ASB Thailand

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Landscape Agroforestry in Northern Thailand:

Impacts of Changing Land Use in an Upper Tributary Watershed of Montane Mainland Southeast Asia

Studies based on the ASB-Thailand Benchmark Site

Mae Chaem District, Chiang Mai Province

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Northern Mountain Area Agroforestry Systems Research & Development Project

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- To submit comments, suggestions or additional input,
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I. The Context, Rationale and Focus of ASB-Thailand Research[1]

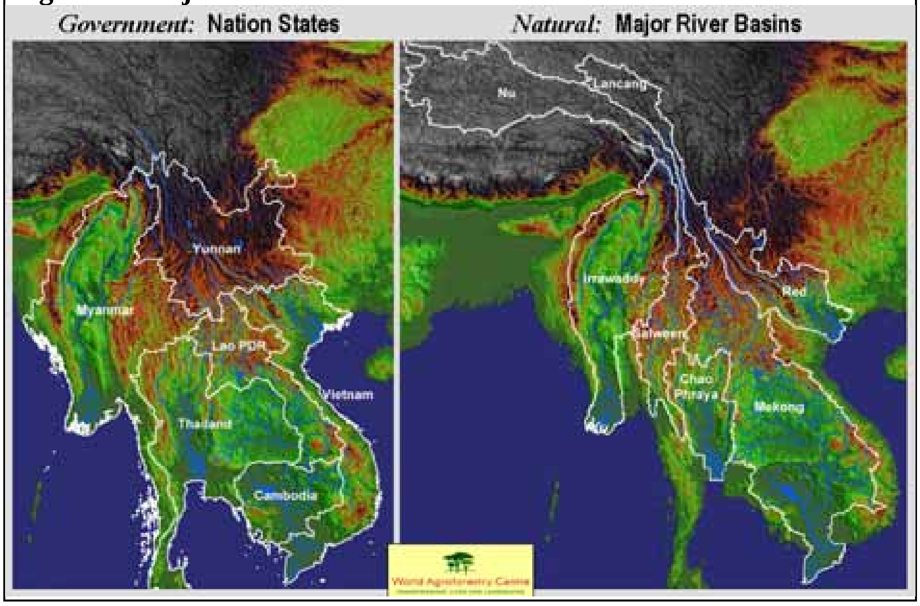
The ASB research program in Southeast Asia[2] seeks to understand processes and dynamics of land use change important in mountainous regions of mainland Southeast Asia, and to help facilitate development of technologies and policies that can improve land use management in these areas. The following sections describe how evolving agroforestry concepts and approaches are being applied in the context of ASB-Thailand and ICRAF activities in mainland Southeast Asia, with a focus on research activities being conducted in an upper tributary sub-basin watershed of northern Thailand. Major components of this approach have included: 1) characterizing the MMSEA eco-regional context; 2) establishing a partnership framework and benchmark research site; 3) identifying forest policy concerns and characterizing land use change in upper tributary watersheds; 4) building on experience with agroforestry modification, adaptation and innovation; and 5) establishing the ASB-Thailand research framework. This chapter presents results of our efforts under each of these components.

A. The MMSEA Eco-Regional Context

Both the ASB Initiative and ICRAF have framed their approaches in terms of the Montane Mainland Southeast Asia (MMSEA) eco-region. As the maps in Figures 1 and 2 indicate:

- Dominant societies in mainland Southeast Asia are centered on major river valleys and lowland areas, that have largely been cleared of forest and converted to agriculture.
- Agriculture in lowland zones was the primary target and beneficiary of agricultural research and Green Revolution technology.
- Agricultural production in these zones includes major 'rice bowl' production areas in the lower reaches of the

Figure 1. Major Broad Boundaries in Mainland Southeast Asia



[1] Substantial parts of this section are adapted from: (1) Plodprasop Suraswadi, David Thomas, Komon Pragtong, Pornchai Preechapanya, Horst Weyerhaeuser. 'Northern Thailand: Changing Smallholder Land Use Patterns'. In: C.A. Palm, S.A. Vosti, P.A. Sanchez, P.J. Ericksen, A.S.R. Juo (eds). *Slash and Burn: The Search for Alternatives.* A collaborative publication by the Alternatives to Slash-and-Burn Consortium, the World Agroforestry Centre, The Earth Institute at Columbia University and the Center for Natural Resources Policy Analysis at the University of California, Davis *(forthcoming 2004)*; (2) Thomas, David E., 'Agroforestry Systems Research: Evolving Concepts and Approaches'. 2001. In *Agricultural Systems for Sustainable Resources Management and Community Organization Development: Proceedings of the First Thailand National Agricultural Systems Seminar, Bangkok, 15-17 Novermber 2000*. Bangkok: Department of Agricultural Research, Ministry of Agriculture and Cooperatives. pp. 277-303.

[2] This program operates under the global CGIAR system-wide Alternatives to Slash-and-Burn (ASB) Initiative

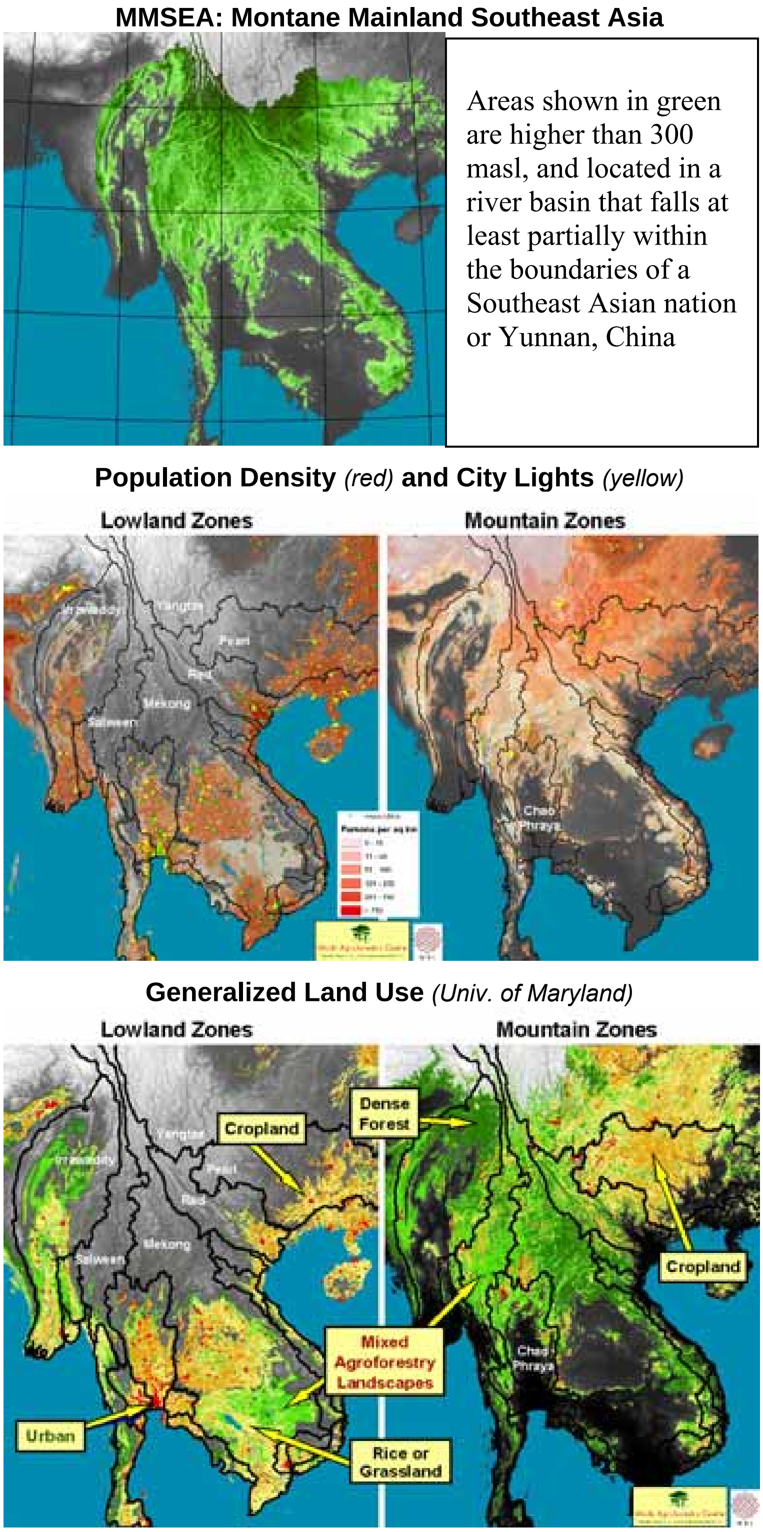
Red, Mekong, Chao Phraya and Irawaddy Rivers. In addition to feeding more than 200 million people, these include main areas of production for the world's two largest rice exporting nations (Thailand and Vietnam).

- Lowland zones are also where centers of political power are located, and where the region's rapid economic growth is focused, particularly in growing urban-industrial mega-cities.

Montane areas include the upper watersheds of important river basins. As demands for water grow and diversify in mainstream lowland societies, competition for water increases. And, as a politically powerful middle class emerges in lowland zones and their urban-industrial centers, there is growing concern about longer-term sustainability of water supplies and environmental services. The natural tendency has been for lowland societies to look upstream for the source of their growing problems.

While both are clearly important, neither river basin nor nation state boundaries have been found adequate by efforts to identify and articulate MMSEA as an eco-region. At the July 2000 second international symposium on MMSEA hosted by Chiang Mai University, we proposed the simple tentative definition indicated and mapped in Figure 2 to define a domain that encompasses most all of the areas under discussion.[3] After soliciting discussion, debate and suggestions on this definition, we made a more elaborate effort to survey this MMSEA domain at the

Figure 2. MMSEA & Lowland Zone Population & Land Use



[3] Thomas, David E. and Pornwilai Saipothong. 2000. 'MMSEA: Where in the World is Montane Mainland Southeast Asia'. *International Symposium II on Montane Mainland Southeast Asia (MMSEA): Governance in the Natural and Cultural Landscape, Abstracts and Papers* (CD-ROM). Chiang Mai, Thailand: Chiang Mai University Regional Center for Social Science and Sustainable Development.

third international MMSEA symposium held during 2002 in Lijiang, China.[4] The first priority domain for ICRAF-ASB research has been on MMSEA portions of the Chao Phraya, Mekong and Red river basins.

Key characteristics commonly found across the MMSEA domain include:

- Watershed headlands that include most remaining forest cover, but are classified as having high rates of deforestation
- Diverse ethnic populations seen as having relatively high growth rates, poverty, and poor access
- Subsistence agriculture, often based on shifting cultivation systems believed to be under growing stress, and sometimes including narcotics production
- Growing perceived development gap with lowland populations,
- Priority target areas for both development & environmental policy at national levels
- Focus of increasing national and international concern about environmental issues, including water, biodiversity and climate change.

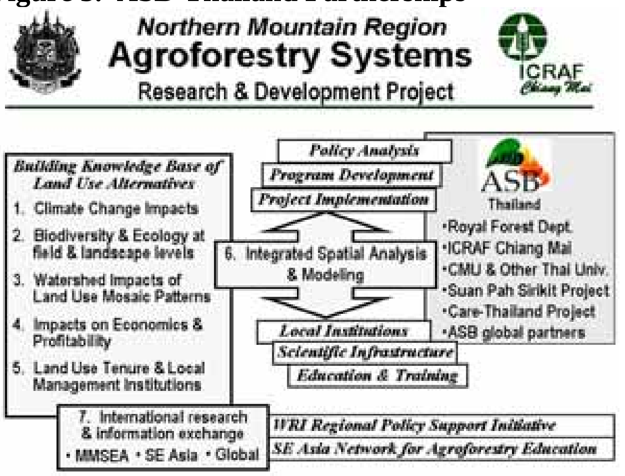
Given strong and growing concern over water in these river systems, the ASB Thailand program uses watershed units as a major component of its analytical framework. Moreover, particular focus is on land use in upper tributaries, where many poor and often marginal minority communities have benefited the least, and sometimes suffered from processes associated with the rapid economic development that has helped shape the international image of Thailand and the region during recent decades. We also seek to incorporate relevant lessons from the Asian economic crisis, as well as constitutional and governance issues emerging in Thai society and the wider region.

Recognizing the increasing importance of issues in the MMSEA eco-region, ICRAF and the ASB Initiative selected northern Thailand as the initial site for work in MMSEA because:

- Since this is where many types of change are most advanced in their development and impact, the hypothesis is that understanding and better managing land use change in the mountains of northern Thailand would both assist efforts to address issues here, and provide important insights and tools useful for improving programs in other areas of MMSEA.
- A capable and well-rounded cadre of Thai partners expressed strong interest in collaborative efforts to address these increasingly important issues, and bring experience derived from a range of previous and on-going pilot research and development projects.

Together, these components have provided a solid foundation for a strategic research program aimed at understanding processes and impacts of land use change in the region, and addressing issues and problems at various hierarchical levels.

