Southeast Asian Studies, Vol. 41, No. 4, March 2004

Some Key Issues Relating to Sustainable Agro-resources Management in the Mountainous Region of Mainland Southeast Asia

KONO Yasuyuki* and A. Terry RAMBO**

Abstract

Most of the people who live in the mountainous region depend on agriculture for their livelihood. They are facing increasing difficulties in meeting their daily subsistence needs, let alone raising their living standards to levels enjoyed by the lowland populations. At the same time, the agro-resources on which the economic welfare of the mountain people depends have been suffering severe degradation with consequent reductions in productivity. Finding ways to intensify agricultural production in a sustainable manner is a critical problem facing both the farmers who inhabit the mountainous region and for the national governments of Laos, Thailand, and Vietnam. In this paper, drawing on the detailed case studies of specific local areas that are presented in the papers in this special issue, we describe some key problems facing agricultural populations in the mountains, examine the driving forces for change, look at the adaptive responses of the farmers to the changing resource situation in the mountains, assess some potential solutions, and set-out some research priorities.

Keywords: population pressure, resource degradation, upland agriculture, Laos, Thailand, Vietnam, human adaptation

I Introduction

The mountainous region of Mainland Southeast Asia stretches from Assam and the Northeast Frontier territory of India across Myanmar, Laos, Thailand, and Vietnam into Yunnan in China. This vast region is physically very diverse. It includes high, sometimes snow-covered mountains, large intermontane basins (e.g., Dien Bien in northern Vietnam), broad plateaus (e.g., the Khorat Plateau in Northeast Thailand), and rolling hills. Thus, although we refer to it in this paper as the mountainous region, not all of its inhabitants live on the steep slopes that this word normally calls to mind. The diversity of land forms in the region is matched by climatic and edaphic diversity and a concomitant diversity of natural vegetation types and cultivated crops. Linguistic and cultural diversity are also extremely high making it difficult to identify any commonly shared characteristics of the region as a

* 河野泰之, Center for Southeast Asian Studies, Kyoto University, corresponding author's e-mail: kono@cseas.kyoto-u.ac.jp
** Center for Southeast Asian Studies, Kyoto University

whole. One common feature, however, is that most of the people who live in the mountainous region depend on agriculture for their livelihood. These people are all facing increasing difficulties in meeting their daily subsistence needs, let alone raising their living standards to levels enjoyed by the lowland populations. Even in countries such as Vietnam where the income of the mountain people has increased considerably in recent years, there is a growing gap between the economies of the mountains and the lowlands that leaves the mountain people relatively worse off than before. Meanwhile, the agro-resources on which the economic welfare of the mountain people depends have been suffering severe degradation with consequent reductions in productivity. Finding ways to more sustainably manage agro-resources is therefore the major challenge for mountain area development. In this paper, drawing on findings of the other papers in this special issue, we will describe some key problems facing agricultural populations in the mountains, examine the driving forces for change, look at the adaptive responses of the farmers to the changing resource situation in the mountains, assess some potential solutions, and set-out some research priorities.

II Key Problems of Agricultural Development in the Mountainous Region

The current situation of the farmers in the mountainous region is a very difficult one. They face severe problems of inadequate food security, poverty, economic and social marginality, and environmental and resource constraints of agricultural productivity. We will discuss each of these problems in turn.

II–1 *Food Security*

Producing sufficient grain to meet basic nutritional needs is the most critical problem faced by most farmers in the mountains. Yamada *et al.* [2004] point out that while at the national level the average per capita rice supply in Laos is 320 kg, in the mountainous areas of northern Laos annual production fluctuates between 227 and 313 kg, making this region the most prone to rice shortages in the nation. In the communities in northern Laos studied by Watanabe *et al.* [2004] 70 percent of the shifting cultivator households were unable to produce enough rice to meet their consumption needs in 2000, up from 40 percent in 1999. The situation in the villages studied by Yamada *et al.* [2004] in northwestern Laos is similar. In the lowland villages relying on paddy rice, 20 percent of households are food short for more than four months per year, 40 percent faces shortages for from one to three months, and only 20 percent are able to meet their annual food needs. Surprisingly, in the mountain villages that rely wholly on shifting cultivation, two-thirds of the households do not suffer a rice deficit and one-third face a short-fall for from one to three months. The hillside villages that depend on a combination of paddy and swidden farming have the worst food security: more than one-half of the households do not produce sufficient grain to meet their needs for four or more months each year.

The situation in Vietnam's mountains is no better. For example, in a commune in the foothills in Bac Ha district, Lao Cai province in Vietnam's Northern Mountain region studied by Sakurai *et al*. [2004], rice production falls short of consumption needs so the people must eat maize, a less favored grain, to meet their basic nutritional needs. Moreover, continuing rapid population growth will worsen the food security situation in future years unless grain production can be increased, a problem common to almost all communities in the mountainous region of Mainland Southeast Asia.

