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**Agrodiversity: Lessons from the highlands of northern Thailand**

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**Introduction**

The Montane Mainland of South-east Asia (MMSEA) covers about half of the total area of six countries, viz., Cambodia, China, Laos, Myanmar, Thailand and Vietnam (Figure 1) and is home to many ethnic minorities (Table 1). Ethnic minorities account for about 15% of total population of the region. Food security is a major concern of local communities as well as national governments. Shifting cultivation, the traditional land use in uplands, is being replaced by other land use systems (Table 2).



Figure 1. Montane Mainland of Southeast Asia (MMSEA)

Table 1. Ethnic diversity and population by country in Montane Mainland of South-east Asia in 1995.

Country	Extent of minority group	Population (x10000 persons)		% minority population
		Ethnic	Total	
Cambodia	36	0.31	9.45	3.2
Laos	47	2.01	4.88	41.2
Myanmar	>12	>6.8	46.55	14.6
Thailand	10	0.79	58.27	1.3
Vietnam	53	9.88	73.81	13.4
Yunnan†	18	8.68	39.90	21.7
Total	176	28.47	192.96	14.7

Source: Kampe (1997), WRI (1994) and Yin (1989); †1989

Table 2. Extent of land under shifting cultivation in mountain area of Greater Mekong sub-region.

Country	Area (x1000 ha)			% forest under shifting cultivation
	Land	Forest	Shifting cultivation	
Cambodia	17,652	12,163	n.a.	n.a.
Laos	23,080	13,173	400	3.04
Myanmar	65,774	28,856	181	0.63
Thailand	51,177	12,735	400	3.14
N. Thailand	16,966	7,523	400	5.32
Vietnam	32,536	8,312	3,500	42.1
Yunnan of China	39,410	9,533	130	1.36

**Source:** Banerjee (1995), Sam (1994), FAO (1995), Fujisaka (1991), Lovelace (1991) and TDRI (1997)

People, Land Management and Environmental Change Programme (PLEC) is a multi-country programme coordinated by United National University dealing with the issues of *in situ* biodiversity conservation, land degradation and livelihood security of the small holders in the humid tropics. Based on the functions of agrobiodiversity (Brookfield and Padoch, 1994; Brookfield and Stocking, 1999; Brookfield, 2001, 2002), it is argued that much of biodiversity could be conserved in agricultural landscapes without any trade-off to crop yields. This article gives highlights of the work carried out in mountain region of northern Thailand as a component of PLEC project.

### **Mountain region of northern Thailand**

Chao Phraya river watershed covers much of the mountainous area of northern Thailand. Opium was a major crop grown in the past but eradication measures taken by international agencies/the Royal Thai Government taken during the last 30 years led to drastic reduction in opium production (Renard, 2001; Kemp and Iamprapai, 2002). This area is now evolving as a new economic development zone (United Nations Drug Control Program, 2000; Asian

Development Bank, 1994; Talbot, 1996).

### **The approach**

The PLEC work carried out in northern Thailand was extension of earlier research on traditional shifting cultivation and highland economic development (Kunstadter and Chapman, 1978; Nakano, 1978; McKinnon and Vienne, 1989; Anderson, 1993; Rerkasem and Rerkasem, 1994). In the beginning four villages, viz., Pah Poo Chom (Hmong) in Chiang Mai, Mae Salap (Akha) in Chiang Rai and Mae Rid Pagae and Tee Cha (Karen) in Mae Hong Son were selected for the studies (Figure 2). Subsequently, 2 villages, viz., Pah Poo Chom and Tee Cha, were chosen for undertaking some additional field research and demonstration. Demonstrations served the purposes of recognized foci of innovations (Brookfield, 2002). Demonstration activities were farmer-driven and aimed for conservation of agrobiodiversity for improvement of local livelihoods (Pinedo-Vasquez et al., 2002).