Figure 3. ASB-Thailand Partnerships



B. Thailand Partnerships and Benchmark Research Site

ICRAF and ASB operations in Thailand operate under a Memorandum of Agreement approved by the Ministerial Cabinet of the Royal Thai Government, which is a full member of the CGIAR system. Implementation responsibility was delegated

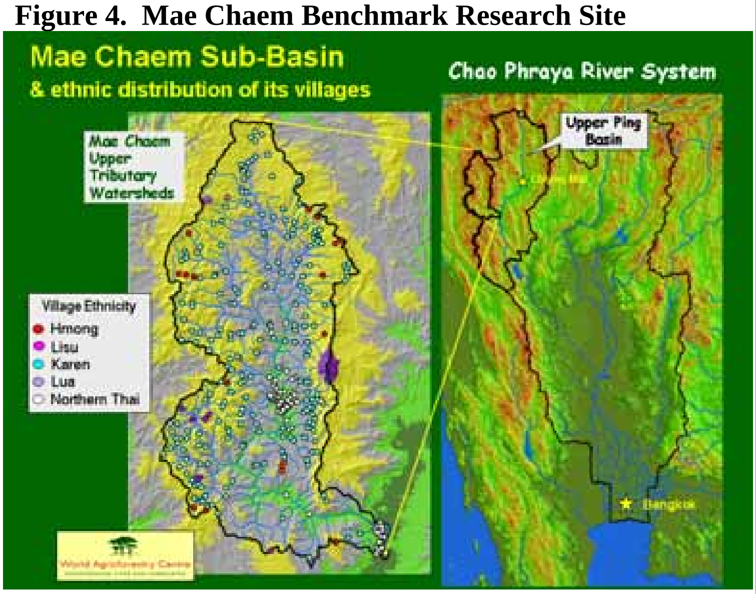
[4] Thomas, David E. 2003. 'Montane Mainland Southeast Asia – A Brief Spatial Overview'. In: Xu Jianchu, Stephen Mikesell (Editors), *Landscapes of Diversity: Indigenous Knowledge, Sustainable Livelihoods and Resource Governance in Montane Mainland Southeast Asia.* Proceedings of the III Symposium on MMSEA 25–28 August 2002, Lijiang, P.R. China. Kunming: Yunnan Science and Technology Press. pp. 25–40.

to the Ministry of Agriculture and Cooperatives, and the Royal Forest Department (RFD) was assigned to serve as the responsible counterpart agency. In order to provide an official framework for an ASB-Thailand consortium, the RFD established the Northern Mountain Region Agroforestry Research and Development Project, an open-ended project that includes both a high-level national steering committee and a working level administrative committee. The Director-General of RFD has served as chairman of the ASB-Thailand Consortium. During 2003, the Royal Forest Department was split into two departments that became part of Thailand's new Ministry of Natural Resources and Environment (MoNRE). The RFD has continued as the host agency for the ASB programme, but MoNRE is now considering transfering these responsibilities to the Ministry level, which would help facilitate collaboration with the range of relevant departments within MoNRE. In addition to the RFD, MoNRE and ICRAF, key participants in the ASB consortium have come from Thai universities, non-governmental and royally-sponsored development projects in the benchmark research area, as well as through various other partnerships in the global ASB consortium.

The ASB research program in northern Thailand seeks to understand processes and dynamics of land use change important in the MMSEA ecoregion, and help develop technologies and policies that can improve land use management in the region. Research conducted under ASB-Thailand gives preference to interdisciplinary, multi-institutional efforts to fill knowledge gaps and solve policy-relevant problems associated with land use issues in mountain watersheds of the northern region. Initial research activities emphasized efforts to build a knowledge base of the five aspects of land use alternatives indicated in Figure 3. An additional spatial analysis and modeling component has sought to integrate this knowledge and provide the six types of outputs also indicated in Figure 3. A further component has linked these efforts with additional research and information exchange at several international levels, through partnerships with organizations such as the World Resources Institute (WRI) and the SE Asia Network for Agroforestry Education (SEANAFE).

The Mae Chaem watershed in Chiang Mai Province was selected as the benchmark research site in association with colleagues in the multi-institutional ASB-Thailand consortium. This 'meso-scale' watershed serves as the main focus for our research efforts. As can be seen in the nested maps in Figure 4, the Mae Chaem sub-basin is an upper tributary of the Chao Phraya river system. It covers nearly 4,000 square kilometres, making up about 15 percent of the area of the Upper Ping Basin and contributing about 17 percent of its total flow.

Figure 4. Mae Chaem Benchmark Research Site



Some initial studies were also conducted on one ridge of the Mae Taeng watershed, where the Sam Mun Highland Development Project was able to facilitate significant change in local land use patterns during 1987-94. This and other pioneering pilot efforts seeking to improve livelihoods and environmental conditions provide both the points of departure and initial direction for the ASB Thailand research program.

This report focuses on trends of change in mosaic patterns of land use in the northern Thailand portion of MMSEA, with particular attention to changing land use practices of mountain minority communities and their impact on environmental services of upper tributary watersheds. Most assessments focus on the ASB-Thailand Benchmark research site at Mae Chaem, which is considered a reasonable representation of conditions in an upper tributary watershed of northern Thailand today.

C. Thai Forest Policy Concerns and Land Use Change in Upper Watersheds

Research under ASB Thailand began with review of policy concerns and issues believed to be associated with changing mosaic patterns of land use in north Thailand, with emphasis on upper tributary watershed areas[5]. Through review of previous and existing efforts to understand and address these issues, we sought to identify strategic knowledge gaps, in order to provide the basis for selection of specific study sites and further program development. Findings from this process are largely summarized in the following sections of this chapter.

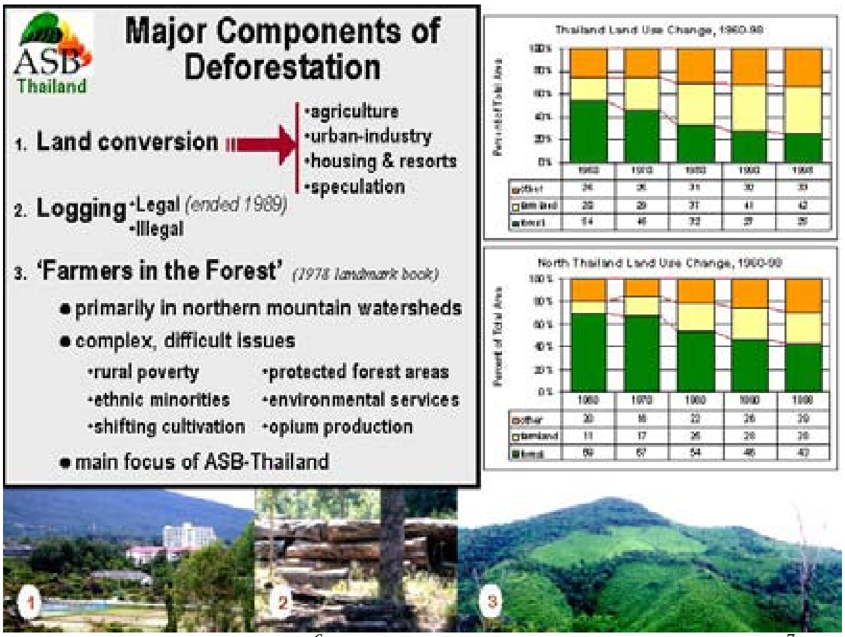
1. Major forest policy concerns

As the vast majority of land in upper watersheds is officially classified as reserved or protected forest, our first task was to examine forest policy concerns, which focus primarily on deforestation and watershed deterioration.

Deforestation

Thailand entered its era of rapid economic growth in 1960 with the launching of its first national 5-year economic and social development plan. While considerable economic development has been achieved, one cost has been loss of more than half of the nations's natural forest resources, resulting in growing concern about loss of biodiversity and contributions to climate change. Figure 5 summarizes overall land use change since 1960 at national and northern regional levels, in terms of land under forest, agriculture and other uses.

Figure 5.



Sources: Adapted from 1) Charuppat[6]; 2) Center for Agricultural Statistics 1994[7] and 1998[8]

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[5] Thomas, D. 1996. "Opportunities and Limitations for Agroforestry Systems in the Highlands of North Thailand". In: *Highland Farming: Soil and the Future?* Proceedings of a forum December 21-22, 1995. MJU - K. U. Leuven Soil Fertility Conservation Project, Mae Jo University, Chiang Mai, Thailand. p. 126-160.

[6] Charuppat, T. 1998. *Forest Situation of Thailand in the Past 37 Years (1961-1998).* Forest Research Office, Royal Forest Department, Bangkok, Thailand. [in Thai]

[7] Center for Agricultural Statistics. 1994. *Land Use for Agriculture*. Agricultural Statistics Publication 449. Office of Agricultural Economics, Ministry of Agriculture and Cooperatives, Bangkok, Thailand. [in Thai]

[8] Center for Agricultural Information. 1998. *Agricultural Statistics of Thailand, Crop Year 1996/97.* Agricultural Statistics Publication 18/1998. Office of Agricultural Economics, Ministry of Agriculture and Cooperatives, Bangkok, Thailand.

Although dramatic decreases in forest cover began later in northern Thailand than in much of the rest of the country, major losses occurred at both levels during the 1970's. Rates of loss appear to have begun to decline by the turn of the millennium, but percentage declines in the north were still above the national average. Moreover, while most remaining forest is in the north, losses there are already greater than most portions of the MMSEA eco-region. Types of deforestation found in northern Thailand may be broken into three major components:

(1) ***Conversion of forest***. Initial conversion of forest after 1960 throughout Thailand was primarily associated with expansion of land for agriculture, as seen in Figure 5, both to feed the growing population and for export crops to fuel the growing economy. Conversion to agriculture was facilitated by heavy logging, and during the late 1970's, agricultural expansion combined with political and national security strategies to further encourage clearance of forests. As agriculture began to expand into increasingly marginal sites, overall population growth rates began to decline, the economy began structural adjustments emphasizing industrial and service sectors, and urban and suburban growth began to accelerate. Thus, further land use conversion became increasingly associated with cities, industry, housing, resorts, and more recently for land speculation. Farmland per capita now appears to be slowly decreasing, while the overall proportion of farmland appears to be stabilizing. Other non-forest land appears to be expanding roughly in proportion to overall population growth. Some of these non-agricultural land uses, such as resorts and golf courses, can convert land directly from forest, while others displace agriculture at the periphery of urban or industrial areas, and may thereby lead to further conversion of forest to agriculture.

(2) ***Logging of natural forest.*** Logging helped fuel economic growth initially, but the combination of huge concession areas overlapping with protected forest areas and local communities, high official and unofficial harvest rates, low replanting rates, settlement and cultivation of logged areas, and slow expansion of plantation forests finally proved unsustainable.[9] Although logging concessions were stopped in 1989, illegal logging is still a problem in reserved forest and protected areas. Large illegal operators make various efforts to conceal their operations, frequently including the hiring of villagers to cut trees for their operations. Forest department policy now emphasizes forest conservation rather than timber production, including strict enforcement of rules to address remaining open frontier mindsets

(3) ***Farmers in the Forest.*** Issues associated with this component are much more complex and difficult. In the mountains of north Thailand various ethnic minorities have long lived as 'farmers in the forest', as described in the landmark book of that name.[10] A web of often contested issues is associated with their land use practices, including opium production, shifting cultivation, rural poverty, and the impact of their land use practices on protected forest areas and environmental services. This component is the main focus of ASB in Thailand.

The 1997 overall distribution of mountain ethnic minority populations living in the midlands and highlands (above 600 m.a.s.l.) are indicated in Figure 6, at both the national and northern region levels, as well as for Chiang Mai province and the ASB benchmark site (Mae Chaem). In addition, Lowland Thais make up about 16 percent of the total population living above 600 m.a.s.l. at the national level, and about 11 percent in the ASB benchmark site. While overall proportions of mountain minorities above 600 masl are quite low when viewed within broader aggregate populations, they frequently make up more than half of the population in upper tributary watersheds such as Mae Chaem.

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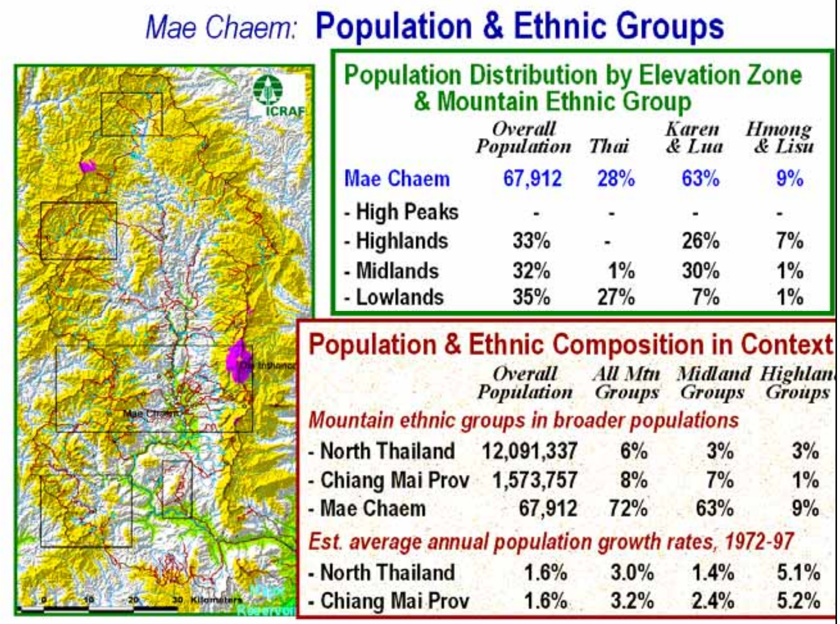
[9] Pragtong, K., Thomas, D. 1990. 'Evolving Systems in Thailand' In: Poffenberger, M. (ed.), *Keepers of the Forest: Land Management Alternatives in Southeast Asia*. Kumarian Press, West Hartford, Connecticut.

[10] Kunstadter, P., Chapman, E., Sabhasri, S. (eds.). 1978. *Farmers in the Forest: Economic development and marginal agriculture in Northern Thailand.* East-West Center Press, Honolulu, Hawaii.

Figure 6. Population distribution circa 1997



The grouping of communities into those with highland, midland and lowland traditions correspond with the altitude zones within which they have been most prevalent, and the types of agroecosystem management practices they traditionally employed. Although such groupings are based on traditional distinctions widely applicable across MMSEA, altitude zones are approximate, geographic domains of ethnic groups overlap, and conditions change and traditions adapt over time. Figure 7 presents estimates from the ASB benchmark site indicating how ethnic groups now distribute themselves among altitude zones, and resulting ethnic distributions within each zone. Note that 27 percent of highland tradition populations (Hmong) are now located in midland and lowland zones, whereas 42 percent of midland tradition populations (Karen) are located in the highland zone (usually near its lower boundary), where they outnumber traditional highland groups by a factor of four.

