the source of the great industrial transformations of the late 20th century and the emergence of the ‘Asian tigers’. South-East Asian countries experienced fast economic growth after 1986 with the development of a dynamic agricultural export industry. The emergence of this new agricultural sector was boosted by accelerated industrialisation and urbanisation, compounded by the strengthening of academic research.

The process of industrialisation in turn had a major impact on agrarian dynamics by feeding the rural exodus, by reducing population pressure in the countryside and by triggering new consumption patterns of urban populations. In the most favourable agricultural environments, farmers took up the challenge of adapting to these major societal changes through intensifying agricultural production (e.g. shifting from rice transplanting to direct sowing; mechanisation of soil tillage) and diversification of income sources thanks to opportunities of off-farm activities in peri-urban areas. Finally, agricultural successes appear inextricably linked to those of poverty reduction. The Green Revolution appeared to solve the problem of a faster population growth rate than an agricultural production growth rate, which had been perceived as a major handicap to development (Dumont 1935).

3) Upland farmers, left behind by mainstream development trends, explore alternative agricultural pathways

These processes of agricultural intensification were supported by a technocratic and prescriptive agricultural development logic. As impressive as the results are, they have been achieved in geographically limited areas which were favourable to the proposed sociotechnical models. The Green Revolution remained marginal in mountainous areas where agricultural modernisation finally gave birth to a new form of poverty (Rigg 2006). Indeed, in mountainous areas, agricultural expansion and intensive farming practices combined with population growth have increased population pressure on the slopes. Fallow periods shortened (from 10–20 years to 3–7 years) while cropping periods lengthened (from 1–2 years to 7–8 years), pushing swidden systems to the limits of their viability. The return on labour decreased gradually with increasing time spent weeding to compensate for the fertility loss caused by the shortening fallow periods. Indeed, as the fallow period helps control weed germination, land use intensification favours weed invasion. In addition, the reduced fallow biomass limits the renewal of the physical, biological and chemical properties of the soil between crop cycles. Soil fertility decreases to an ecological threshold beneath which forest cannot regenerate, and the land turns to savannah. The maintenance of soil fertility then relies on the use of organic fertilisers through crop–livestock associations, or manufactured fertilisers. However, this technological change did not take place everywhere in the uplands of South-East Asia. Instead, upland farmers explored multiple pathways to new agricultural systems.

In some places, upland rice is grown on Imperata cylindrica savannah regrowth after burning and tillage using draught animals, so as to extend the cropping period. After 20 years without fallow or fertiliser, very degraded soils are abandoned and the village is moved. Upland farmers then have to find new areas suited to their traditional practices. But following land privatisation, nomads tend either to settle in areas of fuzzy land rights, such as collective lands or reserves, with all the legal problems that this creates (Chazée 1998; Zingerli et al. 2002), or to migrate to other provinces (Déry 2004).

An alternative to migration is to terrace sloping land, which is feasible when sufficient labour or capital is available and land tenure is secured. This is usually observed (or justified) where the population density is higher than the viability threshold of swidden agriculture (~35 inhabitants / km^2), so that farmers tend to prioritise return on land over return on labour. But this process of agricultural intensification is limited by water availability: the rice terraces must be irrigated. In the absence of water for irrigation, the expected economic benefit from other crops (e.g. maize, cassava) rarely justifies the initial investment in terracing. An alternative option being evaluated by IRRI would be to use new ‘aerobic rice’ cultivars, which can grow on dry terraces (Amudha et al. 2009).

An alternative to terraces for farming on sloping land involves the diversification of food production into less restrictive crops than upland rice, such as maize, cassava or potato, that can be grown with shorter fallow periods.

In the Philippines, for example, Garrity (1999) reports the widespread adoption of contour farming based on natural vegetative strips in combination with fertiliser use. Farmers adapted the practice of contour hedgerows of tree legumes, which suffered from low adoption rates because of high maintenance requirements, into a simpler, buffer-strip system as a labour-saving measure to conserve soil and sustain yields on sloping land.

Finally, access to markets has made possible the shift from subsistence agriculture to commercial farming. The range of agricultural production has greatly expanded in the uplands to include intensive annual crops, livestock and tree plantations. Hybrid maize cultivars have replaced traditional landraces, leading to a sharp yield increase and rapid expansion of cultivated area. Equally dramatic was an accelerated shift towards smallholder tree plantations. This market-driven phenomenon was facilitated by strong productivity increases in maize and other annual crops, enabling large areas to be released from food production to more profitable, and environmentally sustainable, tree-based systems. In some upland areas such as in northern Thailand, ethnic minority groups completely stopped swidden agriculture to engage in export-oriented food crops or cut flowers grown in greenhouses thanks to their proximity to an international airport.