II–2 *Poverty*

Closely linked to the problem of food security is the high level of poverty in the mountains. Incomes are extremely low in most places. In the villages in northern Laos described by Yamada *et al*. [2004] the average per capita cash income was only US$30 per year in the hillside villages, US$38 per year in the mountain villages, and US$43 per year in the lowland villages. Forty-three percent of households in the hillside villages, 32 percent in the mountain villages, and 24 percent in the lowland villages are classified as being poor.

The Lisu villagers in northern Thailand described by Ongprasert and Prinz [2004] achieve somewhat higher cash income levels than the villagers in Laos, averaging US$2,736 per household. Assuming an average of 6 persons per household, this represents a per capita income of more than US$450 per year. Although high by the standards of the mountains, this is four times lower than the national average per capita income. The relative gap between per capita incomes in the mountains and the lowlands is probably even greater in most of the other countries in the region.

II–3 *Economic and Social Marginality*

Not only are the mountain area farmers poor and often hungry, they also tend to occupy marginal economic and social positions within the national systems in which they live. Many mountain people are members of ethnic minorities who do not fully participate in the social life of the nations in which they reside. Because of their cultural distinctiveness and the remoteness of their settlements they often have restricted access to educational services and often lack fluency in the national language. They tend to be ignored by national agricultural extension services although, at least in the case of the Karen in northern Thailand described by Ongprasert and Prinz [2004], some new legume crop species have been introduced by government and NGO extension workers and also private businessmen. Even, however, where extension workers are active, they may have few new technologies that are adapted to mountain conditions to offer to the farmers.

Transportation systems are much less well developed than in the lowlands and, consequently, the costs of shipping agricultural products and inputs are very high. This restricts the participation of upland farmers in the market economy on which they must increasingly depend to meet their basic survival needs. For example, as Ongprasert and Prinz [*ibid*.] point out, adoption of planting of viny legumes as a profitable cash crop by Lisu farmers in

northern Thailand only occurred in villages that were readily accessible by large trucks to move the harvest to market. The more remote settlements could not profitably adopt this useful innovation.

II–4 *Environmental and Resource Constraints*

The conventional view of the mountains emphasizes the poor quality of agro-resources. Soils are considered to be thin, infertile, and easily eroded. Colder temperatures result in lower crop yields and limit production to only one crop per year, a constraint reinforced by dependence of most agricultural production on seasonal rainfall.

Certainly, these are major constraints in many parts of the mountain region. For example, the soils in Northeastern Thailand discussed in the paper by Vityakon *et al.* [2004] are highly leached, low in fertility, and subject to very high erosion rates. Annual soil loss from upland cassava and sugarcane plots reached 20 t/ha, double the US Soil Conservation Service's allowed soil loss tolerance of 10 to 12 t/ha/yr. To compensate for this loss, farmers would have to apply large quantities of expensive chemical fertilizers to maintain production levels in the upland fields. However, as Trelo-ges *et al.* [2004] suggest, income generated by upland crops in the Northeast may not be sufficient to fully cover the cost of replacing soil nutrients lost in their cultivation.

On the other hand, some of the papers offer a considerably more favorable interpretation of environmental conditions in at least some parts of the mountains. According to Ongprasert and Prinz [2004], the limestone-derived soils in their study villages in northern Thailand are highly fertile and able to sustain continuous crop cultivation for an extended period without using chemical fertilizer. These soils originally contained high levels of phosphorous and have maintained a high level of nutrient availability after 17 years of continuous cultivation. The farmers did not mention soil erosion as a problem threatening sustainability. That soil erosion is not a serious threat to agricultural sustainability of sloping land fields in Bac Ha district in Vietnam's northern mountains is asserted by Sakurai *et al.* [2004] based on their measurement of clay content and clay dispersion ratio, although they concede that over the long term, slight but continuing erosion might have reduced soil quality. In any case, the dryland fields in the higher elevation villages are beautifully terraced which would seem to represent a response by these farmers to a perceived threat of erosion. Expansion of terraced areas there, however, is limited by topographical constraints. The area that can be used for irrigated paddy fields is quite limited in most areas in the mountainous regions, as in the case in hillside villages in northwestern Laos described by Yamada *et al.* [2004].

III Driving Forces for Change in Mountain Agroecosystems

A number of forces appear to be driving changes in agricultural systems throughout the mountainous region. These include population growth, environmental and resource degrada-

tion, improved transportation and communications, expansion of the market system and economic globalization, and enforcement of government policies and regulations on land use.