Figure 7. Distribution of Ethnic Groups in the ASB Site by Altitude Zone

Ethnic Group	Population	*Distribution of ethnic groups among zones* (percent)				
		Lowlands	Midlands	Highlands	High Peaks	total
Hmong/Lisu	6,192	15.3	11.5	73.2	-	100
Karen/Lua	42,900	10.6	47.9	41.9	-	100
Northern Thai	18,820	96.6	3.4	-	-	100
Overall	**67,912**	**34.9**	**32.0**	**33.1**	**-**	**100**

Ethnic Group	Population	*Ethnic composition of altitude zones* (percent)				
		Lowlands	Midlands	Highlands	High Peaks	total
Hmong/Lisu	6,192	4.0	3.3	20.1	-	9
Karen/Lua	42,900	19.3	93.8	79.9	-	63
Northern Thai	18,820	76.7	2.9	-	-	28
Total	**67,912**	**100.0**	**100.0**	**100.0**	**-**	**100**

Source: unpublished ICRAF and Ministry of Interior data

From an environmental point of view, the most important distinctions among traditional groups relates to their agroecosystem management approaches. Particular attention has usually focused on shifting cultivation, or 'swidden', components of their systems, where highland groups are associated with 'pioneer swidden', midland groups with 'established swidden', and lowland groups with 'northern Thai swidden'[11]. There has never been a basis for official recognition of forest fallow fields as a component of agricultural land holdings, and clearing of fields in a shifting cultivation system are officially viewed as forest destruction. Critics of these official views claim that when a new field is cleared – especially under 'established' or rotational swidden – an old field is returned to fallow, resulting in no net deforestation. While remote sensing can provide estimates of the proportion of an area that is cleared of forest at a given point in time, there is still a substantial range of issues and policy questions regarding the impact of changing 'farmers in the forest' practices on forest ecosystems.

[11] T.C. Sheng 1979, unpublished report to FAO

Watershed Deterioration.

There are three main aspects of these issues that are high priorities for ASB-Thailand:

(1) ***Deteriorating Watershed Services***. The northern mountains are the headlands of the Chao Phraya river system that nourishes Thailand's key 'rice bowl' production areas in the central plains, as well as the vast urban-industrial complex around Bangkok. Concern about deterioration of mountain area watershed services began in the 1960's when a group of academics from the Kasetsart University Faculty of Forestry began research at three small highland sub-catchments at Doi Pui in northern Thailand. Findings through 1980 are summarized[12], and a series of university bulletins were produced, such as those on effects of clearing hill evergreen forest on soil organic matter[13], physical properties[14], chemical properties[15], and sediment[16]. Subsequent research related to opium crop substitution is also summarized[17]. Whereas summary documents generally indicate impacts of shifting cultivation are modest, compared to impacts on stream flow, erosion and water pollution associated with permanent agricultural fields, road construction and human settlements, bulletins tend to make a more negative assessment of shifting cultivation impacts. Several team members became influential in shaping basic views – especially in downstream society – related to watershed policies and impacts of land use in the mountains on watershed services. As environmental interest in society grows, various of these issues are being further elaborated at a wider range of sites. Forest department researchers led a team who summarized research findings in Thailand for the watershed component of a proposed forest sector master plan[18]. One of Thailand's leading academics in watershed science has also published a recent review on hydrology in highland watersheds[19]. An independent case study of water-related economic issues in an upper tributary of the Ping River broadened analysis of upstream-downstream issues, and identified several data gaps preventing adequate assessments of policy alternatives[20] that have yet to be addressed[21]. While a few studies have begun comparing effects of practices by different ethnic groups, considerably more work is required to assess various water use technologies, to assess shifting cultivation impacts on a full-

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[12] Chunkao, K., Tangtham, N., Boonyawat, S., Niyom, W. 1981. *Watershed Management Research on Mountainous Land, 15-Year Tentative Report, 1966-80*. Department of Conservation, Faculty of Forestry. Kasetsart University, Bangkok, Thailand. [in Thai]

[13] Lapudomlert, P., Santadkarn, P., Chunkao, K. 1974. Changes in Organic Matter after different Period of Clearing at Doi Pui Hill Evergreen Forest, Chiangmai. *Kog-ma Watershed Research Bulletin* No. 18. Faculty of Forestry, Kasetsart University, Bangkok, Thailand. [in Thai]

[14] Chunkao, K., Santudgarn, P., Tangtham, N. 1974. Effects of Shifting Cultivation on some Physical Properties of Hill Evergreen Forest Soils. *Kog-ma Watershed Research Station Bulletin* No. 19. Faculty of Forestry, Kasetsart University, Bangkok, Thailand. [in Thai]

[15] Prachoom, S., Chunkao, K., Tangtham, N. 1974. Deterioration of some Chemical Properties of Soils after Clearing of Hill Evergreen Forest. *Kog-ma Watershed Research Bulletin* No. 20. Faculty of Forestry, Kasetsart University, Bangkok, Thailand. [in Thai]

[16] Aksornkoae, S. Boonyawat, S., Dhanmanonda, P. 1977. Plant Succession in Relation to Sediment in different Areas after Shifting Cultivation at Doi Pui, Chiangmai. *Kog-ma Watershed Research Bulletin* No. 31. Faculty of Forestry, Kasetsart University, Bangkok, Thailand [in Thai]

[17] Chunkao, K. 1983. *Final Report: Research on Hydrological Evaluation of Land Use Factors Related to Water Yields in the Highlands as a Basis for Selecting Substitute Crops for Opium Poppy, 1980-83.* Highland Agriculture Project. Kasetsart University, Bangkok, Thailand.

[18] Royal Forest Department. 1993. *Thai Forestry Sector Master Plan*, Volume 5: Subsectoral Plan for People and Forestry Environment. Royal Forest Department, Bangkok, Thailand.

[19] Nipon Tangtham. 1999. 'Hydrological Roles of Highland Watersheds in Thailand'. In: Bunvong Thaiutsa, Catherine Traynor, Songkram Thammincha (Editors), *Highland Ecosystem Management*: Proceedings of the International Symposium on Highland Ecosystem Management, 26-31 May 1998. Chiang Mai, Thailand: The Royal Project Foundation.

[20] Vincent, J., Kaosa-ard, M., Worachai, L. 1995. *The Economics of Watershed Management: A Case Study of Mae Taeng*. Thailand Development Research Institute, Bangkok, Thailand.

[21] Mingsarn Kaosa-ard. 2000. Unpublished WRI-REPSI report.

cycle basis, or to address effects of interactions and lateral flows among mosaic patches at larger landscape levels. Since one of the most immediate policy concerns in the northern region focuses on downstream impacts of upland land use on stream flow, reservoirs, and crop yields, such work is a priority concern.

(2) ***Growing Upstream-Downstream Conflict***. Growing environmental awareness and concern with nature, pollution and sustainability[22], are converging with increasing demands for water by agriculture, cities and industry, to increase focus of attention on land use in upper watersheds. These trends are projected to continue to build in coming years. Moreover, increasing competition for water resources among a growing range of stakeholders combines with shortages of key data and limited access to existing knowledge, to fuel debate, conflict and confrontation that is frequently based more on emotions than reason. Various 'schools of thought' are developing, some of which appear to reject most all notions of 'scientific' analysis, while others cannot accept notions of 'local knowledge'. What appears to be urgently needed is a widely-acceptable and accessible set of criteria, indicators and measurement tools, that are based on appropriate calibrations with science and local knowledge, for empirical assessment and monitoring of watershed and related environmental services. Associated institutions to manage disputes at various levels also need to be strengthened, along with information and support services. Meanwhile, since action programs must proceed with less than ideal knowledge and tools, systematic learning from such experience needs to be strengthened, in order to bring improvement to action programs at each step along the way.

(3) ***Relevance for the Larger Eco-Region***. Although the impact of change may be greatest in north Thailand, processes underlying this change are already in motion in watersheds elsewhere in the larger MMSEA Asia eco-region, including portions of the Hong (Red), Mekong, Salween, Irawaddy, Yangtze and Xi Jiang (Pearl) river systems[23]. As these issues and processes are also important in those areas, we are seeking to strengthen linkages that can facilitate even wider relevant exchange.

In order to more effectively address these types of forest policy concerns, we must develop a more clear understanding of processes that underlie changing land use patterns, and forces that determine directions and rates of change. Three major factors contributing to the complexity of these processes in northern Thailand include: incentives and pressures for land use change, impacts on traditional mountain land use systems, and the spatial distribution of land use change.

2. Incentives and Pressures for Land Use Change

The complexity of land use issues in northern Thailand is exacerbated by the convergence of six types of pressures and incentives for change, as listed in Figure 8.

(1) ***Demographic change.*** High population growth rates in mountain ethnic minority communities, relative to lowland rates, have combined with migration from neighbor countries to increase land pressure.[24] During recent decades, Thailand has been a safe haven or an economic magnet for many

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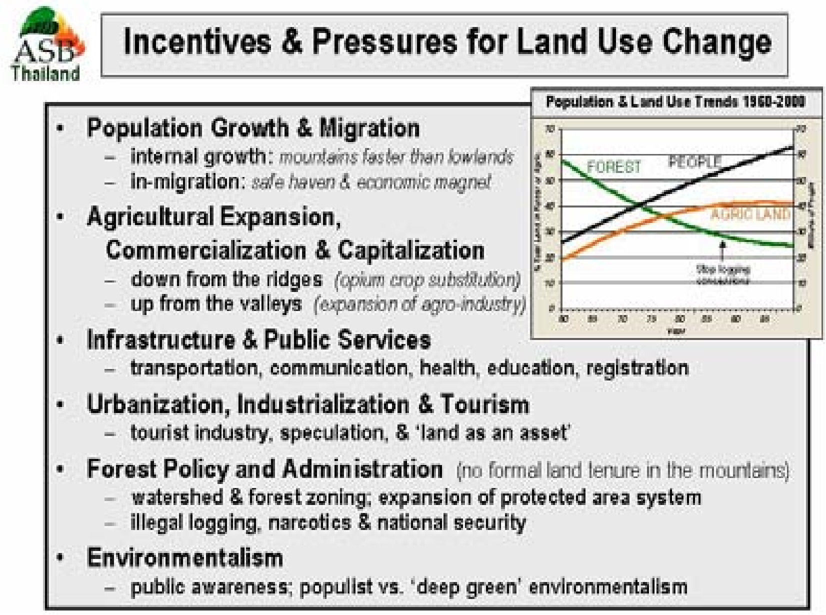
[22] Hirsch, P. (ed.). 1997. *Seeing Forests for Trees: Environment and Environmentalism in Thailand*. Silkworm Books, Chiang Mai, Thailand.

[23] For example, see: a) Revenga, C., Murray, S., Abramovitz, J., Hammond, A. 1998. *Watersheds of the World: Ecological Value and Vulnerability*. Washington DC, USA: World Resources Institute and WorldWatch Institute. b) CMU. 1996. *Montane Mainland Southeast Asia in Transition*. Proceedings of a Workshop held during 12-16 November 1995. Chiang Mai University, Chiang Mai, Thailand. c) Kaosa-ard, M, Pednekar, S., Christensen, S., Aksornwong, K., Rala, A.. 1995. *Natural Resources Management in Mainland Southeast Asia*. Thailand Development Research Institute, Bangkok, Thailand.

[24] Rerkasem, K. 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. International Institute for Environment and Development, London, England.

people in neighboring countries. Since many ethnic minority communities in the midlands and highlands are still being integrated into the regular Thai administration system, they are only included in more recent demographic data. Estimates of ethnic minority populations living above 600 m.a.s.l. in 1997 are shown and compared with total populations in Table 1. When compared with estimates from the same source in 1972[25], highland groups appear to have had average annual increases as high as more than 5 percent per year, whereas midland groups averaged about 3 percent. This compares to an average annual growth rate of 2.0 percent for total populations in Chiang Mai and north Thailand during this 25 year period. While some highland communities may not have been counted in 1972, their relatively rapid rates of population growth remain clear. Growth in midland communities, however, appear far more modest, and very recent data indicate sharp drops in birth rates in highland communities.

Figure 8.



graph data: 1) Charuppat[5]; 2) Center for Agricultural Statistics[6,7], 3) IPS 2000[10]

(2) ***Commercial agriculture.*** Expansion and commercialization of agriculture has followed both from opium crop replacement efforts in the highlands, and from expansion of lowland agro-industry up hill slopes from valley bottoms.[26] Work in northern Thailand on replacement of opium with intensive commercial crops was largely pioneered by projects under the patronage of H.M. the King, followed by a range of publicly, privately and internationally supported projects in various northern areas. While some highland production activities, from cabbages to barley, ginger and some fruit crops, are now conducted through private channels, a range of Royal Project centers specializing in fruits, vegetables or ornamentals have come together under the umbrella of the Royal Project Foundation. Activities now even include marketing a range of products under their own *Doi Kham* brand name. Lowland-focused Thai agro-industry has been expanding into mountain valley areas, resulting in expansion of soybean, maize, potatoes, longan, mango and other crops, up slopes into the midland zone. While these efforts often have the blessing of government rural development and poverty reduction programs, investment requirements, risks and profitability have varied substantially, often in relation to fluctuating environmental and economic conditions. Although a small minority have been successful enough to move out of the lowest income categories, the vast majority of people in mountain areas remain poor.

(3) ***Infrastructure & services.*** Programs for opium eradication and national security further increased efforts to expand road infrastructure in mountain regions. In addition to their direct environmental impact, roads have brought market access for alternative cash crop production to many remote areas, as well as access for illicit logging and forest extraction operations. Expansion of government services is another dimension of public policy, including registration of minority communities, as well as education and health services, electricity and media access, all of which help increase opportunities for integration of these communities into national society.

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[25] Kunstadter, P., Chapman, E., Sabhasri, S. 1978. *op. cit.*

[26] TDRI. 1994. *Assessment of Sustainable Highland Agricultural Systems*. TDRI Natural Resources and Environment Program. The Thailand Development Research Institute, Bangkok, Thailand.

(4) ***Urban industrialization and tourism.*** Expansion of tourism, resorts and recreational facilities are bringing new claims, pressures and opportunities to mountain areas.[27] Urbanization and industry have also begun affecting various aspects of life and decision making. These processes have encouraged land speculation in many areas. As perceptions of land have shifted from a production input into a financial asset; substantial areas are now in limbo after the Asian financial crisis.