Farmers' practices were evaluated for their impacts on biodiversity and 'best' practices were identified for demonstration. Participatory method was adopted to identify the existing land use stages and field types in the agricultural landscapes. The major land use/field type included headwater area, community forests, swidden fields, fallow lands, mixed perennial plots or fruit orchards, intensive cropping area, home gardens and edges of different land use types. Sample plots (10 m x 10 m) were laid out in major land use stages and fields for measuring plant diversity and abundance (Khruasam, 2000; Rerkasem, 2000). In cases of small edges and home gardens, measurements were made in the whole unit. Local names and uses of different species were discerned from key farmers who assisted in the survey (Zarin et al., 1999).

By the end of the year 2000, village Pah Poo Chom had reached completion stage of PLEC demonstration (Box 1 and 2). Village Tee Cha is, however, being kept for research on improved fallows and traditional management of swidden crops with limited demonstration activity (Box 3).

## Box 1. A socio-ecological profile of Pah Poo Chom village, Thailand

Pah Poo Chom is a Hmong Njua or blue Meo village located at 920 m amsl in the watershed of Huai Mae Chaem. The landform of the site is residual hills, with granite and shale as parent materials (Lampaopong et al., 1985). The soil is acidic (pH: 5.0-5.3) and a sandy loam with good drainage. Soil is >1.5 m deep in lower crop fields with gentle slopes but <30 cm deep in the upper fields with steep slopes. Soil erosion does not seem to be a severe problem (Rerkasem and Huijun, 1995). Agriculture is practised largely on lower elevations with gentle slopes (10-25%). Farmers maintain dense ground cover of *Mimosa invisa* during the wet season. Monoculture of cabbage and lychee (*Litchi sinensis*) as a canopy crop with annual crops grown underneath are the dominant agricultural land uses (Figure 3). Many farmers maintain patches of varying size, shape and species composition within and between major land uses, the “edges” (Brookfield et al., 1999). Scattered patches of forest trees and other useful species are common in the riparian landscapes (Korsamphan et al., 2001). Steep slopes and hilltops are generally covered in community managed forests.

**Agrodiversity: the lessons***Interactions between the PLEC people and the community*

While demonstration activity could be carried out on individual basis, there is always a need of community support for achieving conservation linked sustainable livelihoods. When we started demonstration in Pah Poo Chom village, there was a severe conflict within community in respect of use of water for irrigating cabbage. The PLEC team adopted community based land use planning as a means of conflict resolution. Data on land use, land holding, crops and cropping practices, and other biophysical and agricultural information were presented to the community to facilitate conflict resolution. Agroforest edges managed by a farmer in higher reaches were used to illustrate as one of the ‘best practices’ for biodiversity conservation. This kind of field demonstration also helped in rejuvenation of cultural conservation ethos in younger generations

(Box 4). With confidence gained through participatory learning, the community was able to set-up a farmers' association which subsequently was formally organized as Village Committee for Forest Protection and Biodiversity Conservation (VCFP&BD).

Box 2. Major changes during 1960-2001 period in Pah Poo Chom village, Thailand

**1960-69**

About 10 Hmong families moved down from the border of Thailand/Myanmar to settle in Pah Poo Chom permanently. For some years, the condition of the village was rather poor due to intensive logging granted as forest. Hmong people traditionally living at higher elevations were not very comfortable in this village located at lower elevations (Walker, 1971). The village was about to collapse at some point of time in the past (Cooper, 1984). Many families left the village and those who stayed behind continued shifting cultivation leading to further degradation of forests. Bamboo was harvested intensively to maximize income. As a result of depletion of natural resources, people had to go far away to earn wages. Often they were paid very low wages (Thai *Baht* 6.00-8.00 day<sup>-1</sup> i.e., US \$ 0.3-0.4 day<sup>-1</sup>). In the late 60s, the Tribal Research Centre promoted cultivation of food crops and livestock to eliminate opium cultivation (Oughton, 1970).

**1970-79**

In early 1970s, the Thai-Australia Highland Agricultural Project (TAHAP) introduced napier grass (*Pennisetum purpureum*) to increase fodder yield. About 100 *rais* (16 ha) of valley land was developed for irrigated paddy cultivation but after some time it had to be abandoned. However, exposure to irrigation led people to undertake intensive cabbage production as well as to protect headwater area. In 1969, a farmer brought in *Mimosa invisa* to fence his kitchen garden. This weed escaped and became a dominant element of the village landscape. Farmers observed its soil conservation potential and started using it as 'living mulch'.