III–1　*Population Growth*

Rapid population growth is a force for change everywhere in the mountain region of Mainland Southeast Asia. In Northeast Thailand, for example, as Vityakon *et al.* [2004] report, the population grew from 3 million to 18 million people in the 65 years from 1920 to 1985. This increase in the number of people, along with wide-spread adoption of cash-cropping, led to rapid clearance of forest land to open new fields in the uplands. At a more micro-level, the population density of the small Da Bac Tay ethnic minority settlement of Ban Tat in Vietnam's Northwestern Mountains described by Tran Duc Vien *et al.* [2004] increased from 10 persons/km^2 in 1954 to 75 persons/km^2 in 1999. This has forced shortening of the fallow period of the swiddens from 12 years or more to only 3 or 4 years. In northern Laos, according to Watanabe *et al.* [2004], population increase in recent years has forced shifting cultivators to shorten the period of fallow from 40 years to only 5 years.

III–2　*Environmental and Resource Degradation*

Degradation of the environment and natural resources has occurred in many parts of the mountain region. Deforestation, accelerated soil erosion, and loss of biological diversity are widespread problems, although, as the papers in this special issue show, there is a great deal of variation from site to site, with some areas showing less impact than others.

The area covered by forest has declined in many areas, often dramatically. According to Vityakon *et al.* [2004], in Kham Muang village in Northeastern Thailand, the forest area declined from 2,000 *rai* at the time when the village was first settled in 1897 to only 400 *rai* in 1987. Reduction of the number of trees has adversely affected soil quality and forced farmers to rely on purchased chemical fertilizer inputs to maintain crop productivity in their upland fields. The shrinking area for grazing cattle and buffalo has led to a decline in the number of livestock with a consequent decrease in the supply of manure that was formerly used to maintain the fertility of crop fields. It has also reduced the supply of natural forest products on which the farmers earlier relied to meet many of their basic survival needs.

Decline in the area and quality of forests has had especially serious consequences for shifting cultivators. In the mountains of northern Laos, for example, as is pointed out by Watanabe *et al.* [2004], farmers have greatly reduced the area of shifting cultivation fields planted to dry rice because of sharp declines in yields that accompanied shortening of the fallow period and the consequent worsening of competition from weeds.

III–3　*Improved Transportation and Communication Systems*

Vityakon *et al.* [2004] show how cropping systems in Northeastern Thailand have changed in response to improvements in the transportation system. In the nineteenth century, agriculture was almost exclusively subsistence-oriented. Cattle, which could transport them-

selves to the market in the Central Plains of Thailand, were the only source of cash. In the 1890s, completion of the first railroad to link the Northeast to Bangkok caused some farmers to begin producing small quantities of rice for the market. It was only after the construction of the Friendship Highway in the 1950s that cultivation of kenaf, followed somewhat later by cassava and sugarcane, became widespread. Similar changes in cropping systems in response to improved access to transportation have occurred throughout the mountainous region.

III–4 *Expansion of the Market System*

Expansion of the free market system, especially in the formerly centrally-planned economies of Laos and Vietnam, is an increasingly strong force for change in upland agricultural systems. For example, in northern Laos, according to Watanabe *et al.* [2004], shifting cultivators have begun to protect volunteer mulberry tree seedlings in their fallowed swiddens and to experiment with ways to propagate and intercrop this cash crop in response to development of a domestic paper processing industry and creation of export market channels. In addition to improving farm incomes, the mulberry trees substantially increase the biomass that develops in the short fallow period which, when it is burned, improves weed control in the next cropping cycle. Also in the mountains in northern Laos, according to Yamada *et al.* [2004], local people now earn a substantial share of their total cash income from the sale of forest products directly in local markets as well as to middlemen. Certain very valuable materials used in making Chinese medicines and incense are traded directly to Chinese buyers.

In Northeastern Thailand, as is discussed by Trelo-ges *et al.* [2004], farmers began to plant sugarcane in place of cassava in their upland fields after construction of a sugar mill close by their village created a reliable market. Those farmers fortunate enough to obtain a guaranteed production quota from the mill invest much more than non-quota holders in production inputs, applying chemical fertilizer at twice the rate of the latter. The non-quota holders, facing market uncertainty, often sell their immature crop to quota holders who then are responsible for managing it until the harvest. Although regularly rotating sugarcane with cassava can help to restore soil fertility that is depleted to a greater extent by cassava, farmers make decisions about whether to plant cassava or sugarcane in their upland fields primarily based on the expected market prices for these crops.