(5) ***Government policies.*** Forest policy has brought forest reserves, national parks, wildlife sanctuaries, and protected watershed forests, which preclude formal recognition of land use claims in most mountain areas. In some areas, land has been degazetted from reserved or protected status when local communities have demonstrated long term residency and met other requirements. The magnitude of the impact of reserved and protected areas on populations living above 600 masl are indicated in Figure 9. Note that the ASB benchmark site (Mae Chaem) is well placed to study issues associated with communities living within reserved forest, planned reserves and parks, and de-gazetted areas.

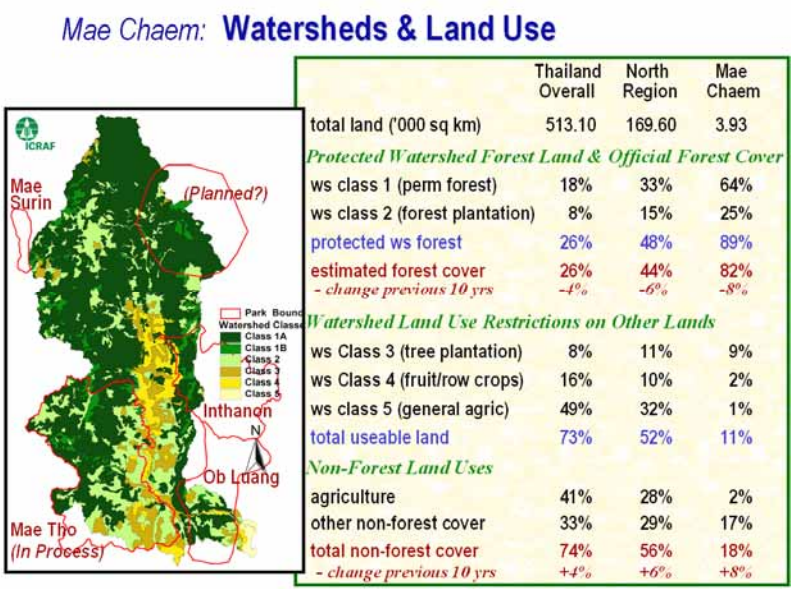
Figure 9. Status of land occupied by populations above 600 m.a.s.l., 1997

Land category	National	North	Chiang Mai	Mae Chaem
	-- number of people living within land category --			
Reserved forest	611,400	589,279	174,224	30,794
National parks	39,421	37,877	15,742	311
Wildlife Sanctuaries	40,600	30,900	6,755	-
No hunting areas	2,001	1,957	1,895	-
De-gazetted areas	283,878	250,104	46,689	3,309
Planned reserves	8,322	8,322	8,322	4,615
Military lands	5,500	-	-	-
Total	**991,122**	**918,439**	**253,672**	**39,029**

Source: adapted from Hilltribe Welfare Division, 1998[9]

The perceived importance of watershed issues has prompted another set of policies directly related to land use in mountainous areas of northern Thailand. A watershed classification system was developed and implemented throughout the country, initially under the aegis of the National Research Council, subsequently under the Ministry of Science, Technology and Environment, and now under the Ministry of Natural Resources and Environment. Five categories of watershed classes have been overlaid on 1:50,000 scale topographic maps, and a set of restrictions on land use associated especially with categories 1 and 2 have official standing as 'critical' or 'protected' watersheds under a resolution of the ministerial cabinet. The distribution of land among these categories at nested levels of resolution are indicated in Figure 10.

Figure 10.



	Thailand Overall	North Region	Mae Chaem
total land ('000 sq km)	513.10	169.60	3.93
Protected Watershed Forest Land & Official Forest Cover			
ws class 1 (perm forest)	18%	33%	64%
ws class 2 (forest plantation)	8%	15%	25%
protected ws forest	26%	48%	89%
estimated forest cover	26%	44%	82%
- change previous 10 yrs	*-4%*	*-6%*	*-8%*
Watershed Land Use Restrictions on Other Lands			
ws Class 3 (tree plantation)	8%	11%	9%
ws Class 4 (fruit/row crops)	16%	10%	2%
ws class 5 (general agric)	49%	32%	1%
total useable land	73%	52%	11%
Non-Forest Land Uses			
agriculture	41%	28%	2%
other non-forest cover	33%	29%	17%
total non-forest cover	74%	56%	18%
- change previous 10 yrs	*+4%*	*+6%*	*+8%*

While proportions of land in classes with severe restrictions appear modest at the national level, this changes as one moves to increasingly smaller upstream units. Although only 25 percent of the country is placed in class 1 and 2, the proportion doubles at levels of the northern region and major basins like the Ping, and climbs to about 90 percent in the Mae Chaem watershed, a major upper tributary of the Ping River. Thus, conditions at the ASB site are rather typical of

[27] Dearden, P. 1996. 'Trekking in northern Thailand: Impact distribution and evolution over time'. p. 204-225. In: Parnwell, M. (ed.). *Uneven Development in Thailand*. Avebury, Ashgate Publishing Ltd., Aldershot, England.

conditions in upper tributaries. Since downstream environmentalists and other interests are using these maps in calling for severe restrictions and even relocation of communities out of mountain areas, related watershed policies need considerable careful analysis and exploration of options. Other forest land zoning exercises associated with specific policy initiatives have had various further effects on local communities and land use in the north.

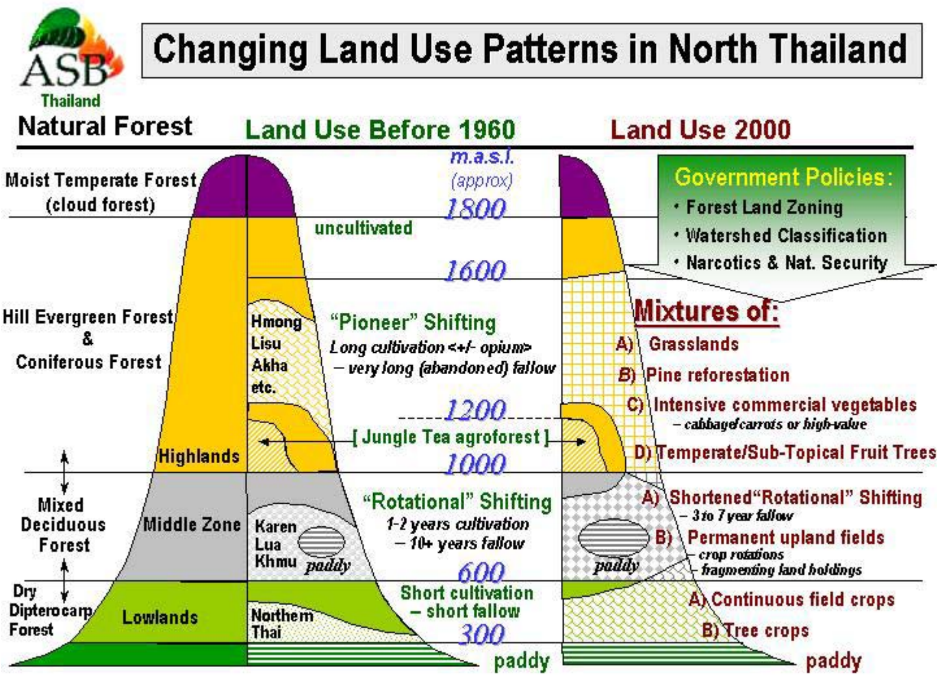
Rural poverty programs in the mountains have largely been conducted through the Public Welfare Department, various special projects, or by missionaries.[28] However, rural development decision making, is now shifting to elected local governments under the 1997 constitution and associated reforms. Various other new provisions, including a community forestry law, are now being considered by Parliament. All government agencies, including the forest department, must now reform their policies and programs to conform with the many new mandates involved.

As mountain areas are also the focus of other concerns, including illegal logging, narcotics and national security, the government has multi-agency development policies, plans and projects specifically for highland and midland areas. While opium eradication programs have made major progress, problems remain with illegal logging, illegal import of methamphetamines, and spillover effects of armed conflict in neighboring countries.

(6) ***Environmentalism***. Rapid growth of environmental awareness in the general public has also been associated both with a ‘populist’ element calling for more local control over natural resource management, as well as with a more ‘deep green’ element that believes local communities should be excluded from protected areas for the longer term benefit of larger society. Although these two factions were allies during the early emergence of the environmental movement into the national public policy arena, they have since split into camps that frequently oppose each other. Tension between these elements is substantial and growing, and occasionally breaks out into open conflict.

3. Impacts on Traditional Mountain Land Use.

Figure 11. Generalized Patterns of Land Use Change



Another factor adding to the complexity of land use issues relates to how these forces affect ethnic groups and land use within key altitude zones. As a conceptual baseline, Figure 11 presents some basic altitude zone features needed to understand distribution of resources, people and activities, and their change over time, in northern Thailand and many parts of the MMSEA ecoregion.

The natural ecology associated with mountain terrain in northern Thailand is generally reflected in natural forest types, which are strongly

[28] Renard, R., Bhandhachat, P., Robert, G., Roongruangsee, M., Sarobol, S., Prachadetsuwat, N. 1988. *Changes in the Northern Thai Hills: An examination of the impact of hill tribe development work, 1957-1987*. Research Report 42. Research and Development Center, Payap University, Chiang Mai, Thailand

associated with altitudinal gradients, as modified by geology, aspect, fire, and other factors. In combination with the ethnic complexity of the region, it becomes apparent that past complex traditional patterns of land use in largely forested landscapes have reflected both the ecological and cultural diversity of the region. Literature reviews of classic studies on the range of traditional land use systems are included in research documents by Grandstaff[29], Kunstadter[30], Keen[31] and various others. A recent study by Schmidt-Vogt[32] includes an updated bibliography. During recent decades, however, incentives and pressures for change have brought changing mixtures of land use[33], with substantial loss of mature secondary forest.

With strong co-variance of forest types, ethnic composition and land use practices according to altitude zones, previous studies suggest three major types of traditions with which traditional land use systems have associated. Their basic features and trends of change (examples in Figure 12) include:

(1) ***Highland traditions*** have been associated with relatively mobile villages and 'pioneer'-type long cropping - very long 'abandoned' forest fallow that is really only viable in areas where small populations have access to extensive areas. As this 'most destructive' type of shifting cultivation has also been associated with opium production, which is generally limited to areas above 1,000 masl, these areas have been primary targets of opium eradication and highland development programs and projects. Today, pioneer shifting cultivation and opium have been largely replaced by commercial vegetable production that is now pushing into the midlands[34], with

Figure 12.Major Ethnic Groups in Mae Chaem

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[29] Grandstaff, T. 1976. *Swidden Society in North Thailand: A diachronic perspective emphasizing resource relationships*. Ph.D. dissertation. University of Hawaii, Honolulu, Hawaii.

[30] Kunstadter, P., Chapman, E., Sabhasri, S. 1978. *op. cit.*

[31] Keen, F.G.B. 1972. *Upland Tenure and Land Use in North Thailand*. SEATO Cultural Programme

[32] Schmidt-Vogt, D. 1999. *Swidden Farming and Fallow Vegetation in Northern Thailand.* Geoecological Research Vol. 8. Franz Steiner Verlag, Stuttgart, Germany.

[33] Thong-ngam, C., Shinawatra, B., Healy, S., Trebuil, G. 1996. 'Farmer's Resource Management and Decision-Making in the Context of Changes in the Thai Highlands'. p. 462-487. In: CMU. 1996. *Montane Mainland Southeast Asia in Transition*. Chiang Mai University, Chiang Mai, Thailand.

[34] TDRI. 1994. *op. cit.*

cabbage and carrots currently the most prominent crops. There has also been substantial planting of pine plantations by the forest department in grassland areas believed to have been the result of pioneer shifting cultivation.

Land user concerns in this zone center on markets for commercial crops and land security. Wider environmental concern about land use in this zone centers on deforestation of hill evergreen forest areas, and impacts on stream flow, erosion and pesticide pollution.

In contrast, some lower elevation highland areas feature traditions centered on 'miang' or 'jungle tea' production, where *camellia sinensis L.* is planted as an understory tree in hill evergreen forest. Leaves are steamed and sold with or without fermentation, for chewing as a traditional stimulant by people in the region. Although located in the lower reaches of the highland zone, these systems are usually operated by people from lowland or midland ethnic groups. While numerous 'miang' operations continue today, with livestock often integrated into the system, the forest 'buffer' traditionally separating them from shifting cultivation systems now appears to be decreasing.

(2) ***Midland traditions*** are associated with 'established' villages and systematic short cropping - long 'rotational' forest fallow systems that often include paddy land where geography allows, and quite systematic management of landscape compartments, including areas kept under permanent forest cover. Management of these often rather complex forest fallow systems is also associated with quite sophisticated local knowledge of ecological relationships. Today, pressure from population growth, expanding lowland and highland systems, and government policy, has reduced land availability for these quite land extensive traditional systems, often resulting in much shorter forest fallow cycles, and even conversion to fixed fields in some areas. Even sacred groves in their landscapes are threatened. Livestock also graze among compartments in many midland systems.

Land users in this zone now have major concerns about food security and land security; crop markets are also a concern for those who have begun incorporating commercial crops into their systems. Wider environmental concerns about land use in this zone tend to focus primarily on deforestation, and to some extent on water use and stream pollution.

(3) ***Lowland Thai traditions*** have largely focused on irrigated paddies and home gardens, sometimes with supplemental short cropping - short fallow cultivation on nearby lower slopes. During recent decades, in addition to intensification of paddy and lowland vegetable production, there has been considerable further expansion of field crops, and in some cases orchards, into forested watersheds above paddy lands. Much of this expansion, which is now pushing into the midlands from below, is also associated with production for national or export markets through growing Thai agro-industrial firms or cooperative mechanisms.

Major concerns of land users in this zone today center on markets for commercial crops, availability and quality of irrigation water, and land security in areas where fields have pushed into reserved forest lands. Wider environmental concerns in this zone tend to focus on water use, pollution and deforestation – primarily as they relate to perceived negative externalities of upstream land use.