**1980-89**

During 1980-87, with assistance from World Bank, Lychee (*Litchi sinensis*) and other fruit trees were introduced in home gardens for local consumption. Farmers started growing Lychee on a large scale subsequently. With government incentive on household registration, many families moved down to valley land. Cabbage was introduced in 1985 adopting the technology developed during 1970s in United Nations Crop Replacement Program (Geddes, 1976). Opium production was virtually stopped. Potential of Ruzi grass (*Brachiaria ruziziensis*) in soil and water conservation was demonstrated in uplands but farmers did not adopt it, as this species seemed to be an invader.

**1989-93**

The Thai-Australian Highland Agricultural and Social Development Project (TAHASD) chose this village for developing a model for watershed management (TAHASD, 1993). Grass-strips were introduced to reduce soil and water loss from steep slopes. Natural forests around hilltops were conserved and gaps filled in through reforestation. Conflicts within and between village communities were resolved involving all sections of the society in resource development planning. Looking at the success of cabbage cultivation and continuity of external assistance, many people returned to the village.

**1993-96**

Vegetable production was intensified under the influence of market and Pah Poo Chom became economically a well-off village (Thepsaran, 1998). Average household could earn an annual income of *Baht* 36,000 (Village survey, 1996). Pressure on forests on steep slopes started building up as a result of increasing attention to vegetable cultivation and profit maximization. Internal conflicts on land use, distribution of irrigation water and forest protection emerged as major issues for village administration.

**1997-2001**

Following recognition of Thailand as a Newly Industrialized Country (NIC), all external aid for highland development ended in 1998. A master plan for highland development, control of narcotic crops and environment conservation was developed to ensure continuity of support to the highland community. However, government support was quite low due to macro-economic collapse in Thailand and the region as a whole.

### Box 3. Socio-economic profile of Tee Cha village, Thailand

Tee Cha is a Pwo Karen village in Sop Moei, a border district of Mae Hong Son province, situated at an elevation of 700 m amsl in Salween river basin. The village is said to be >200 years old and has been ignored by national/international development agencies. The village comprises 41 households, with a total population of 148 persons. The village economy is of subsistence type based on shifting cultivation. Farmers may sell minor forest products but the market is unreliable and there are policy restrictions on collection of these products. Annual household income ranges between Baht 5,000-10,000. Livestock constitute a major source of income. Presently, there are 6 parcels of fallow lands and length of cultivation cycle is much shorter than the traditional 10-20 year long cycles (Rerkasem, 2001; Sabhasri, 1978; Zinke et al., 1978) (Figure 4). As local communities have decided to conserve the existing forest cover, expansion of shifting cultivation in future is less likely. People have been able to maintain productivity of upland rice and swidden crops under short cultivation cycles by enriching fallows with a tree species *Letha* or *Pada* (*Macaranga denticulata*). This is a fast growing tree species with huge production of seeds and association with arbuscular mycorrhizal fungi (Yimyam et al., 2001, 2002; Youpensuk and Lumyong, 2002; Youpensuk et al., 2004)

### Box 4. Environmental perceptions, indigenous knowledge and traditional conservation of biodiversity-rich systems in village Pah Poo Chom, Thailand

Kunstadter and Chapman (1978) stated that, unlike, Karen and Lua who maintain productive forest fallows in shifting cultivation, the Hmong, cause irrecoverable damage to forests. However, Tapp (1986) gives positive example of Hmong's perception. When mining started in Smoeng district, entire Hmong community moved out, as they perceived that intensive mining would change the watercourse such that their livelihood will be badly affected. Hmong have also been observed to manage large number of domesticated species/cultivars and wild species (Sutthi, 1990, 1996). They believe that presence of *Litsea cubebe*, *Caroyota obtuse* and *Dendrochide stimulans* determines quantity/quality of opium production. Community has designed strict rules to protect forests in the headwater region. Forest products can be collected from the area called as utility forest.