II. Socioecological issues associated with land use transitions

1) Deforestation, land degradation and poverty

The South-East Asian agricultural development model based on the combination of territorial expansion and production intensification causes environmental problems. In the large irrigated production basins (the valleys and deltas), environmental problems relate mainly to the concentration of agricultural activities, such as the loss of biodiversity, hydrologic changes due to landscape homogenisation, and pollution caused by agrochemicals. In the uplands, deforestation, soil erosion, savannisation and biodiversity loss are the main negative impacts of agricultural expansion on fragile ecosystems (De Koninck 1998; Tomich et al. 2004; Fox 2000; Fox and Vogler 2005).

In a context of ecological fragility, arable land scarcity and endemic poverty, shifting cultivation is believed to engender deforestation and soil erosion, which undermine farming and exacerbate poverty. In turn, increased poverty drives upland populations to further intensify their pressure on natural resources to maintain a decent living. Lestrelin (2010) describes a ‘chain of degradation’ in which deforestation increases runoff and soil erosion, leading to downstream sedimentation and siltation of wetlands and reservoirs; and explains its impacts on rural development policies in the uplands, which favour forest conservation over agricultural expansion. Since the early 1990s, Thailand, Vietnam and Laos have used land-use planning and land allocation as the main regulatory instruments for reorganising local access to land resources, delineating forest conservation areas and reducing the allocation of fallow land per capita, hence limiting the extent of shifting cultivation.

The idea that shifting cultivation and population growth engender a downward spiral of land degradation and poverty in the uplands has also provided incentives for the relocation of remote communities closer to state services (e.g. schools, health centres), with better access to markets, in an attempt to lift them out of poverty. Many villages have thus been displaced from remote areas, with significant impacts on local access to land. In many places, land reforms and resettlement policies have led to agricultural land shortage and have placed upland communities in situations of extreme poverty (Castella et al. 2006a; Lestrelin et al. 2012). Combined with plantation conversion, land sale, natural population growth and unplanned immigration, swidden eradication policies have propelled and sustained the land degradation trajectory (Lestrelin and Castella 2010).

Finally, environmental issues play a central role in land-use transitions and livelihood changes. On the one hand, land degradation processes caused by deforestation have become major driving forces behind economic diversification and household differentiation. On the other hand, land degradation issue are taken up by the states in their discourses to justify poverty alleviation policies that have critical impacts on land-uses and, in turn, on land degradation processes and extent.

2) Commercial agriculture and livelihood vulnerability

Livelihood diversification can be considered as a reaction to land degradation. Some farmers maintain production by cultivating larger areas and allocating additional labour to annual crop cultivation, while other farmers shift to non-farm occupations, and thus are able to untie their livelihoods from land-related constraints. These changes have been largely promoted by government policies aimed at providing income alternatives to upland farmers. Indeed, in most upland areas of South-East Asia, poverty alleviation policies have succeeded swidden eradication policies. Depending on the socioecological context, different incentives are provided to encourage subsistence farmers to engage in commercial agriculture. Besides household-based cash crop production, with or without support from farmer associations or cooperatives, two other models of commercial agriculture have spread all over the region in recent years: large- to medium-scale land concessions leased from the state, and contract farming involving production agreements between private companies and smallholders.

Typically, agribusiness companies negotiate with the state for the acquisition of large tracts of land that are leased over several decades for the development of tree plantations. In many cases, investors can cover part of their initial expenses even before the crop enters production thanks to the extraction and sale of the timber available in the concession area before land conversion. Concessions are the preferred investment scheme for large companies, as it allows them to secure their initial investment over the long period of the lease agreement. Large-scale concessions have been a key factor of the rapid expansion for oil palm plantations, first in Malaysia since the 1980s and then in Indonesia in the 1990s, and more recently, and to a lesser extent, in Thailand and neighbouring countries (De Koninck et al. 2012).