III–5 *Government Policies*

Government policies have profound impacts in many parts of the mountain region. For example, in northern Laos, as Watanabe *et al.* [2004] report, new regulations to protect forests and strictly limit clearing of new swiddens have forced shifting cultivators to shorten fallow periods and attempt to intensify production on their existing plots. As Yamada *et al.* [2004] observe, Lao government policies intended to counter environmental degradation and protect remaining forest have given little consideration to ensuring that upland people

have access to natural biological resources, despite the very important role that forest products play in local livelihoods. In Thailand as well, establishment of forest reserves has limited farmers' access to land. According to Ongprasert and Prinz [2004], one of the reasons that the Lisu farmers in a village located in a forest reserve in northern Thailand adopted planting of viny legumes in their swiddens was because the vines effectively controlled weeds. They had to adopt this method of weed control after they were prohibited from using tractors to cultivate their fields by government forestry officers who were seeking to protect the forest from further encroachment.

In Northeastern Thailand, as reported by Vityakon *et al.* [2004], the shift from subsistence-oriented to commercially-oriented farming occurred in the past partially in response to government policies aimed at fostering cultivation of crops for export. Construction of an extensive road network, which was initiated by the government in the 1950s for military and security reasons, provided further impetus to commercialization by making it possible for the farmers to move their products to market quickly and cheaply.

IV Adaptive Responses

In the face of rapid changes in many dimensions of their agricultural situation, upland farmers have engaged in a number of adaptive responses. These include intensification of grain production in paddy fields (where conditions for their construction are favorable), adoption of cash cropping, exploitation of forest resources, migration, and technological innovation.

IV–1 *Intensification of Grain Production in Paddy Fields*

According to Tran Duc Vien *et al.* [2004], composite swiddening as practiced by the Da Bac Tay in Vietnam's Northwestern Mountains is more sustainable than pure shifting cultivation because the high production of the wet rice fields reduces the area needed for swiddens. In recent years, the farmers have intensified paddy production by adopting high yielding varieties and applying chemical fertilizers. The small paddy area now yields half of the grain needed to meet local consumption requirements. Although this type of intensification contributes to higher sustainability of the cropping systems there is a cost in the form of loss of biodiversity. Farmers have decreased their planting of traditional rice varieties and in some areas traditional varieties no longer exist.

Vityakon *et al.* [2004] report that in Northeastern Thailand, farmers have increased rice production by adopting improved varieties and applying chemical fertilizers. Sediments eroded into the wet rice fields from cassava and sugarcane fields cleared in formerly forested uplands also contribute to maintaining nutrient balance in the paddy fields. In northern Laos, however, Watanabe *et al.* [2004] report that excessive clearance of upland forests for swiddens is believed by villagers to have made dry season paddy cropping more difficult because of the reduced flow of water in the river that supplies irrigation water to the paddy fields.

IV–2 *Replacement of Subsistence Farming with Cash Cropping*

In many parts of the mountain region, farmers are shifting from subsistence-oriented farming to cash crop production. In northern Thailand, for example, Lisu shifting cultivators have largely abandoned growing of upland rice, their traditional subsistence crop, in favor of raising maize for sale to the market. Beginning in the 1980s, the farmers began sowing viny legumes (lablab bean, rice bean, and cowpea) as a relay crop in the maize fields. This "accelerated seasonal fallow," as it is called by Ongprasert and Prinz [2004], simultaneously restores soil fertility and generates substantial additional income. In 1997, the average gross income from sale of farm products was more than US$2,700, with almost half of that sum earned from the sale of legumes. Although planting of legumes is beneficial from an ecological standpoint, it is only sustainable as long as market prices for the beans are high. By 2001, prices for the legumes had declined by one half or more and the farmers largely ceased to plant them.

Not all farmers in the region have wholly abandoned subsistence-oriented agriculture even as they engage in greater production of cash crops, however. For example, in Northeastern Thailand, as Vityakon *et al.* [2004] show, farmers have followed a dual track strategy of mixing subsistence and commercially-oriented cropping. Growing of rice for home consumption had always been the main concern of Northeastern farmers who, until the 1950s, had only a very limited involvement in the market. However, as transportation improved and sale of crops to the market became easier, they started widespread planting of cash crops, first kenaf and later cassava and sugarcane, in the uplands. At the same time, however, they continued to devote much of their effort to producing glutinous rice in the paddy fields to meet their household subsistence needs. In fact, cash earned from the sale of upland crops is used to purchase needed inputs to maintain yields of subsistence rice in the paddy fields.

IV–3 *Exploitation of Forest Resources*

Natural biological resources, especially non-timber forest products, but also wild plants and animals collected in the farmers' fields, make a major contribution to the livelihoods of many of the upland villagers described in these papers. In the villages in northern Laos described by Yamada *et al.* [2004], natural biological resources continue to play a major role in people's livelihoods. On average, sale of natural products contributes between 11 and 61 percent of household cash income. In the case of poor households, the share of total income derived from natural biological products ranges from 33 to 61 percent of total cash income. Much of this cash is used to purchase rice to make up for local shortfalls in production. As Yamada *et al.* [*ibid.*] observe: ". . . natural biological resources are indispensable as a source of cash income to achieve food security for poor people." They further suggest that the value of these resources may increase in the future because degradation of forests in every country in the region is diminishing the supply of wild products and increasing their prices. Thus, rather than focusing exclusively on agriculture, the development strategy for this area might

be better aimed at promoting a balanced mixture of agriculture and forests.