Edges are another type of land use characterized by a rich biodiversity. The edges are small fields but it is duty of all households to protect integrity of the edges. Farmers in Pah Poo Chom are more dependent on forest products when cash crops turn to be failure due to adverse biophysical conditions or low price/demand in the market.

**The edges: 'biodiversity hot spots' in the village landscape**

Mixed cropping and multi-layer structure of home gardens or community forests are basic traditional features of shifting cultivation landscapes in northern Thailand (Kunstadter and Chapman, 1978; Grandstaff, 1980; Rerkasem and Rerkasem, 1994). In the village Tee Cha where traditional shifting cultivation is still practiced it is not uncommon to find 30-40 types of crops in a field. Hmong are known to maintain a high level of diversity of non-rice staple crops (Anderson, 1993; Sutthi, 1989, 1990, 1996). When traditional land use systems are abandoned, erosion of crop genetic diversity follows (Sutthi, 1990).

**Box 5. Edges for maintenance and enrichment of biodiversity****Edges type 1. Conservation of swidden crops and local vegetables**

These edges appear in the landscape as small patches (2 m x 10 m to 30 m x 30 m size) around cabbage fields. A complex mixture of as many as 40 traditional crops may be maintained by expert farmers. Some edges appear at sites considered not suitable for common crops. There are 75 crop species in the edges of the village. Some edges may support a household for 8-10 months in a year. All varieties of Hmong glutinous corn, for example, are being continuously conserved in the edges for own consumption. As corn is becoming popular in the lowland markets, farmers can readily grow glutinous corn after main season cabbage for cash.

**Edges type 2. Agroforests**

Such edges exhibit a range of structure: edges with a few perennial species such as bamboo and wild banana strips to very complex systems comprising a large number of trees and other perennials. Management of agroforest edges also range from virtually no management, i.e., exclusive dependence on natural regeneration to intensive management where human interventions strike a balance between wild and domesticated species. The Hmong community traditionally conserves forests as a component of village landscape (Tapp, 1986). In Pah Poo Chom, some forest patches are protected for adequate recharge of groundwater. The land is community owned and landowners in the vicinity have a major responsibility for protection of these forests. Species diversity varied from 18 species in a casually managed plot to 114 species in a carefully managed plot.

Farmers in the demonstration site have successfully developed the ‘edges’ to manage and conserve a wide range of crops previously grown mixed with upland rice or opium (Box 5, Table 3). Edges are so diverse that farmers get one product or the other throughout the year. Men have strong bias toward specialized production of cabbage or lichee in pure culture. Unfortunately, this strategy does not work very well. The probability of ‘good year’ for cabbage is very low. When price is exceptionally high, output turns out to be very low and *vice versa*.

Table 3. Plant species and their mean density in a typical edge in the village Pah Poo Chom village, Thailand

Plant name	Individuals per edge
<b>Domesticated species</b>	
(Hmong) Glutinous corn ( <i>Zea mays</i> L.)	300
Shallot ( <i>Allium ascalonicum</i> L.)	1150
(Hmong) Leaf mustart ( <i>Brassica juncea</i> L. [Czern & Coss])	250
Pumpkins ( <i>Cucurbita moschata</i> [Duch. ex Laus] Duch ex Poir)	4
Coriander ( <i>Coriandrum sativum</i> L.)	5
Sweet potato ( <i>Ipomoea babatas</i> (L.) Lamk.)	3
Lychee seedlings ( <i>Litchi chinensis</i> L.)	1
<b>Semi-domesticated species</b>	
Wild bitter gourd ( <i>Momordica</i> sp.)	20
Susumber ( <i>Solanum torvum</i> Sw.)	1
<b>Wild herbaceous species</b>	
Lum phasi ( <i>Crasscephalum crepidiodes</i> [Bent.] S. More)	1
Amaranth ( <i>Amaranthus viridis</i> L.)	1
Edible fern ( <i>Asytasiella neesiana</i> Lindau.)	11
Tong sard for food or sweet swapping ( <i>Phrynium capitatum</i> Willd.)	9 (hills)
Wild banana ( <i>Musa acuminata</i> Colla.)	22 (hills)
Kong (Zingiberaceae) edible fruit, leaves used for rice barn and fibre for rope	5 (hills)
Total (15 species)	1,783

Source: Rerkasem (2000)

Agroforest edges are usually casually managed patches but Saophang devote substantial time and energy towards management of their agroforest edges (Korsamphan et al., 2001). Species diversity in the edges varies depending upon the intensity of management. We observed 114 species in an edge. Edges, apart from conserving biodiversity, may enable an annual income of *Baht* 40,000-60,000 as compared to *Baht* 15,000-35,000 from cabbage production.