Recently, projects have begun promoting more trees in the landscape in all zones, with primary emphasis on fruit trees and community forest. In addition to eliminating opium, many projects now seek to establish or strengthen locally protected forest areas, control fire, and restrict activity on steep slopes and watershed headlands. There is also renewed interest in 'jungle tea' complex agroforests in some lower areas of the highlands, which continue to endure and seem to help protect at least nearby forest areas.

Overall trends associated with changing land use mixtures of mosaic patterns in these zones include:

- Differences between altitude zone land use domains of ethnic groups are becoming less distinct.
- Change appears to be associated with increased competition over land resources, 'degradation' or conversion of traditional systems, increased agricultural commercialization based on 'lowland' technologies, and larger areas cleared of forest at any one time.
- Very little research and development has aimed at understanding traditional systems or the impacts of the transformations they are going through.

Moreover, major policy-related issues associated with these changes in Mae Chaem and similar upper tributary areas include:

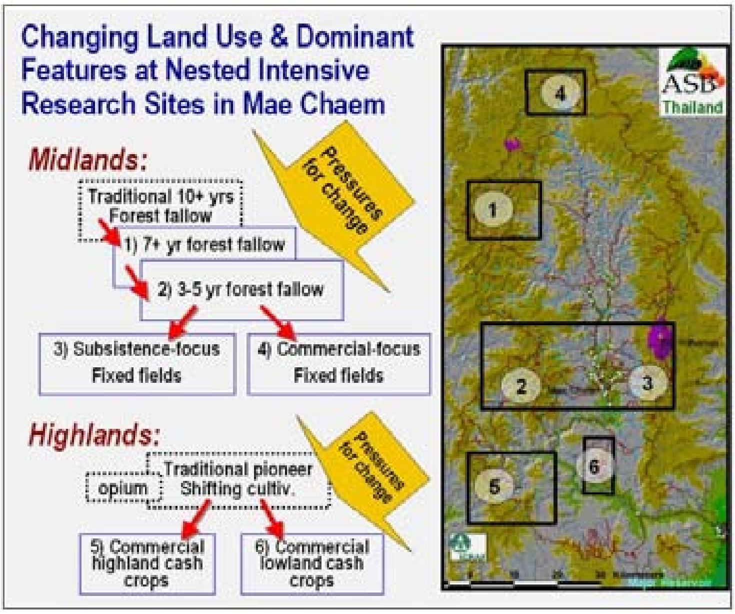
(1) perceived deterioration of the natural resource base due to deforestation and intensifying agricultural production in upper tributary watersheds, and its immediate and longer-term impacts on resources used by downstream society

(2) needs of poor mountain communities to have secure access to resources and services that will allow them to improve their food security and livelihoods

(3) associated growing upstream-downstream tension and conflict.

4. Spatial Distribution of Land Use Change

Figure 13. Major Land Use Patterns in Mae Chaem

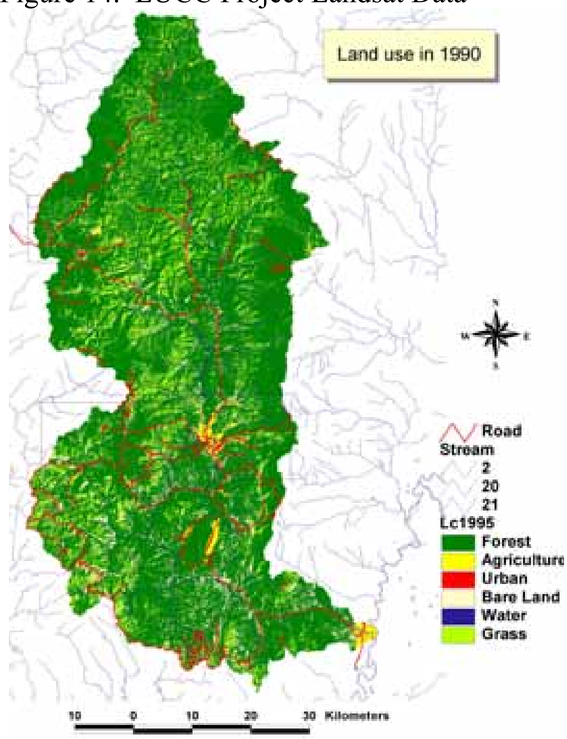


source: Pornwilai Saipothong & D.Thomas, ICRAF

Land Use Practices.

These influences, processes and patterns of tradition and change, however, are not evenly distributed across major landscape levels. The ASB Benchmark research site is large enough to capture most of the generalized pattern and various types of land use transformations discussed above, with the exception of 'miang' tea agroforests, which have never been a prominent feature in this area. Examples of current manifestations of how major transformations in land use change are spatially distributed around the ASB Benchmark research site are shown in Figure 13. While some areas in box 1 have forest fallow approaching full traditional cycles, no fully traditional highland systems can now be observed in this sub-basin. This distribution provided a basis for locating more intensive studies at various nested sites within the watershed, in order to understand more clearly the historical patterns of change and the current impacts of these types of land use on both local livelihoods and environmental services

Figure 14. LUCC Project Landsat Data



Based on LUCC data from Suwit Omsongwang, MoNRE

Land Cover.

Estimates of proportions of land in forest, agriculture and other non-forest categories at levels within which the ASB-Thailand research site (Figure 14) is nested are presented in Figure 15. Again, conditions in upper tributary watersheds are quite different from impressions given by data aggregated at wider regional or national levels. As one moves down the hierarchy from nation to northern region to Mae Chaem watershed, for example, forest cover increases from 27 to 46 to 79 percent, while agriculture decreases from 41 to 28 to 1.5 percent. Within Mae Chaem, roughly similar trends occur among altitude zones from valley bottoms to mountain peaks.

One must be cautious, however, in interpreting how such data represents midland and highland agricultural systems. Agricultural land in major lowland zones is associated with quite clearly recognizable boundaries. In areas such as Mae Chaem, however, estimates from remote sensing currently limit forest fallow agriculture to cropped clearings after the end of the rainy season – harvested, uncropped and early fallow land are often seen as 'other non-forest', while older fallows are considered forest. Considerably more work has been needed to improve our ability to monitor and assess traditional and transitional land use systems in these areas.

Figure 15. Nested Levels of Distribution of Land Cover, 1990

		Proportion of total area *(percent)*			
		Total	**Forest**	**Agriculture**	**Non-forest**
Thailand	**Overall**	**100**	**27.3**	**41.2**	**31.5**
North **Region**	*Overall*	**100**	**46.4**	**28.0**	**25.6**
Mae Chaem (ASB)	*Overall*	**100**	**79.4**	**1.5**	**19.0**
Mae Chaem	High peaks	100	98.8	-	1.2
Mae Chaem	Highlands	100	81.5	0.4	18.1
Mae Chaem	Midlands	100	74.8	1.6	23.7
Mae Chaem	Lowlands	100	85.4	7.5	7.1

Sources: Adapted from 1) Charuppat 1998 (Royal Forest Dept.)[5]; 2) unpublished RFD and ICRAF data

Sub-District Administration Units.

Another important level of variation occurs among units within watersheds at the level of the ASB-Thailand site or larger. One useful way to disaggregate the 4,000 sq. km. Mae Chaem watershed into sectors is to use administrative sub-district (tambon) boundaries. There are 10 sub-districts that cover about 90 percent of the watershed and define the domains of elected local government bodies that are being up-graded under the 1997 national constitution, which includes provisions for local participation in natural resource management. Figures 16 and 17 indicate the relative size of these sub-districts, how their land is distributed among altitude zones, and a few major features of upland land use within their domain.

Note that general effects of changes in altitude zones are modified locally by such factors as geology and geography, road access, projects and government programs. One major challenge is to understand how processes within and across altitude zones interact in influencing change in mosaic patterns of land use, and the benefits and costs of this change for both local communities and larger society. A second major challenge is how to strengthen the capacity of elected sub-district governance institutions to effectively administer land use management to meet both local and national needs.

Figure 16. Sub-districts in Mae Chaem

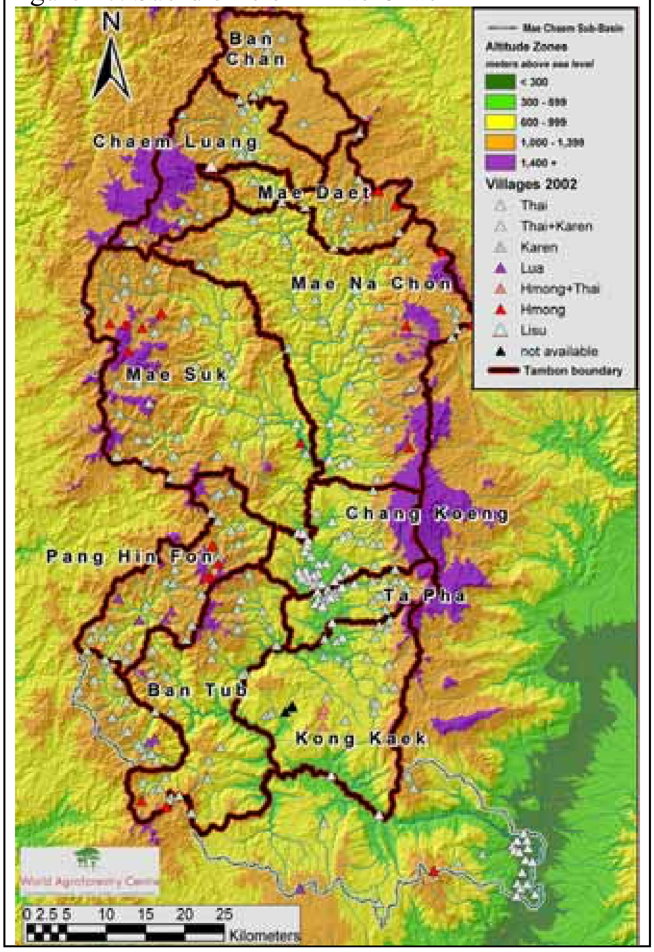


Figure 17. Sub-Districts in ASB Benchmark Watershed by Altitude Zone

Tambon (sub-district)	Area *hectares*	Proportion of total tambon area (*percent*)				Upland Land Use Features
		Peaks	Highlands	Midlands	Lowlands	
Ban Chan	18,504	-	91.8	8.2	-	hh SC, fixed, hi-value horticulture
Chaem Luang	24,851	1.9	83.5	14.6	-	med-long SC, veg.
Pang Hin Fon	24,167	-	75.0	25.0	-	short-long SC, veg., new park
Mae Daet	16,453	-	69.5	30.5	-	short-med SC, fixed., new park
Mae Suk	68,200	-	59.3	37.6	3.0	short-med SC, fixed, vegetables
Mae Na Chon	72,545	0.6	44.9	51.2	3.3	short-med SC, fixed., new park
Ban Tub	40,647	-	35.8	53.2	11.0	short-med SC, fixed, new park
Kong Khaek	36,918	0.2	18.0	60.6	21.3	fixed fields, park
Ta Pha	10,672	0.1	24.9	44.8	30.1	fixed fields, park
Chang Koeng	19,961	7.9	19.5	48.7	23.9	town, fixed fields, park
Total	332,917	0.8	50.5	41.3	7.4	

Sources: Adapted from unpublished data from Royal Forest Dept., ICRAF, Care-Thailand, and Ministry of Interior data

D. Experience with Agroforestry Modification, Adaptation and Innovation

Clearly, agroforestry systems research in North Thailand did not begin with a blank slate. In addition to numerous traditional forms of agroforestry and local adaptations and innovations, various projects and programs have and are seeking to promote various forms of agroforestry fields and components of agroforestry landscapes. In order to build upon existing knowledge and anchor our work in real-world conditions, we have made substantial effort to survey the relevant types of agroforestry at both field and landscape levels, to learn from a range of pilot development projects, and to review a range of promising innovative approaches to improving land use technologies.

1. Surveying Field and Landscape-Level Agroforestry

In order to help structure our approach to understanding various types of existing agroforestry and their current status, one of our initial activities was to put together a classification of generic forms of agroforestry fields and landscapes in northern Thailand, which is summarized in Figure 18.

Figure 18. Generic Types of Agroforestry Systems in North Thailand

1. Sequential Systems *(maximum growth rates at different times)*		
a. Field-Based Systems (unit = single field)	Source	Status
Pioneer Shifting Cultivation mature forest → repeated cropping → 'abandon'	indigenous	very rare
Relay & Transitional Intercrops (young trees + crops) → forest or orchard	old (taungya)	establish plantations & orchards
Rotational Systems -- ***Annual - Perennial Crop Rotations*** [annual → short perennial crop]	unknown	unknown
b. Landscape-Based Systems (unit = many fields + common land)	Source	Status
Forest Fallow Swidden [1-2 crops → (long) natural fallow] + protected areas	indigenous	degrading (?)
Composite Forest Fallow Swidden permanent paddy + [1-2 crops → (long) natural fallow] + protected areas	indigenous	degrading (?)
Intensified Rotational Systems		
-- ***Improved Fallow Management*** [1-2 crops → short improved fallow] + protected areas (+/- paddy)	local	little study
-- ***Annual - Perennial Crop Rotations*** [annual → short perennial crop] + protected areas (+/- paddy)	unknown	unknown
2. Simultaneous Systems *(grow at same time → competition / trade-off effects)*		
a. Field-Based Systems (unit = single field)	Source	Status
Regular Pattern Systems		
-- ***Row Pattern:*** e.g. orchards, alley cropping, countour hedgerows	induced	promoted
-- ***Linear Pattern:*** e.g. boundaries, live fences, windbreaks	local	promotion
Mixed/Irregular Pattern Systems		
-- ***Home Gardens:*** mixed species, age; multi-storey	indigenous	promoted
-- ***Complex Agroforests:*** very diverse, forest-like; e.g. miang tea	local	little study
-- ***Silvo-Pastoral Systems:*** trees, palatable shrubs, pasture	little study	little study
b. Landscape-Based Systems (unit = many fields + common land)	Source	Status
Community Mosaic Systems multi-level management [household + community + local govt]		
-- ***Watershed Mosaic:*** sited / managed to preserve watershed functions permanent fields (annual + perennial) + perm. watershed forest	induced	emerging promoted
-- ***Protected Forest Mosaic:*** sited / managed to preserve forest services permanent fields (annual + perennial) + protected forest	local & induced	emerging

Field-based systems are those where the management unit focuses only on a single field, whereas landscape-based systems are also managed at a level that includes many fields and often common land areas in a broader landscape unit. Field-based and landscape-based systems are both divided into sequential and simultaneous types of systems, depending on their basic approach to dealing with plant competition. It can be noted that:

- Most sequential systems are believed by many to be degrading or extinct, but most have had little systematic study. An exception is the *taungya* system that is still sometimes used as a transitional phase in the establishment of orchards or forest plantations. Sequential annual-perennial crop rotations are possible, but actual examples have not yet come to our attention in northern Thailand.
- Although improved fallow management is at least an interim alternative being investigated is some areas of MMSEA, emphasis of most projects and promotion campaigns here has been on the transformation of sequential systems into simultaneous ones.
- While most field-based simultaneous systems are among the most familiar forms of agroforestry, such as alley cropping, contour hedgerows, boundary plantings, silvo-pastoral systems, and home gardens, the category of complex agroforests is relatively new. Although the most popular examples of this quite newly-recognized form are traditional systems in Sumatra – such as 'jungle rubber' and the damar agroforests – the 'miang' tea gardens of northern Thailand and their recent variants are also in this category.
- One of the most interesting contributions of agroforestry in northern Thailand is the emergence of simultaneous landscape-based forms of agroforestry that have been tentatively classified as community mosaic systems. These systems are basically derived from traditional sequential composite forest fallow swidden systems that have been transformed as a result of land use pressures and opportunities found in northern Thailand. The major thrust of this transformation has been the conversion of the forest fallow shifting cultivation component into permanent fields (which sometimes become agroforestry fields), coupled with conversion of remaining fallow areas into community managed and/or protected permanent forest compartments in the landscape mosaic.