In other areas, however, deforestation and over-exploitation of natural biological resources have adversely affected farmer livelihoods. Thus, in Northeastern Thailand, according to Vityakon *et al*. [2004], pioneering farmers made heavy use of wild resources from the forest until the middle of the twentieth century, when widespread deforestation resulting from the expansion of cash cropping drastically reduced the supply of these products. Decline in the area of forest also reduced availability of grazing for livestock resulting in a serious decline in the number of cattle and buffalo. Local communities belated took steps to establish protected forests but the remaining area is too small to meet all the people's needs. It is suggested by Vityakon *et al*. [*ibid*.] that increasing the number of trees in the agricultural landscape will be an effective way to increase local self reliance and improve livelihoods.

IV–4　*Migration*

In many parts of the mountainous region farmers have traditionally coped with land scarcity and declining crop productivity by migrating to frontier areas to establish new settlements. The Hmong, who have moved southward from China into Laos, Vietnam and Thailand over the past several centuries, are the archetypical migrant shifting cultivators. According to Vityakon *et al*. [2004], the Northeastern Thai farmers also had a long-established tradition of "land pioneering" in which people from old, densely populated villages budded off to establish new settlements in the forests. In recent years, however, the forest frontier has closed in Northeastern Thailand—as it has everywhere in the uplands of Mainland Southeast Asia—so that migration to find new land is no longer an option. In the Northeast, people from overcrowded villages have migrated in large numbers to Bangkok, and even gone abroad to work as construction laborers and in the informal service sector, but this response has not occurred to any significant extent elsewhere in the region. In Vietnam, the lowlands are already overcrowded and the cities have a huge pool of unemployed workers so that there are no opportunities open to migrants from the uplands. Thus, out-migration is unlikely to be an effective adaptive strategy for upland people in the future. Solutions to their livelihood problems will have to be found *in situ*. Consequently, innovative ways to sustainably intensify agriculture in the mountains must be found, a search that the farmers have already initiated themselves.

IV–5　*Farmer Innovations*

Many of the papers reveal the great extent to which innovations in upland cropping systems are generated by the farmers themselves, often with little or no input from scientists or extension workers. For example, according to Tran Duc Vien *et al*. [2004], the composite swiddening system of the Da Bac Tay minority farmers in Vietnam's Northwestern Mountains, which is more productive and sustainable than pure shifting cultivation systems, has been practiced by farmers of this minority group for many generations. In recent years,

in response to growing population pressure, they have incorporated new features into the system, including planting of canna and ginger as cash crops in the swiddens. Hmong farmers in the hilltop community in Bac Ha district studied by Sakurai *et al.* [2004] have constructed elaborate terraces on their sloping land for several generations. This technology may have been originally borrowed from China but, in recent years, construction has been accelerated due to continuing reduction in average farm size.

The use of viny legumes as an accelerated fallow by the Lisu in northern Thailand described by Ongprasert and Prinz [2004] also appears to be largely a local innovation intended to generate an additional cash crop while simultaneously improving weed control. Similarly, Lao Thung shifting cultivators in northern Laos, according to Watanabe *et al.* [2004], have begun to experiment with incorporating mulberry trees into their fallow management practices to accelerate regeneration of their fields and generate extra cash income.

A major challenge facing development policy-makers, scientists, and extension workers is to find ways to incorporate local knowledge and farmer innovations into agricultural development efforts in the uplands. Unfortunately, for many reasons, little has been done in this regard to date.

V Potential Solutions

A number of potential solutions to problems of agricultural development in the mountainous region are suggested by papers in this special issue. These include introduction of improved crop varieties, diversification and commercialization of farming systems, restoration of soil fertility, and diffusion of new technology.

V–1 *Introduction and Development of Improved Crop Varieties*

Introduction of already available high yielding varieties may offer significant opportunities to increase agricultural production, particularly in areas with fertile soils. Thus, Ongprasert and Prinz [2004] observed in an area with limestone-derived soils in northern Thailand that the first group of farmers who started using a hybrid variety enjoyed 50 percent higher yields. The following year almost all households in the village adopted the hybrid variety. However, because most plant breeding has been carried out under the controlled water and fertility conditions of lowland experimental stations, relatively few improved varieties are adapted to the more difficult conditions characteristic of the mountainous region. Varieties which are well suited to the mountain conditions, such as having tolerance to water stress, soils with low fertility, and low temperatures, should be selected and/or developed through the collaborative action of farmers and government agencies.