This model has developed rapidly since the 2000s, driven by massive investments by multinational corporations in agricultural commodities, and by incentives provided by governments to favour foreign direct investments. While rubber or coffee, for example, used to be produced mostly by smallholders in Thailand, Indonesia and more recently Vietnam, the recent expansion of these tree crops into marginal areas, such as Laos, Myanmar or Cambodia, increasingly takes the form of large private concessions (Fox and Castella 2013). Despite political discourse stressing the positive impact of foreign investment on the adoption of intensive and 'modern' cropping practices by upland farmers, the rapid expansion of tree plantation concessions has two major negative consequences for local livelihoods. The first is related to disputes with smallholders being evicted from their land without proper compensation; many land conflicts have been reported recently in Cambodia and Laos, for example (Baird 2011; Kenney-Lazar 2012). The second is that farmers are gradually turned into daily wage workers, with negative consequences for their livelihoods and for the availability of family labour for smallholder agriculture. This lack of labour on large commercial farms is often compensated for by massive migration of workers from poorer areas of the country or from neighbouring countries. The generalisation of this new class of poor landless agricultural workers, often illegal migrants, has created many tensions in places where integration into the local society is problematic.

An alternative to land concessions that allows private companies to use local labour is to develop contract-farming schemes. In the nucleus estate model, smallholder farms around the concession are contracted so as to increase the throughput for the processing plant, without the need to acquire more land. The estate plantation also serves as a trial and demonstration farm for private agricultural extension agents to introduce to 'satellite' smallholder farmers the management techniques of the crop. Nucleus estates have often been used in connection with resettlement or transmigration schemes, such as in Indonesia for oil palm and other tree crops. Contract farming can be structured in a variety of ways depending on the crop, the objectives and resources of the company and the experience of the farmers. In Thailand, for example, contract farming has long been used by the sugar industry. Quotas are distributed by the mills to individual farmers or production groups at the beginning of each growing season, and quality is tightly controlled. The government regulates prices, promotes and manages technical research centres, and encourages producer associations. Such schemes are generally associated with tobacco, sugarcane and bananas and with tree crops such as coffee, tea, cocoa and rubber, but can also be used for fresh vegetables and fruits, poultry, pork and dairy production. Wherever governments do not allocate state land to investors and farmers do not have any capital to invest in the conversion to commercial agriculture, so-called '2+3 contract farming' arrangements have spread rapidly in recent years. Under this arrangement, rubber smallholders in Laos provide land and labour (2 factors), and private investors provide seedlings, herbicides and equipment (3 factors), in addition to technical expertise and market outlets.

Depending on the level of financial investment by investors, on their monitoring capacity and on relations with government extension workers, this contract farming model involves a variable risk of default by both investor and farmer.

Driven by the increasing demand by China for agricultural commodities and by large investments by international corporations, the boom of commercial crops has had a tremendous impact on local livelihoods in the last decade. While specialising in a limited number of commodities, growers have become more vulnerable to price fluctuations and are dependent on a larger number of intermediaries. They are also more indebted than before. As inputs are often provided on credit, households find themselves in debt when yields or prices fail to reach the expected levels. Rapid economic differentiation has enlarged the gap between rich lowland areas and marginal uplands, but at the same time it has also increased economic inequalities between upland farmers who were able to seize investment opportunities, with the enormous risks involved, and the late adopters or landless workers.

3) Territorialisation of the upland margins and landscape governance issues

The socioecological changes described above came with profound transformations of the agrarian landscape. Revisiting the regional historical pathways of land use change, we identified a succession of 3 state territorialisation processes that are common to most South-East Asian countries.

Securing the margins and exploiting abundant natural resources

Early upland development policies were aimed at securing the territorial 'margins' of the countries, initially to avoid political unrest during colonial times, and later during the Indochina war, when opponents were hiding in the dense remote forests. Thailand, Indonesia and Vietnam asserted their political control over remote and potentially subversive upland populations by colonising the 'margins' through state-sponsored agricultural expansion (De Koninck 2006). Roads opened into the forest brought in first timber logging companies, and then later settlers who migrated from the lowlands to expand cash crops into upland areas formerly dominated by swidden agriculture. This happened for example in north-eastern Thailand in the 1960s, and then in Indonesia with the transmigration policy supporting the spread of oil palm into remote forested areas, and more recently with massive internal migrations organised to support the expansion of coffee plantations in the central plateaux of Vietnam. These population movements brought state institutions and dominant lowland populations (e.g. Kinh ethnics) to the uplands. In Laos, characterised by a rough terrain and limited state resources, upland populations were also moved down the hills through village resettlement, officially to provide them with better access to state services (e.g. schools, health centres), but also to establish tighter control over their movements and their access to natural resources (Scott 1998; De Koninck 2006; Baird and Shoemaker 2007; Lestrelin et al. 2012). These common objectives of securing the national territory, turning subsistence farmers into taxpayers, integrating upland ethnic minorities into the national identity and reinforcing state control over key resources led to the rapid expansion of commercial agriculture, pushing the deforestation fronts to the periphery of the national territories.