### Conclusions

PLEC demonstration site has now become a model village landscape for participatory learning encouraged through the national program of Farmers' Field School. This model demonstrates a positive relationship between biodiversity conservation and rural development. Farmers' Field Schools provide an opportunity of extension of PLEC models beyond the demonstration sites (Thongngam et al., 2002).

### References

- Asian Development Bank, 1994. Economic Cooperation in the Greater Mekong Subregion: Toward implementation. In: Proc of the 3<sup>rd</sup> Conference on Sub-regional Economic Co-operation among Cambodia, People's Republic of China, Lao People's Democratic Republic, Myanmar, Thailand, Vietnam. Hanoi, Vietnam, 20-23 April, 1994. Asian Development Bank, pp. 88-90.
- Anderson, E. F. 1993. Plants and People of the Golden Triangle: Ethnobotany of the Hilltribes of Northern Thailand. Silkworm Books, Bangkok. 279 pp.
- Banerjee, A. K. 1995. Rehabilitation of Degraded Forests in Asia. World Bank Technical Paper No. 270. World Bank, New York. 43 pp.
- Brookfield, H. and Padoch, C. 1994. Appreciating agrodiversity: A look at the dynamism and diversity of indigenous farming practices. *Environment* 36: 6-11 & 37-45.
- Brookfield, H. and Stocking, M. 1999. Agrodiversity: definition, description and design. *Global Environmental Change* 9: 77-80.
- Brookfield, H., Stocking, M. and Brookfield, M. 1999. Guidelines

- on agrobiodiversity in demonstration site areas. PLEC News and Views (Special issue) 13: 17-31.
- Brookfield, H. 2001. Exploring Agrobiodiversity. Columbia University Press, New York. 348 pp.
- Brookfield, H. 2002. The conservation and promotion of biodiversity on-farm: the evolution of PLEC's mission, 1992-2002. PLEC News and Views 20:7-18.
- FAO. 1995. Forest Resources Assessment 1990: Global Synthesis. Forestry Paper No. 114. FAO, Rome.
- Fujisaka, S. 1991. A diagnostic survey of shifting cultivation in northern Laos: targeting research to improve sustainability and productivity. Agroforestry Systems 13: 95-109.
- Geddes, W.R. 1976. Migrants of the Mountains. Oxford University Press, London. 274 pp.
- Grandstaff, T. 1980. The development of swidden agriculture (shifting cultivation). Teaching and Research Forum No. 23, A Development and Change reprint. The Agricultural Development Council, Inc., Bangkok. 24 pp.
- Kampe, K. 1997. Introduction: Indigenous peoples of South-east Asia. In: McCaskill, D. and Kempe, K. (Eds.) Development or Domestication? Silkworm Press, Chiang Mai. pp. 1-25.
- Kemp, K. and Iamprapai, P. 2002. Assessment of experience with alternative development in the Thai highlands: 30 years of evolution. Paper presented at the regional workshop on Asia, preceding the international conference on the Role of Alternative Development in Drug Control and Development Cooperation. 7-12 January 2002. Hosted by the German Federal Ministry of Economic Cooperation and Development (BMZ) and organized by Zentralstellum fur Ernährung und Landwirtschaft (ZEL), Feldafing, Munich, Germany. 13 pp.
- Khruasam, D. 2000. Management, Conservation and Utilization of Plants: A Village case of Pah Poo Chom, Mae Taeng district, Chiang Mai province. Master Thesis. Department of Biology, Faculty of Sciences, Chiang Mai University, Chiang Mai. 248 pp.
- Korsamphan, C., Thongngam, C. and Rerkasem, K. 2001. Biodiversity management and utilization of forest edges in a Hmong community. In: CMUPN lab working Papers 1:

- Report of a workshop on Regeneration Ecology and Management for Degraded Landscapes and Forest Ecosystems. Chiang Mai University, Chiang Mai. pp. 95-110.
- Kunstadter, P. and Chapman, E.C. 1978. Problems of shifting cultivation and economic development in northern Thailand. In: Kunstadter, P., Chapman, E.C. and Sabhasri, S. (Eds.) *Farmers in the Forests: Economic Development and Marginal Agriculture in Northern Thailand*. University Press of Hawaii for East-West Center, Honolulu. pp. 3-23.
- Lampaopong, B. Manajuti, D. and Sukasem, J. 1985. A study on land characteristics of coffee cultivation in northern Thailand. In: *Proceedings of Coffee Research Report on Arabica Coffee Growing and Production*. Highland Coffee Research and Development Centre, Chiang Mai University, Chiang Mai. pp. 58-81.
- Lovelace, G. W. 1991. Research on swidden agriculture in Sepone district. In: *Report on the 1991 SUAN-EAPI-MAF workshop on Swidden Agroecosystems in Sepone District, Savannakhet Province, Lao PDR*. The SUAN Secretariat, Khon Kaen. pp. 3-10.
- McKinnon, J. and Vienne, B. 1989. *Hill Tribes Today: Problems in Change*. White-Lotus, Bangkok. 507 pp.
- Nakano, K. 1978. An ecological study of swidden agriculture at a village in northern Thailand. *Tonan Ajia Kenkyu (South East Asian Study)* 18: 411-446.
- Oughton, G. A. 1970. A proposal for the Development of Phaphuchom village (Meo). *Nikhom Chiang Dao Resources and Development Potential Survey – Report 1*. Tribal Research Centre, Chiang Mai. 29 pp.
- Pinedo-Vasquez, M., Gyasi, E.A. and Coffey, K. 2002. PLEC demonstration activities: a review of procedures and experiences. In: Brookfield, H., Padoch, C., Parsons, H. and Stocking, M. (Eds.) *Cultivating Biodiversity Understanding, Analysis and Using Agricultural Diversity*. Intermediate Technology Development Group for United Nations University, London. pp. 105-125.
- Renard, R. D. 2001. *Opium Reduction in Thailand 1970-2000. A thirty-year Journey*. Silkworm Books, Bangkok. 199 pp.

- Rerkasem, K. 2000. UNU-PLEC Annual Report, Chiang Mai Activity 1999-2000. Chiang Mai University, Chiang Mai. 52 pp.
- Rerkasem, K. and Huijun, G. 1995. Report on a workshop on agroecosystems and biodiversity in montane mainland southeast Asia. PLEC News and Views 5: 5-10.
- Rerkasem, K. and Rerkasem, B. 1994. Shifting cultivation in Thailand: its current situation and dynamics in the context of highland development. IIED Forestry and Land Use Series No. 4., 140 pp.
- Sabhasri, S. 1978. Effects of forest fallow cultivation on forest production and soil. In: Kunstradter, P., Chapman, E.C. and Sabhasri, S. (Eds.) *Farmers in the Forests: Economic Development and Marginal Agriculture in Northern Thailand*. University Press of Hawaii for East-West Center, Honolulu. pp. 160-184.
- Sam, D.D. 1994. Shifting Cultivation in Vietnam: Its Social, Economic and Environmental Values relative to Alternative Land use. IIED Forestry and Land Use Series No. 3., 56 pp.
- Sutthi, C. 1989. Highland agriculture: from better to worse. In: McKinnon, J. and Vienne, B. (Eds.) *Hill Tribes Today*. White-Lotus, Bangkok. pp. 107-142.
- Sutthi, C. 1990. Mountain and upland agriculture and genetic resources in Thailand. In: Riley, K.W., Mateo, N., Hawtin, G.C. and Yadav, R. (Eds.) *Mountain Agriculture and Crop Genetic Resources*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi. pp. 201-216.
- Sutthi, C. 1996. Traditional Slash and Burn Agriculture in the Highlands: Indigenous Technical Knowledge. (Technical Report 00-39-12). Tribal Research Institute, Chiang Mai. 210 pp.
- TA-HASD. 1993. Thai-Australia Highland Agricultural and Social Development Project. Project Brief. Hill-Tribe Welfare Division, Australia International Development Assistance Bureau, Chiang Mai. 28 pp.
- Talbot, K. 1996. Roads, people and natural resources: towards a regional policy framework for transport infrastructure in montane mainland Southeast Asia. In: Chiang Mai University Consortium *Montane Mainland Southeast Asia in Transition*.