Together, this generic classification provides a framework for investigation of agroforestry systems and their role in rural livelihoods and landscape management in northern Thailand

2. Learning from Previous and Current Pilot Development Projects

In response to these influences, trends and patterns of land use change, various innovative farmers and pilot projects have been seeking ways to improve livelihoods while reducing pressure on forest lands and protected watersheds. Some of these are very local efforts by individual households or local leaders, while others are facilitated or promoted by recent or on-going projects of various scales conducted by government agencies or non-governmental organizations. ASB-Thailand has sought to learn from, build on, support and work in partnership with such efforts.

Sam Mun Highland Development Project.

One recent project particularly noteworthy in this regard is the 1987-94 Sam Mun Highland Development Project (SMHDP), an inter-agency project led by the Royal Forest Department in coordination with the Office of the Narcotics Control Board, with funding assistance from the United Nations Drug Control Program and the Ford Foundation. The 2,000 sq km project area was located in midland and highland zones of a ridge of mountains beginning northwest of Chiang Mai city and extending to the Myanmar border. This area, like ridges in the ASB-Thailand benchmark watershed, was once an important opium production area, which in 1989 still totaled over 800 hectares. Although this was one of the last in a series of internationally-supported projects meant to focus on opium crop substitution, it is generally recognized as the most effective and the most integrated in its approach. Its Thai leadership made serious efforts to learn from both the mistakes and successes of previous projects, and even academics usually very critical of forestry policies and projects have recognized the value of their approach.[35]

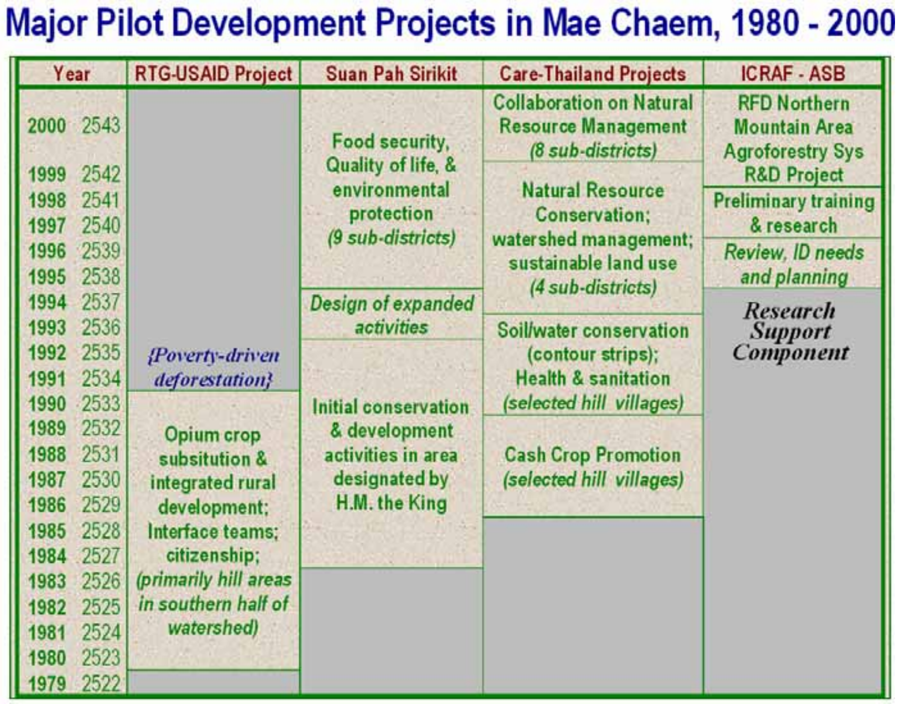
[35] Ganjanapan, A. 1997. The Politics of Environment in Northern Thailand: Ethnicity and highland development programs. p. 202-222. In: Hirsch, P. (ed.) *Seeing Forests for Trees: Environment and Environmentalism in Thailand*. Silkworm Books, Chiang Mai, Thailand. (page 208).

To paraphrase the words of a former project director, the SMHDP focused on developing and improving the capability of community organizations, so that they could be self reliant in managing their communities, food resources and other natural resources (soil, water, forest) in a manner that (1) is appropriate to their lifestyles and values; (2) ensures community stability; and (3) develops their community and environment in response to both local needs and government policies, including control of opium production.[36] The project assumed that people and forests can live in harmony, and emphasized food self-sufficiency, income generation, reduced chemical usage, reduced swidden cultivation, forest protection, initiation of watershed management networks, and tools for local land use planning. Many of the methods and tools pioneered by this project, such as participatory land use planning[37] and 3-dimensional village land use models, are now being used and further adapted by subsequent projects in Thailand and neighboring countries. In addition to some of the land use changes mentioned in following sections, the project also assisted communities in gaining access to health and education services, citizenship, and infrastructure improvements needed to implement their development plans. In terms of its major objectives, areas under shifting cultivation were reduced by more than 80 percent, while total forest are more than doubled[38]. Data on areas planted to opium in the project area, as verified by national and international drug agencies through remote sensing, indicate a 90 percent decrease during 1989-94.

Major Development Projects in the ASB Benchmark research site.

As in many of the upper tributary watersheds of northern Thailand, national (and international) policy priorities have been reflected in activities conducted by a series of development-oriented projects. In addition to activities of the Royal Project Foundation that began in the 1960's, the three lines of project activity most active in Mae Chaem since 1980 are indicated in Figure 19, along with timing of the research support activities under ASB-Thailand and ICRAF.

Figure 19.



(1) ***RTG-USAID Project***. The first major project intervention was a 10-year effort supported by USAID and the Thai government, with objectives aimed at reducing opium crops and integrated rural development, within the context of national security concerns during that period. Few would deny the success of this project in contributing to the demise of opium production and reducing problems associated with citizenship in the Mae Chaem watershed.

[36] Limchoowong. S. 1994. *Final Report of the Sam Mun Highland Development Project, 1987-1994*. Project AD/THAI 86/334-335. United Nations International Drug Control Program, Bangkok, Thailand. (page 11)

[37] Tan-kim-yong, U., Limchoowong, S., Gillogly, K. 1994. *Participatory Land Use Planning: A method of implementing natural resource management*. Sam Mun Highland Development Project. Watershed Conservation Division, Royal Forest Department, Bangkok, Thailand.

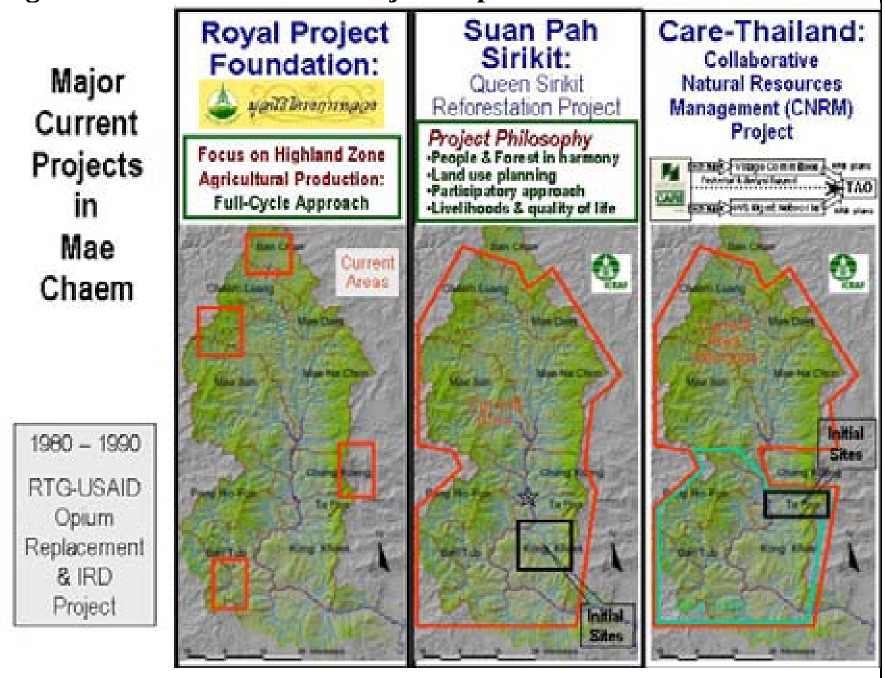
[38] Ibid., p. 58

There were also a number of innovations under this project that would subsequently have more widespread relevance, such as the 'interface teams' composed of villagers from different ethnic groups and local field officers from various agencies.

Events shortly after termination of the project, however, indicated that relatively less success had been achieved in addressing issues related to rural poverty and natural resource management. The most obvious manifestation of this was a surge in deforestation as fields of upland soybeans and maize were pushed up watershed slopes from the lowlands, and as fields of intensive cabbage production began to expand rapidly in highland areas. As a result, agencies responsible for natural resource management in upper tributary watersheds – primarily the Royal Forest Department – became very concerned.

In order to address these issues, two additional lines of project activity that also began during implementation of the RTG-USAID project subsequently took on a much expanded role. Together with the activities of the Royal Project Foundation, they are major sources of pilot project experience on which ASB-Thailand research is based. The areas within Mae Chaem where they are active are seen in Figure 20. Brief summaries of their operations include:

Figure 20. Sources of Pilot Project Experience



(2) ***The Royal Project Foundation***. This long-standing project locally important in several areas of Mae Chaem and elsewhere in northern Thailand, and with potential importance for a much wider range of locations, is a direct legacy of pioneering opium crop substitution efforts under the leadership of H.M. the King of Thailand. Beginning in the 1960's, the various pilot operations earlier known simply as 'The King's Project', are now operated under the umbrella of the Royal Project Foundation. In the Mae Chaem watershed, there are several locations where the Royal Project Foundation is currently active, working particularly with high-value specialty vegetable production in the Wat Chan area of the far north, and with ornamental plants and fruit trees at enclave villages inside the boundaries of Inthanon National Park. Major focus is on a vertically-integrated 'full-cycle' approach that includes extension, processing, transportation, retail outlets, and their own 'Doi Kham' brand name.

(3) ***Queen Sirikit Forest Development Project*** (***Suan Pah Sirikit***). Building on earlier smaller-scale efforts initiated by H.M. the King of Thailand in an area of southeastern Mae Chaem, this interagency project in the Mae Chaem watershed has been conducted under the patronage of H.M. the Queen since 1996.[39] The Royal Forest Department has a leading role in implementation through its 10 watershed management units in the area. The project philosophy is that people can live in harmony with the forest through community participation in conservation and forest resource development, collaboration among villagers and government agencies in local land use planning, improving

[39] Suan Pah Sirikit Project. 2000. Summary of Results of Project Implementation during Fiscal Year 1999. Suan Pah Sirikit Project, Watershed Conservation Division, Royal Forest Department, Chiang Mai, Thailand. [in Thai]

livelihoods and the quality of life in ways that protect watershed headlands, and coordination of relevant government agencies to facilitate systematic development. Expanded work began in response to rapid deforestation after the end of the RTG-USAID project in the late 1980's, which despite some useful innovations was unable to have a lasting positive impact on watershed management. The Suan Pah Sirikit project has built on promising innovations, and adapted several participatory methods and tools used in the Sam Mun Project, along with experience from various Royal Projects and other sources. Project staff, some of whom have been working in Mae Chaem for 15 years or more, have been very valuable overall partners of ASB-Thailand, and have participated directly in various research activities.

(4) ***Care-Thailand Collaborative Natural Resources Management Project***. Initial activities of Care in Mae Chaem were under a USAID-funded project that supported cash crops and improved home gardens for better nutrition. As the RTG-USAID project ended, Care shifted its emphasis to soil and water conservation, health and sanitation. During its next phase, as Care-Thailand began its transformation into a Thai NGO, it implemented the Integrated Natural Resources Conservation project, focused on working with local communities to promote sustainable management of agriculture and fragile watershed forests in 4 sub-districts of Mae Chaem. Project components included agroforestry, soil and water conservation, rice paddy and fish pond development and non-farm income generating activities. Project partners included the Royal Forest Department, other government agencies and the local government administration, with technical assistance from Chiang Mai University to study and implement approaches for promoting community participation in sustainable land use. The project provided valuable assistance during establishment of the ASB-Thailand benchmark site. Beginning in 2000, effort shifted to their new Collaborative Natural Resources Management Project, which expands activities to 8 sub-districts, and focuses more directly on institutional strengthening of village conservation committees, watershed management networks, and sub-district governments to manage local natural resources to meet both local and national needs. ASB-Thailand is working closely with them to provide support through our efforts to develop science-based tools for participatory watershed management.