Stopping land degradation and rationalising land use

During the 1990s, new territorialisation policies emerged in reaction to the rapid resource depletion that occurred during the previous period. Logging bans were imposed in Thailand, Vietnam and the Philippines after dramatic landslides and flash floods. More generally, policymakers became conscious that the natural resources that they had used to support rapid economic development were limited. International development agencies spread sustainable development discourses and conditioned their support to increased environmental awareness. New upland policies consisted in rationalising land use through land zoning and land use planning. Scientific expertise replaced national integration as the main instrument for developing the country (Lestrelin et al. 2012). Forests were classified according to their dedicated purpose (conservation, protection or production), and land suitability maps were established with the support of international experts to define the best use of all upland areas (i.e. forestry, agriculture or livestock). In most South-East Asian countries, national protected areas were created in the 1990s. In addition, a large range of land management and planning approaches were tested and applied at the micro and meso levels (e.g. community-based natural resource management, integrated catchment management, upland–lowland integrated planning projects), while master plans were developed at the national level. While R&D projects achieved interesting results as instruments for change, their influence was gradually reduced as private sector investments promoted by the governments took off.

Turning land into capital

Whereas Malaysia had granted land concessions to oil palm companies for several decades, other countries such as Thailand and Indonesia granted concessions at the large scale only in the 1990s, and private Chinese and Vietnamese investments in Laos and Cambodia boomed in the 2000s. Granting land concessions has become a key policy instrument to increase land productivity of supposedly underutilised uplands while achieving other goals such as introducing modern technologies into remote areas and providing stable employment to rural populations. With the 'green neoliberal' development models put forward by donors such as the World Bank and the Asian Development Bank (Goldman 2001) and a growing demand from the (mainly foreign) private sector to gain access to the country's land and natural wealth, market forces have become a key instrument for facilitating sustainable development (Lestrelin et al. 2012). Consequently, the focus of land use planning has shifted from 'rationalising' existing land uses to identifying 'empty' space or freeing space for the development of large-scale mining, hydropower, plantation and agribusiness concessions. Despite commendable efforts made to harmonise land use plans across scales, the granting of concessions at a rapid pace in the absence of tight monitoring on the ground has led to many disputes and is the source of many land conflicts that have arisen in recent years.

In Indonesia and Laos, for example, the state decentralisation process allowed districts or provinces to grant land concessions. But the limited coordination between administrative levels and between line agencies ended up allocating the same pieces of land several times to different users, creating confusion and tensions over access to natural resources.

With the rapid integration of upland areas into the world market, multinational agribusiness companies are gradually replacing the states in driving land use transitions. Despite the high contribution of agriculture to economic development, states have gradually disengaged from agricultural production, leaving the management of agricultural frontiers to multinational companies (De Koninck et al. 2012). Relations between upland dwellers and agribusiness companies are multiple and complex. They depend on the companies, the crops, state regulations and how different stakeholders can negotiate local arrangements. In some cases, local communities manage to benefit from opportunities offered by companies, while in other cases, land-grabbing practices deprive smallholders of their land without proper compensation. Between these two extremes, smallholder agriculture has evolved continuously to adapt to successive land use policies, land degradation and the emergence of new actors with competing development claims. Through these successive reconfigurations, smallholders have demonstrated their capacity to innovate.

III. What are the prospects for conservation agriculture?

Today, there is a broad consensus about the necessity to buffer the negative consequences of the agrarian transition and to ensure the sustainability of smallholder-based agriculture. To address problem of land degradation, in 2005, the government of Laos issued a decree that generalises the use of conservation agriculture (CA) across the country. In Indonesia, complex agroforests that retain about half of the biodiversity of the dense natural forests and that connect forest patches to each other to create conservation corridors are under threat from the rapid expansion of oil palm plantations (Feintrenie and Levang 2009). Different payments for environmental schemes have been designed and tested with limited success to prevent this land use conversion (Feintrenie et al. 2010). In South-East Asia, as around the world, the international scientific community is en route to a ‘doubly-green revolution’, i.e. agriculture that is both productive and environmentally friendly (Conway 1997). It involves a shift from a logic of controlling nature to working with ecosystems: playing with the diversity of farming systems, not trying to homogenise the fields and the people (Griffon and Weber 1996). The idea that a second Green Revolution cannot result, like the first, from a simple transfer of technology has made its way in the scientific community.