V–2 *Diversification and Commercialization of Farming Systems*

Diversification and commercialization of farming systems through adoption of mixed and

relay cropping, introduction of tree crops such as fruits, and promotion of livestock rearing and agroforestry can help to raise incomes of farmers in the mountainous region. Numerous government and NGO projects are already promoting such solutions. For example, Watanabe *et al.* [2004] propose the introduction of paper mulberry during the fallow period of shifting cultivation in northern Laos because this type of agroforestry does not significantly degrade soil fertility and also provides farmers with cash income even from their fallow fields. Moreover, this type of fallow generates an increased quantity of biomass to be burned in the next cultivation cycle which is expected to be beneficial for weed control.

Ongprasert and Prinz [2004] describe a successful case of improving a shifting cultivation system by means of crop diversification. The cropping system of a Lisu village in northern Thailand was formerly shifting cultivation of maize interplanted with several vegetables including cucumber, wax guard, and pumpkin. At the beginning of the 1980s, villagers introduced three viny legumes, cowpea, rice bean and lablab bean and established a new cropping system. These three legumes are relay-cropped with the major crops and harvested during the dry season. This diversified cropping system fulfilled multiple functions including creating new sources of cash income, controlling weeds, and maintaining soil fertility. Unfortunately, use of this improved system was largely abandoned when the prices of legumes dropped sharply.

Access to markets is always one of the biggest constraints on crop diversification. However, transportation conditions are improving and the market for agricultural products is expanding accordingly as a consequence of national-level economic growth. Greater involvement in the market may expose the farmers to greater risks from unpredictable declines in the prices for their products. In order to mitigate the risk of price fluctuations, a wide range of diversification options should be explored.

V–3　*Restoration of Soil Fertility*

Soils in many parts of the mountainous region are already seriously degraded. Restoring fertility levels will be essential if cropping systems are to be intensified. As chemical fertilizer use is limited in the mountainous region due to its high cost and poor transportation conditions, *in-situ* restoration methods for soil fertility must be applied. At the field or plot level, as mentioned above, relay-cropping of legumes is one of the more promising methods that has already been successfully tried in many areas. Terracing and contour cultivation, as suggested by Sakurai *et al.* [2004], could minimize soil erosion and help to restore the physical and chemical property of the soil. These restoration methods, however, may only be effective under specific edaphic conditions and have limited applicability on steeply sloping land.

At the system or the watershed level there is a wide range of possible solutions. In many cases, the system consists of primary forest on the mountain tops, a complex mosaic of secondary forest, fallow land and upland fields of shifting cultivation on the slopes, and lowland paddy fields in the valley bottoms. Lateral movement of nutrients in surface and sub-surface water flows may have a significant impact on the nutrient balance of each of the subsystems

within the watershed as is pointed out by Vityakon *et al.* [2004], Trelo-gas *et al.* [2004], and Tran Duc Vien *et al.* [2004]. In the composite swiddening system in the northwestern mountains of Vietnam described by Tran Duc Vien *et al.* [*ibid.*] almost all loss of N, P and K from sloping swidden fields occurs in the form of run-off. The nutrients lost from the swidden fields, however, provide more than one half of the inputs of N and P into the lowland paddy fields. It would seem that well-organized allocation of forestland, upland fields and paddy fields at the watershed level might help to create farming systems that utilize nutrients more effectively.

V–4 *Diffusion of New Technology*

In addition to improvement of crop varieties, introduction of new technology, including chemical fertilizer, herbicides, and farm machinery, could facilitate agricultural development in the mountainous region. In any case, farmers are already embracing much of the available new technology although the consequences of this are not always positive ones. For example, as is pointed out by Vityakon *et al.* [2004], farmers in Northeastern Thailand adopted chemical fertilizers and two-wheel hand tractors when they shifted from subsistence-oriented to commercially-oriented farming. Trelo-gas *et al.* [2004] point out that chemical fertilizer application for sugarcane cultivation is widely practiced in Northeast Thailand and Tran Duc Vien *et al.* [2004] indicate that chemical fertilizers are now even used to grow rice for subsistence purposes in the remote mountainous area of Northern Vietnam. Ongprasert and Prinz [2004] found that herbicide use spread in northern Thailand due to the lack of labor for manual weeding. Lack of labor also led farm mechanization there.

Shifting cultivators in Laos still seldom use chemical fertilizer, but a government research center already started experimental work on the use of a slow-releasing type of chemical fertilizer in order to mitigate the nutrient loss by erosion. Herbicide use is also likely to spread widely in the near future in parallel with changes in the cropping system from shifting cultivation to continuous cultivation.