Other Projects.

ASB-Thailand is also seeking to learn from the experience of a range of other previous projects, such as the Thai-German Highland Development Project, the Thai-Australian Highland Development Project, and others, as well as a range of other on-going governmental and non-governmental activities.

Indeed, the relatively high density of former and current development projects is one of the useful characteristics of the ASB-Thailand Benchmark research site, in that it provides an opportunity to assess the impacts of changes – both intended and unintended – associated with various types of projects that are being implemented at a growing number of sites around the MMSEA eco-region.

3. Promising innovations to improve land use technologies

Drawing on experience of these projects, including numerous examples of ideas and adaptations that came directly from innovative local farmers, we can see that most promising technical approaches to improving livelihoods while reducing pressure on forest and/or watersheds have focused either on decreasing the area required for upland rice and/or increasing trees in the landscape.

Meeting food security needs, while decreasing the area required for upland rice

Increased pressure to reduce the total amount of land used to produce upland rice under shifting cultivation has induced three basic types of response to altering approaches for meeting basic food security needs. All three are based on the expectation that intensified agricultural production will reduce pressure on forest components in the landscape.

(1) ***Increasing paddy fields.*** Preliminary findings indicate that expansion of irrigated paddy land in areas where terrain and water resources are suitable, often in small pocket areas, can allow communities to greatly reduce land requirements for upland rice production. Given the greater

productivity per unit area of paddy rice, reductions can be by a factor of 10 to 20, depending on paddy yields and the length of the swidden fallow cycle. The response of farmers to efforts by the Sam Mun Project to help them overcome existing barriers to paddy expansion resulted in a 330 hectare increase in paddy during 1988-92. While expansion of paddy appears to be a reasonable approach to help conserve forest in upland areas, some downstream interests have begun questioning whether the paddy expansion approach uses too much water[40].

(2) ***Permanent field upland rice***. In some areas under the Suan Pah Sirikit Project where terrain does not allow sufficient expansion of paddy to meet local subsistence needs, innovative farmers under pressure have developed a crop rotation system for permanent upland fields, in which upland rice is rotated to soybeans every third year. This has allowed them to reduce the total area required for upland rice production by a factor of 3 to 7, and also provides some cash income from the soybeans. Land taken out of upland rice is converted to permanent community-protected forest. Farmers using this system for 10 years claim they have not experienced yield reductions. Due to higher input costs and poor soybean prices since the Asian economic crisis, many farmers are now switching to new higher-yielding maize cultivars for their rotation crop, and it is not yet clear whether or how this will affect the sustainability of crop yields. ASB-Thailand began conducting the first known agronomic and economic studies of this system.

(3) ***Permanent fields of high-value commercial vegetables***. This approach involves meeting food security needs through generation of cash income, primarily in highland areas where the climate supports production of temperate zone vegetables. One prime example of this approach is found in the Ban Chan sub-district of Mae Chaem where a project of the Royal Project Foundation has been operating for many years.[41] Many villagers are producing high value specialty vegetables that are largely marketed through the Royal Project. These intensive systems use much less land than shifting cultivation, but while profits can be quite high, various crops suffer from periodic severe damage due to pests or climatic variation, or from sometimes drastic fluctuations in prices. Many villagers are responding to these factors by diversifying their production into two or more crops[42], including some fruit trees. Another stabilizing factor in this area has been expansion of paddy land, which was possible in some fairly large areas of gentle terrain. Traditional forms of shifting cultivation are now quite rare in this area, and locally-recognized land ownership has largely been privatized to households. Several ASB studies are being conducted in this area on current technologies and their historical development. Diversified cash crop approaches are also found in other areas of the watershed.[43]

Although highland cabbage and carrot production also involves this strategy, it has come under strong criticism on environmental grounds due to planting on steep slopes and heavy application of pesticides. Some projects are trying to introduce conservation farming practices and alternative pest management technologies into these systems, but with little success so far. Our partner pilot projects in Mae Chaem are continuing to explore alternatives.

Improving local livelihoods, while increasing trees in the landscape

There have generally been three major directions of efforts to increase trees in midland and highland landscapes.

(1) ***Simple agroforestry***. This approach has primarily centered on planting of fruit trees in agricultural fields, following approaches pioneered in the Royal Project. In highland zones, primary focus is on

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[40] Mingsarn Kaosa-ard. 2000. Unpublished World Resources Institute - REPSI report.

[41] Royal Project Staff. 1999. Annual Implementation Report, 1999. Wat Chan Development Center of the Royal Project. Royal Project Foundation, Chiang Mai, Thailand. [in Thai]

[42] Benchaphun Ekasingh. 2000. Unpublished report

[43] see reports cited in the economics research section of this report.

temperate zone fruits, such as Chinese apricot, plums, pears, persimmons, litchee, and others. In midland zones emphasis shifts more to sub-tropicals, such as mango or longan. Sam Mun Project efforts to encourage fruit tree production resulted in an expansion of area planted to fruit trees from just over 100 hectares in 1988 to more than 500 hectares in 1994. This data actually understates the full impact, since many trees were also planted around houses, along field boundaries, or in other ways that did not facilitate calculation of area planted. Further planting has continued after the end of the project.

A preliminary ASB study of fruit tree agroforestry in Sam Mun Project areas[44], found a substantial range of strategies and planting configurations deserving further analysis.

(2) ***Complex agroforests***. The primary example of an indigenous complex agroforest in northern Thailand is the 'miang' or 'jungle tea' plantations embedded in hill evergreen forest. As mentioned earlier, this system continues to endure despite concern that its market may be disappearing as young generations stop the practice of chewing the leaves. The Sam Mun Project encountered some success in helping Karen producers get out of debt cycles linked to buyers in the market, allowing them to obtain higher prices and profits. Moreover, prices for 'miang' tea appear to have recovered from low levels of 10 years ago, and many producers now claim their biggest problems are sources of hired labor and fuelwood required to process the tea. One forestry officer formerly working with the Sam Mun Project has conducted substantial research on the practices involved.[45]

An interesting variant on the direction for development of this system has been observed among farmers in an area adjacent to the Sam Mun Project area. Their approach involves gradual transformation of 'miang' complex agroforests, by substituting trees producing fruits and seeds crops for many or most of the forest and/or tea trees. During this process, they are careful to maintain a very complex structure in their agroforest, which mimics the complexity of the original. One preliminary study examined 19 examples of this type of operation[46], and further explorations appear warranted.

Although 'miang' tea plantations are not present in the Mae Chaem watershed, one area has been identified where coffee is being grown under forest shade in a somewhat similar manner. This site is at least useful for comparing some of the biophysical characteristics of these types of 'agroforest' land use practices.

(3) ***Community-managed forest.*** These efforts seek to maintain and expand areas of permanent forest that local communities protect and manage. Such efforts often seek to build on traditional concepts and beliefs of especially midland groups, in finding ways to convert forest fallow in fragile areas to permanent forest, or to reforest other types of degraded areas, either through tree planting or protection of natural regeneration. It is interesting to note that during implementation of the Sam Mun Project, the forest department reforested 4,855 hectares using their standard planting techniques. Although villagers used these techniques on only 242 hectares, they collaborated in protecting 59,220 hectares of naturally regenerating forest. The key to this approach was in reaching clear mutual agreement on land use plans, and active roles by village institutions in controlling use, fire, etc. A second key was in reaching clear understanding about how areas of community managed forest could be used by the local community.

One of the concerns expressed by various academics and NGO workers is that communities who stop shifting cultivation will lose access to an important range of natural products that they obtained from forest fallow fields during intermediate stages of regeneration. This is yet another area where existing data is very poor or absent, and further study is urgently needed.

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[44] Withrow-Robinson, B., D. Hibbs, P. Gypmantasiri, D. Thomas. (1998). "A preliminary classification of fruit-based agro-forestry in a highland area of northern Thailand". *Agroforestry Systems* 42 (2): pp. 195-205.

[45] Preechapanya, P. 1996. Indigenous Ecological Knowledge about the Sustainability of Tea Gardens in the Hill Evergreen Forest of Northern Thailand. Ph.D. diss. University of Wales, Bangor, Wales.

[46] Tanpanich, . 1997. (citation)

Promising institutional changes and pilot project innovations.

While these changes in technologies can help shift proportions among components within land use mosaics, there are also important institutionaldevelopments.:Three major examples include

(1) ***Land Use Planning***. Pilot experiments have shown it is possible to reach mutually-acceptable land use agreements among villagers and agency officials using participatory methods. Pioneering efforts under the Sam Mun Project developed what is now a widely accepted approach known as 'participatory land use planning' (PLP). In the words of its chief architect:

> "Participatory land use planning can be defined as an operational tool or process which creates conditions of frequent communication and analytical discussions, hence strengthening local organization by generating common understandings and shared rights and responsibilities among project partners, who carry out activities that lead to the solving of local forest management problems and other related community problems".[47]

The conceptual framework of PLP is conflict resolution applied to issues of natural resource management and development, and cannot be understood simply as a method of land use planning. The ability to manage land use comes out of basic changes in the roles of the stakeholders, with changes occurring as parties come to understand each others' positions. Essential to this concept is open access to information on all sides, involvement of a third party, and presence of long-term community workers. The end goal is to help upland villagers become active participants in watershed forest protection rather than the unwilling subjects of government control.

Various tools were explored to help facilitate this process and document mutual agreements that were reached. Particularly useful tools include scale contour maps and scale 3-dimensional models of the local landscape, which served both as a centerpiece for discussions and negotiations, and as a clear and accessible record of land use zones established through mutual agreement.

Once basic agreements were reached, villagers articulated their own sets of rules, penalties for violators, and mechanisms for enforcement. Penalties often included fines substantially higher than those imposed by lowland law, and communities subsequently proved their willingness and ability to enforce their rules. And on occasions when violators were outsiders who challenged their rules and rights to enforce them, local leaders sought assistance from project staff or local authorities.

Variations of this approach and its tools are being further adapted and refined by various next-generation projects, including those conducted by ASB pilot project partners in Mae Chaem. If these efforts can provide a basis for land security, a major obstacle will be removed.[48]

(2) ***Watershed Management Networks.*** Projects have also experimented with local, multi-village, and usually multi-ethnic group, watershed management networks to coordinate land use management across larger sub-watershed landscapes. Building on earlier work, the Sam Mun Project facilitated establishment of watershed networks, and encouraged them to formulate their own rules, penalties and enforcement mechanisms. The approach was basically an extension of the PLP process to the wider sub-catchment level, involving communities already familiar with PLP at the village level. With increased levels of upstream-downstream conflict now being encountered in many areas, various projects and organizations are promoting watershed management networks, again including those conducted by our partner pilot projects in Mae Chaem. One recent study indicates they have considerable potential for continuing after the end of the projects that help facilitate their establishment.[49]

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[47] Tan-kim-yong, U., *et. al.* 1994. *op. cit.*, page. 6.

[48] Shinawatra, B. 1994. "Property Rights, Institutions, and Access to Resources: Impacts on sustainable intensification in northern Thailand". Agricultural Economics Report 14. Multiple Cropping Centre, Chiang Mai University, Chiang Mai, Thailand.

[49] Mingsarn Kaosa-ard. 2000. Unpublished World Resources Institute - REPSI report.

(3) ***Constitutional and Legal Reform***. Under the 1997 constitution and related legal reforms, opportunities are emerging that may allow arrangements such as those being formulated and mapped using participatory land use planning to gain formal recognition. Examples include constitutional provision for local participation in natural resource management, laws and programs to upgrade and strengthen elected local governments, and community forestry legislation now under consideration by Parliament (but still opposed by some environmental interests). Yet a range of questions regarding how to implement such changes remain unresolved, including how to strengthen the still embryonic sub-district governments frequently found in poor mountain ethnic minority areas, as well as how agencies such as the forest department can best interact with the thousands of local government bodies involved. ASB partner pilot projects in Mae Chaem are among those seeking effective ways to address these issues.

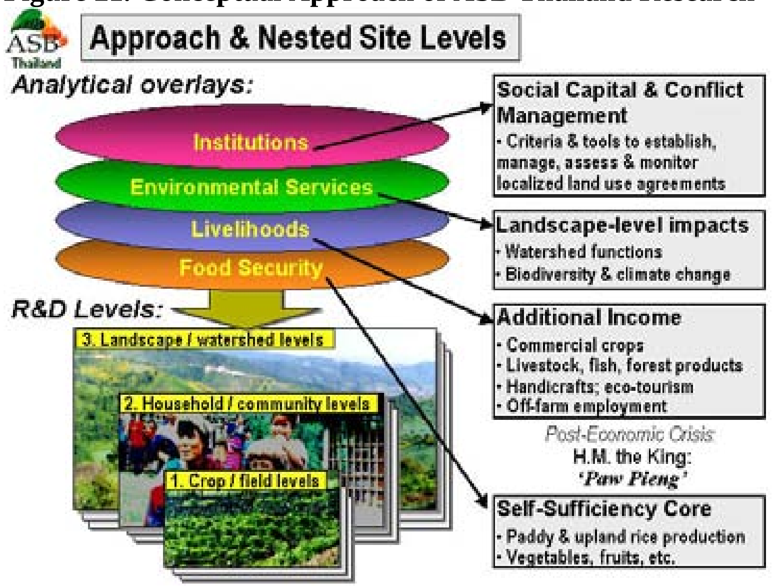
E. Articulating the ASB-Thailand Collaborative Research Framework

As we have seen, land use in upper tributary watersheds of northern Thailand is in a period of stress and transition. Traditional land use management practices resulted in a complex pattern of fixed and shifting cultivation components embedded in a forest matrix, reflecting both the ecological and cultural diversity of these areas. Due to a range of influences converging on the region, these largely officially unrecognized traditional systems are under stress, land use patterns are changing, and many communities are among the poorest in the nation. There is also growing concern in downstream society about the implications of these changes for their own livelihood systems and for the overall environment.