The ability to influence the agrarian transition towards sustainable development is one of the major challenges of international research (Young et al. 2006).

Many communities are mobilised worldwide to give the scientific basis for this new, intentional transition and to put it into practice on the ground. Indeed, the uncertainty inherent in rapidly changing socioecological environments forces scientists to rethink and adapt their research practices. Far from controlling transformations, they can at best influence their direction and speed. Beyond a better understanding of the natural and human environments, or the design of new technologies, researchers are asked to define new development pathways and new modes of governance towards sustainable development as defined by the Millennium Development Goals (Raskin et al. 2002).

1) Adapting innovations to the coexistence of intensive and extensive agricultural systems

In South-East Asia, agricultural expansion and intensification are interacting at multiple scales (village, district, region) between lowlands and uplands, paddies and swiddens, central and peripheral spheres of power. The same types of relations between lowland and upland populations as those described at the level of upland villages exists between irrigated areas of Asian mega-deltas (e.g. Chao Phraya in Thailand, Irrawaddy in Myanmar, Red and Mekong rivers in Vietnam) and marginal upland areas that surround them. Historically the same processes of agricultural expansion and intensification have been at work between 'lowlands–paddies–centre' and 'uplands–swidden–periphery' at all scales: village, commune, district, province, country and South-East Asia. All over Asia, intensification of the lowlands, first through labour and then through capital (through mechanisation and chemical inputs), has clearly contributed to improved farm productivity. Encouraged by the individual allocation of forest lands, this process of lowland intensification decreased the pressure on the slopes for families who had access to lowland fields (Castella et al. 2006a). If swidden systems persist today it is because some farmers do not have access to fertile lowlands. Among them are ethnic minorities, but also young generations of farmers who have not inherited enough lowland from their parents or who have not managed to engage in off-farm activities. Beyond land issues, the reasons for the persistence of swidden agriculture despite population densities exceeding the viability threshold of these systems are to be found in the complex interactions between intensive and extensive systems at local scales.

In fragile upland ecosystems, extensive agricultural practices spread the risk of crop failure and form part of risk management strategies. Furthermore, the different modes of fertility reproduction interact dynamically at the local scale, through biomass flows or through livestock movements between cultivated and non-cultivated parts of the landscape. In addition, non-agricultural functions of fallows (e.g. forage, timber, medicinal plants, land ownership demarcation) contribute significantly to swidden persistence despite increasing land pressure. Finally, pathways towards 'sustainable agriculture' should remain compatible with the persistence of extensive systems, as the coexistence of extensive and intensive cultivation practices is essential to the sustainability of the whole system.

2) Identifying windows of opportunity in space and time

Beyond sustained efforts to increase the system's resilience or its ability to adapt to unavoidable changes (e.g. by maintaining the diversity of farming systems and practices), major transitions can be triggered by innovations that arrive at the right time, when the conditions for success are met; that coincide with a window of opportunity sometimes limited in space and time. Steering the transition towards desirable futures then consists of assessing whether the context is favourable to the adoption and diffusion of the innovation and creating the conditions for change to happen (Kemp et al. 1998).

In maize production areas of Laos, for example, Lestrelin and Castella (2011) identified two windows of opportunity for CA: First, at an early stage of the commoditisation and intensification of agriculture, when swidden agriculture is no longer an option and upland farmers are in search of low-input alternative practices; dissemination efforts and technical support to CA may allow smallholders to engage in more sustainable practices. Second, at the stage of land degradation and diversification from intensive tillage–based cropping systems; CA can easily become an economically and ecologically sound alternative. The concept of a socioecological niche for innovation (Giller et al. 2009) helps define areas where -and times when- particular types of technical innovations are more likely to be adopted by smallholders. Soil erosion, access to farm inputs and markets and the presence of smallholders with sufficient land, labour and capital are key criteria for identifying these niches. Physical accessibility (i.e. distance to markets or decision centres) and social accessibility (i.e. relative marginalisation of social groups depending on their ethnicity, gender or religion) also distribute development opportunities in space and the capacity of smallholders to adapt to changes (Castella et al. 2005).