Although diffusion of new technology is inevitable in the course of agricultural development in the mountainous region, it should be recognized that new technologies can have negative impacts. For example, cheap but toxic pesticides are still widely sold in many countries and can have serious affects on people's health. Introduction of machine-plowing instead of no tillage farming on sloping land will undoubtedly increase the risk of soil erosion.

VI Future Research Priorities

If intensification of agriculture in the mountainous region is to be done in a sustainable manner that also enhances human welfare, careful research must be done to identify opportunities and pitfalls. Key research areas relate to improvements in agronomy and agroforestry

and incorporation of local knowledge and practices into national development strategies and policies for managing forest and agricultural lands.

VI–1　*Agronomic Research*

Agricultural production in the mountainous region still can be significantly increased by means of technology improvement, as was mentioned in the previous section. Development and dissemination of new crops and varieties, improvement of soil and water management, and finding more effective methods of weed control are all promising avenues for research.

Among the Mainland Southeast Asian countries on which this special issue is focused, Thailand has the longest history of agronomic research to improve mountain agriculture. The Thai government set up several research stations in the northern mountainous areas in the 1970s and initiated projects to eliminate opium growing and to introduce alternative farming options including growing of coffee, beans, vegetables, and mushrooms, animal breeding, and fish culture. In other countries, however, governments have been slower to devote resources to improvement of upland agriculture. The Lao government set up the National Agriculture and Forestry Research Institute in 1999, which is focused on the integrated agricultural development of the northern mountainous region. The Vietnamese government only established the Northern Mountainous Agriculture Research Center in 2002. These efforts to develop appropriate agricultural research institutions reflect the changes in agricultural policy goals from being exclusively production-oriented to welfare- and environment-oriented ones.

Consequently, agronomic research needs to shift its focus in order to develop technology which provide higher benefits to the mountain people and is suitable to the mountain environment, rather than just increasing production. The concept of site-specific technology is much more meaningful in the mountainous areas than in the lowlands because environmental and cultural diversity is much greater and the modification of production environment by means of large-scale irrigation and land reclamation projects is much more difficult in mountainous areas.

Employing a system perspective on agriculture is another important and effective approach in agronomic research in the mountainous areas. Efficient use of *in-situ* resources should have a high priority as a target of technology development in the mountains because of their remoteness and difficult transportation conditions. Application of chemical fertilizers and herbicides in the uplands may not be as simple or as effective as in the lowlands because of the high risk of run-off. Fertility management and weed control might be better achieved through modifications in the management of farming systems. The mosaic distribution of agricultural land and forest land within the landscape can be advantageous if we can establish a nutrient recycling system at the watershed level. Livestock may play an important role in the lateral transport of nutritients within the system that deserves further attention from researchers.

VI–2 *Agroforestry Research*

Agroforestry is often thought to be limited to the planting of annual crops among the tree seedlings on newly reforested lands. However, a new type of agroforestry based on shifting cultivation is widely emerging, in which agricultural and forest land use alternate regularly. The planting of paper mulberry in fields fallowed after shifting cultivation, as is discussed by Watanabe *et al.* [2004], is representative of this new type of agroforestry. It incorporates trees into the shifting cultivation cycle as an improved form of fallow management. By using this method, farmers can simultaneously restore soil fertility and gain economic benefits, particularly by the collection of non-timber forest products growing in the fallowed fields.

The function of fallowing in shifting cultivation has been a question that has long engaged researchers but no consensus has yet been achieved as to whether its main contribution is to fertility recovery or weed control. In this special issue, Sakurai *et al.* [2004] and Watanabe *et al.* [2004] support the latter view. It may be, however, that both answers may be correct depending on specific local conditions. This question is closely related to questions about methods for improving fallow management. If rapid fertility restoration is the goal, then legume cropping may be a suitable strategy, but if controlling weeds is the principal objective, then accelerating the regrowth of forest vegetation on fallow plots may be the best strategy for producing the large volume of biomass needed to ensure a sufficiently thorough burning to effectively destroy weeds.

The uses of secondary forest that emerges after shifting cultivation is also an emerging research issue. Secondary forest has generally been thought of only as deteriorated forest or recovering forest, but it has some functions which primary forest does not have. Secondary forest provides local people with a wide range of non-timber forest products, as Yamada *et al.* [2004] found. These products are mostly collected from light-demanding pioneer species which seldom exist in primary forest. This suggests not only the economic importance but also the biological significance of secondary forest. Secondary forest may have lower species diversity than primary forest, but it undoubtedly contributes to increasing the overall biodiversity of a watershed.

Yamada *et al.* [2004] suggest that the degradation of natural environment has accelerated in every country in the mountainous region and that this has resulted in a growing scarcity of natural biological resources. This increases the economic value of both remaining areas of primary forest and of secondary forests in the region. Non-timber forest products are a major component in the growing cross-border trade between China and Southeast Asian countries. Research on cultivation of non-timber forest product is a high priority topic in regard to developing systems of improved fallow management to make shifting cultivation more economically and environmentally sustainable.