- Chiang Mai University, Chiang Mai. pp. 246-276.
- Tapp, N.1986. The Hmong of Thailand: Opium People of the Golden Triangle. Indigenous Peoples and Development Series. Report No. 4. Anti-Slavery Society and Cultural Survival Inc., London. 72 pp.
- TDRI. 1997. Assessment of Sustainable Highland Agricultural Systems. Natural Resources and Environment Program, Thailand Development Research Institute, Bangkok. 149 pp.
- Thepsaran, S.1998. Information on Ban Pha Pu Chom Village. In: Community Based Natural Resource Management Experiences in Upland and Highland Areas. Proceedings of International Workshop. Thai-German Highland Development Program, Chiang Mai.
- Thong-ngam, C., Areetham, T., Kaewpha, P., Thepsarn, S., Yimyam, N., Korsamphan, C. and Rerkasem, K. 2002. Scaling up PLEC demonstration site for national pilot program: a case example of Hmong Njua village in northern Thailand. PLEC News and Views 19: 7-16.
- United Nations Drug Control Program. 2000. Thirty Years Fighting Through Leaderships and participatory Cooperation. Activities Report in East Asia and Pacific of the United Nations International Drug Control Programme, Bangkok, pp 30.
- WRI. 1994. World Resources, 1994-95. Oxford University Press, New York and Oxford, pp. 400.
- Yimyam, N., Lodkaew, K. and Rerkasem, K. 2001. Nutrient cycling through *Macaranga denticulata* in rotational shifting cultivation. In: CMUPNlab Working Papers 1: Report of a Workshop on Regeneration Ecology and Management for Degraded Landscapes and Forest Ecosystems, Chiang Mai University, Chiang Mai, pp. 81-94.
- Yimyam, N., Rerkasem, K. and Rerkasem, B. 2003. Pada (*Macaranga denticulata* (Bl.) Muell. Arg.), a fallow enriching species in shifting cultivation. Agroforestry Systems 57: 79-86.
- Yin Ma,1989. China's Minority Nationalities. Foreign Languages Press, Beijing, 450 pp.
- Youpensuk, S. and Lumyong, S. 2001. Endomycorrhizas in *Macaranga denticulata* on the highlands in Mae Hong Son

- province. In: CMUPNlab Working Papers 1: Report of a Workshop on Regeneration Ecology and Management for Degraded Landscapes and Forest Ecosystems, Chiang Mai University, Chiang Mai, 182-185.
- Youpensuk S, Dell B, Lumyong S and Rerkasem B. 2004. Arbuscular mycorrhizal fungi from the rhizosphere of a fallow enriching tree, *Macaranga denticulata* Muell. Arg. and their effect on the host plant. *Agroforestry Systems* 60: 239–246.
- Zarin, D.J., Guo, Huijun and Enu-Kwesi, L. 1999. Methods for the assessment of plant species diversity in complex agricultural landscapes: guidelines for data collection and analysis from the PLEC Biodiversity Advisory Group. *PLEC News and views* 13: 3-16.
- Zinke, P.J., Sabhasri, S. and Kunstadter, P. 1978. Soil fertility aspects of the Lua's forest fallow system of shifting cultivation. In: Kunstadter, P., Chapman, E.C. and Sabhasri, S. (Eds.) *Farmers in the Forests; Economic Development and Marginal Agriculture in Northern Thailand*. University of Hawaii for East-west Centre, Honolulu.