Regularities can also be identified in the complex transition processes in the form of trajectories that repeat themselves in space with a longer or shorter time-lag. For example, phenomena that have been described in Thailand, Indonesia and other parts of the world affected by the opening of roads in forested uplands, or land privatisation by agribusiness investors in a context of fuzzy land tenure, can be identified in Laos today. Lessons can be drawn from the past experiences of neighbouring countries to adapt intervention mechanisms (e.g. environmental regulations, payments for environmental services, eco-certification) to the particular context of each area in relation to its stage in the socioecological transformation pathway.

3) Connecting actor-networks and negotiating innovation pathways

Transitions can also be initiated by tensions or transformations happening at higher levels, as for example the negative externalities of intensive agriculture on the environment (e.g. land degradation, pollution), massive migrations or political reforms. Environmental activists seek to transform the sociotechnical systems by combining bottom-up pilot experiments with, for example, organic production or renewable energy, and top-down advocacy approaches, for example, anti-globalisation movements against multinational agri-food business and agrochemical industries or anti-GMO campaigns.

Changes often occur through the reorganisation of actor-networks in reaction to situations deemed unacceptable (e.g. land grabbing) or in contexts of collective actions aimed at designing more desirable futures (e.g. Landcare organisations in Australia and the Philippines). The linkages between local and regional drivers of the transition are provided by multiple actor-networks: research and extension networks define recommendation domains for innovations; transport networks determine accessibility gradients; commercial networks define market chains and outlets; and sociotechnical networks facilitate communication, access to information and credit. Network structure and density determine the capacity of the socioecological systems to adapt to endogenous or exogenous factors of change. Indeed, poverty and vulnerability are usually correlated with marginal positions in a social network. Therefore, opportunities should be provided to vulnerable and disadvantaged groups to make connections and build alliances that enable them to solve their own problems.

Moreover, inflections or bifurcations in land use trajectories are systematically linked with some kind of negotiation among stakeholders, be it implementation of a new policy or granting a concession. The quality of the negotiation then determines to a large extent the type of trajectory that will unfold and who will be the winners or losers of the negotiated changes. In turn, the quality of the negotiation is determined to a large extent by who takes part, the level and quality of information held by each stakeholder, and the power relations that may allow some stakeholder groups to impose their views on others. Improving the quality of the negotiation can certainly help influence pathways of changes.

Experience in Vietnam illustrates such negotiation process in the context of the diffusion of CA techniques (Castella et al. 2006b). The adoption of cropping systems with cover crops was possible only as part of the concerted management of forage resources across the village. Several scenarios were discussed with a group of farmers selected for their representativeness of the different types of land use found in the village. By facilitating common understanding of problems related to crop–livestock interactions and providing visualisation and simulation support, researchers engaged local communities in negotiating alternative scenarios that could be explored collectively. Through active engagement of local actors in a collective learning process, local dynamics of change then appear as internally negotiated forms of the technical or organisational innovations that are proposed by outsiders (e.g. extension agents, researchers, private companies).

Throughout South-East Asia, decentralisation policies provide a legal framework to engage local communities in public consultations and to increase the legitimacy of local actors as forces for proposition and negotiation. Development projects promote community management of renewable resources and participatory approaches (Neef 2005). But they often struggle to move away from conventional discourse and to put their recommendations into practice on the ground.

In short, the institutional context is favourable for the implementation of a concerted management of natural resources and territories, but methods are still lacking, or are not used by extension agents on a significant scale.

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The 3rd International Conference on Conservation Agriculture in Southeast Asia

Conservation Agriculture and Sustainable Upland Livelihoods
Innovations for, with and by Farmers to Adapt to Local and Global Changes
-
Proceedings

Hanoi, Vietnam
December 10-15, 2012
www.conservation-agriculture2012.org

Front cover: Patricia Doucet (CIRAD)
Document design: Patricia Doucet, Martine Duportal, Damien Hauswirth (CIRAD)
English revision (abstracts and keynotes): Matthew Stevens (Science Scape Editing)
English revision (portfolio and texts): Peter Biggins (CIRAD)

Printed by: Tran Cong Co. Ltd., Hà Nội, Viet Nam

Co-published: by CIRAD, NOMAFSI, University of Queensland

ISBN CIRAD: 978-2-87614-687-7
EAN CIRAD: 9782876146877

Distributed by CIRAD, UPR SIA - TA B 01/07, Avenue Agropolis, 34398 Montpellier cedex 5, France
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