VI–3 *Role of Local Knowledge and Practices in National Development Strategies and Land Use Policies*

The mountainous region is characterized by great environmental and cultural diversity. This

suggests the difficulty of applying standardized development policies to this region and the importance to incorporating local knowledge and practices into national development policy. All too often, national policies fail to take local realities into sufficient account. For example, collection of natural biological resources based on local knowledge plays a significant role in income generation in Northwestern Laos, as Yamada *et al*. [2004] describe, but this role is largely ignored in Lao government policies for development and management of forest lands. Similarly, as is pointed out by Vityakon *et al*. [2004], Thai national policies to promote production of export crops in the Northeast did not take into account the loss of valuable natural products on which local people depended for many of their livelihood needs that resulted from conversion of forest into cropland.

Land and forest resources management are key issues of national development strategies in the mountainous region because these resources are essential for both economic and environmental purposes. There is a rich store of local knowledge about how to best manage these resources but this knowledge differs from village to village and by ethnic group. Developing a more comprehensive understanding of such local knowledge is an important research priority because it can provide the basis for more effective and efficient implementation of modern regulations by national governments and reduce the potential for conflict between local and national interests.

Conclusion

The people of the mountainous region of Mainland Southeast Asia face growing difficulties in making their livelihood. Developing agriculture in ways that will increase productivity while also meeting social needs and protecting the environment is an urgent task. Intensification of upland farming systems is a key element of agricultural development in the mountainous region. The papers in this special issue present considerable information on the causes, mechanisms, and consequences of some efforts at intensification in many different localities in the mountainous region. They suggest that, even in the difficult agricultural environment of the mountains, intensification is possible and can result in greatly increased productivity. They also reveal that it can have adverse environmental consequences when the technical means employed are not well adapted to local conditions. They also show that adoption of sustainable farming systems is as much constrained by economic, social, and policy factors as it is by availability of technology and environmental limitations. Perhaps most importantly, these case studies illustrate the very great extent to which local conditions limit the available options for agricultural development in different areas in the mountainous region. It would appear that no single solution can be found to the problem of sustainable management of agro-resources there and that, consequently, research needs to focus on understanding how specific farming systems function in specific local contexts. Incorporation of such site specific knowledge into national development policies remains a

major unresolved problem.

References

Ongprasert, Somchai; and Prinz, Klaus. 2004. Intensification of Shifting Cultivation by the Use of Viny Legumes in Northern Thailand. *Southeast Asian Studies* 41(4): 538–549.

Sakurai Katsutoshi; Kawazu Hiwasa; Kono Yasuyuki; Yanagisawa Masayuki; Le Van Tiem; Le Quoc Thanh; Nittaya Dangthaisong; and Trinh Ngoc Chau. 2004. Impact of Agricultural Practices on Slope Land Soil Properties of the Mountainous Region of Northern Vietnam: A Case Study in Bac Ha District, Lao Cai Province. *Southeast Asian Studies* 41(4): 503–518.

Tran Duc Vien; Nguyen Van Dung; Pham Tien Dung; and Nguyen Thanh Lam. 2004. A Nutrient Balance Analysis of the Sustainability of a Composite Swiddening Agroecosystem in Vietnam's Northern Mountain Region. *Southeast Asian Studies* 41(4): 491–502.

Trelo-ges, Vidhaya; Limpinuntana, Viriya; and Patanothai, Aran. 2004. Nutrient Balances and Sustainability of Sugarcane Fields in a Mini-Watershed Agroecosystem of Northeast Thailand. *Southeast Asian Studies* 41(4): 473–490.

Vityakon, Patma; Subhadhira, Sukaesinee; Limpinuntana, Viriya; Srila, Somjai; Trelo-ges, Vidhaya; and Sriboonlue, Vichai. 2004. From Forest to Farmfields: Changes in Land Use in Undulating Terrain of Northeast Thailand at Different Scales during the Past Century. *Southeast Asian Studies* 41(4): 444–472.

Watanabe Etsuko; Sakurai Katsutoshi; Okabayashi Yukoh; Nouanthasing, Lasay; and Chanphengxay, Alounsawat. 2004. Soil Fertility and Farming Systems in a Slash and Burn Cultivation Area of Northern Laos. *Southeast Asian Studies* 41(4): 519–537.

Yamada Kenichiro; Yanagisawa Masayuki; Kono Yasuyuki; and Nawata Eiji. 2004. Use of Natural Biological Resources and Their Roles in Household Food Security in Northwest Laos. *Southeast Asian Studies* 41(4): 426–443.