Although many believe there have been many negative impacts, and conflict is growing among various stakeholders and segments of society, there is also a growing body of experience that suggests promising approaches for improving directions and rates of change. Yet, there are numerous major gaps in the knowledge, methods and tools required to further develop these approaches, and effectively implement them on a broad scale across a complex range of conditions.

The Royal Forest Department has given a mandate to ASB Thailand to assist the department and other key organizations in addressing these needs and challenges. The Northern Mountain Area Agroforestry Systems Research and Development Project interfaces with and facilitates interdisciplinary, multi-institutional research by the ASB-Thailand Consortium in subject areas of mutual interest in Thailand, as well as collaboration with international research and information exchange at eco-region, Southeast Asia and global levels.

Figure 21. Conceptual Approach of ASB Thailand Research



Our conceptual approach, as indicated in Figure 21, seeks to develop and integrate analytical overlays focused on food security and livelihoods, on environmental services, and on institutional and land use security, each of which examines processes and issues at specific field practice level, at household and community levels, and at landscape and watershed levels.

All of these efforts seek to build on existing knowledge and experience, and strengthen ongoing research and development efforts, by identifying and filling strategic gaps in research and pilot project testing required to improve policies and expand adoption of promising approaches. Specific aspects of emphasis in these efforts have evolved during the last eight years. Implementation of this approach has been an interactive learning process that has evolved through two major phases and is now entering a third phase. Major components of the program, the current status of which is summarized in the following chapters of this report, have included:

1. Assessing costs, benefits and trade-offs of component land use practices.

One of the key weaknesses of pilot efforts to improve land use technologies has been the lack of quantitative data on their impact on either local livelihoods or environmental services (watershed services, biodiversity, climate change), on trade-offs among these factors, or on their prospects for longer-term sustainability. Yet, this information is critical for formulating and justifying changes in forest land policies required for their widespread adoption and sustainability. Thus, the first phase of ASB-Thailand activity focused most of its effort on studies that would 'help fill the cells' of the ASB 'linkages matrix' for component land use practices in north Thailand. Findings from these efforts are presented in chapters II, III and IV of this report.

2. Scaling-up to real-world landscapes.

The second major area of activity is directed toward scaling-up these analyses to the level of landscapes actually found in mountain areas of north Thailand. In addition to combining properties of mosaic pattern components, landscape-level interactions and emergent properties also need to be studied to assess overall impacts of mosaic land use patterns. One study of two villages in the Sam Mun Project, for example, found that while villagers perceive substantial improvement in forest components of their landscape over the last decade, water and wild animals have become more scarce, and they still have questions about their food and economic security in the future.[50]

While very substantial progress was made during the first phase toward assessing overall impacts and trade-offs of alternative agroforestry landscape management strategies, more detailed examination of specific examples is required to convince various parties to current public policy debates.

Thus, building on earlier pioneering work[51], studies in several sub-watersheds of the ASB site with different mosaic patterns were conducted during the second phase of ASB-Thailand research. Nearly 1,400 square kilometers has been mapped in collaboration with members of 53 administrative villages, reflecting both their current actual land use and their own zoning categories and boundaries. How land use patterns have changed during the last 50 years has been verified through aerial photo analyses in more than half of these villages. And in another line of second phase ASB Thailand activity, explorations of nested modeling of landscapes at different levels has begun making major contributions to our ability to understand and articulate how key processes function and interact in the context of complex mountain agroforestry landscapes.

3. Improving technology for local land use planning, watershed networks and local governance.

The third major area of activity has been to develop and test improved technology to support local land use planning, watershed management networks, and associated functions by local institutions and government agencies. Particular emphasis has been placed on: a) articulation of local land use zoning for use in negotiating, and working toward establishing and monitoring localized land use agreements; b) use of simple, widely-acceptable tools that can be used at local levels to measure land use impact on watershed services, and help to resolve local disputes and document local conditions; c) exploration of information systems capable of monitoring compliance and providing transparency and accountability in enforcing land use agreements, as well as helping to monitor the overall status of livelihood development

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[50] *Ibid.*

[51] Ekasingh, M., Shinawatra, B., Onpraphai, T., Promburom, P., Sangchyoswat, C. 1996. 'Role of Spatial Information in Assessing Resources of Highland Communities in Northern Thailand'. p. 402-425. In: CMU. 1996. *Montane Mainland Southeast Asia in Transition.* Chiang Mai University, Chiang Mai, Thailand.

and environmental conditions; and 4) various types of support for local pilot sub-watershed management networks and their linkages with other levels of organization.

4. Providing technical support for scaling up

The fourth major area has been to provide technical support for formulation and implementation of larger-scale pilot activities to test ASB findings beyond the benchmark watershed site, in collaboration with the Royal Forest Department and other implementing organizations. Particular efforts have already begun through collaboration with efforts to develop multi-level river basin management organizations. This work is expected to move to center stage during the emerging third phase of ASB-Thailand activity. We fully anticipate that the knowledge and experience gained through collaboration under ASB-Thailand will make significant contributions to efforts to improve the design, implementation and assessment of appropriate policies and approaches for program and project improvement.

5. International research collaboration and information exchange

The final major area is aimed toward facilitating and supporting meaningful exchange and collaboration with organizations and programs conducting related work in neighboring countries of MMSEA, as well as in other ASB eco-regions around the world. Our vision is to help strengthen Thailand's ability to function as a peer-to-peer node, both contributing to and benefiting from the emerging global web of scientific infrastructure aimed at addressing rural poverty, land use and environmental issues. We have already made considerable progress in forging such linkages with colleagues in the Lao PDR, Vietnam and Yunnan, China, and we expect substantially more progress during the third phase of ASB Thailand activity. In close collaboration with the new Ministry of Natural Resources and Environment, as well as colleagues in the university and NGO communities, and international colleagues at regional and global levels of ASB -Thailand is working to further develop and strengthen specific partnerships and activities to accomplish this goal.

II. Environmental Service Assessments

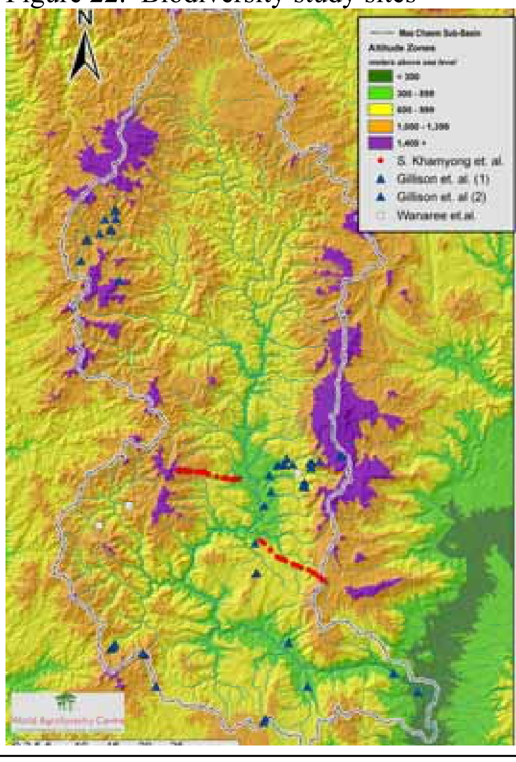
This chapter presents preliminary findings from a range of research activities conducted at nested sites within the Mae Chaem watershed during 1997-2000, some of which have led to continuing follow-up work that is still in progress. These studies have centered on efforts to provide additional primary data and analyses to fill knowledge gaps related to biophysical aspects of policy-relevant issues. Studies have been clustered under four issue areas: 1) implications of land use change for plant biodiversity; 2) agronomic sustainability and child nutrition impacts of change in sequential agroforestry systems; 3)contributions to climate change; and 3) impacts of mosaic land use patterns on watershed functions.

A. Implications of Land Use Change for Plant Biodiversity

While biodiversity is another issue area of global concern, again most studies have focused primarily on various types of species richness in natural forest ecosystems. Four complementary lines of study under the first phase of ASB-Thailand research sought to help expand considerations included under these issues by: 1) using innovative approaches to assess plant biodiversity across a range of land use types found in mosaic landscape patterns, and 2) exploring biodiversity distribution and utilization in agroecosystems of midland tradition mountain ethnic minority communities, and in complex home gardens found in some lowland Thai areas. Funding support was provided by the Asian Development Bank and ASB regional and global sources. Sites of the first three studies are shown in Figure 22, while sites for the fourth study were all in areas of the district town in Mae Chaem.

1. Andy Gillison et. al.: PFA Surveys

Figure 22. Biodiversity study sites



Rapid assessments of plant biodiversity using the plant functional attribute (PFA) methodology were conducted by a team led by Dr. Andy Gillison at 28 sample sites in Mae Chaem selected to represent a range of natural conditions and land use types. Findings have been summarized in an ASB report[52], and they have been combined with those from Indonesia in a paper on environmental context of biodiversity assessment[53], as well as in a paper on relationships between biodiversity and profitability that is still being developed for submission to the *Conservation Ecology* journal.

These assessments have confirmed the applicability of the tool in this region, including similar correlations with species diversity and other components as found in other regions of the world where the method has been tested under the ASB programme. One new component of the method added in Mae Chaem assessments was identification of local uses of plant species by an ethnic Karen key informant who joined the survey team. Various researchers in Thailand have now been trained in the using PFA methods and analysis, including field staff from the Royal Forest Department conducting research at four other sites in northern Thailand.

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[52] Gillison, A.N. and N. Liswanti. 2000. 'Biodiversity and Productivity Assessment for Sustainable Agroforest Ecosystems: Mae Chaem, Northern Thailand Preliminary Report'. Alternatives to Slash and Burn Project: Phase II Above-Ground Biodiversity Assessment Working Group Summary Report 1996-99. Nairobi: ASB Coordination Office, International Centre for Research in Agroforestry

[53] Gillison, A.N. and N. Liswanti. November 1999. 'Assessing Biodiversity at Landscape Level: The importance of environmental context'. Paper prepared for the AGEE volume resulting from the ASB-ICRAF international symposium on environmental services (publication forthcoming).

Although the sample size of initial assessments was still far too small to characterize the wide range of land use variation found in Mae Chaem, findings do indicate a series of increasing plant functional complexity (PFC) along a series of fallows of increasing age and variable origin, towards complex forests and woodlands. These are distinguished along a seasonality/precipitation gradient separating evergreen from deciduous vegetation types. More specifically:

- Intensive vegetable production was in a class of its own, with a PFC value of 58 (7 spp).
- Other agricultural fields, ranging from upland rice in permanent or swidden fields to coffee under forest shade trees had PFC's between 190-250 (30-33 spp).
- A series of forest fallow fields of different ages progressed from a first year PFC of 292 (40 spp), to a third year PFC of 445 (43 spp), to a five year PFC of 498 (64 spp), and a 10 year PFC of 513 (63 spp). Increases in mean basal area and canopy level followed a similar pattern.
- For natural forest, dry deciduous forest sites had PFC values ranging from 287 to 436 (31-50 spp), whereas various types of hill evergreen ranged from 416 to 703 (48-69 spp). The only mixed deciduous forest site in this sample was a heavily logged, fired and grazed area now being allowed to regenerate as community forest (PFC=490, 40 spp).

These findings suggest that while permanent agricultural fields have reduced levels of plant functional complexity and species richness, rotational forest fallows in the hill evergreen zone may approach levels comparable to natural forest after 5 to 10 years of growth, although structural characteristics such as their canopy height and mean basal area are still significantly less than more mature secondary forest.

2. Sunthorn Khamyong et. al. Transects of forest plant communities

A second study[54] specifically focused on forest biodiversity was conducted by Dr. Soontorn Khamyong and his research staff from the Chiang Mai University Department of Forest Resources, who employed PFA assessments at 36 sites along two transects, one along altitudinal gradients on each side of the Mae Chaem valley. In addition, they used plant community analysis for further assessment of forest trees (height <1.5 meters) at 129 plots along the same transects, and studied soil conditions at 16 selected sites.

Data from these assessments allowed the researchers to identify six major types of forest communities: 1) dry dipterocarp; 2) mixed deciduous; 3) pine-dry dipterocarp; 4) pine-dry dipterocarp-hill evergreen; 5) pine-hill evergreen; 6) hill evergreen. Findings also confirmed substantial variability within forest types, associated both with site characteristics and mosaic patterns of various stages of secondary forest regeneration largely related to various forms of shifting cultivation. Rotational shifting cultivation fallows in these areas currently range from 1 to 5 years in duration. Moreover, only relatively small areas of hill evergreen forest remain on the upper slopes and ridges of these sub-catchments. There are indications that hill evergreen areas were once larger, but much of this area is now planted to pine plantations, presumably after it had been cleared and used for highland shifting agriculture.

By applying the modified Shannon-Wiener index to calculate the forest condition index (FCI) for various forest types along each of the two transects, it was found that only lower elevation dry deciduous forests of the western transect were in poor condition (FCI=13). Mixed deciduous forests of both transects (56-63), and much of the pine and hill evergreen forests of the western transect (50-60) are in good condition, whereas remaining forests are in intermediate condition (26-48). No forests along either transect can be classed as in very good condition.

Species richness was found to be highest in the mixed deciduous forest (76-86), followed by hill evergreen forest (62-65), pine forests (37-64) and dry deciduous forest (38-58). In comparison to the Gillison PFA study, these findings help fill the data gap on mixed deciduous forest and suggest that the

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[54] Khamyong, Soontorn, Dusit Seramethakun & Chartchai Naktippawan. 1999. 'Biodiversity Assessment of Natural Forests in the Mae Chaem Watershed, Chiang Mai Province, Thailand'. Unpublished final report submitted to ICRAF-Chiang Mai. Forest Resources Department, Chiang Mai University.

level of species richness Gillison found in 5 to 10 year forest fallows is comparable to more mature hill evergreen forest in good condition. At a broader landscape level, aggregation of data for each of the sub-catchment transects resulted in a total of 180 species in 127 genus and 64 families for the western transect, and 138 species in 93 genus and 50 families for the eastern transect. About 65 percent of species in each transect were trees.

A third field study was also conducted to assess plant biodiversity of a sample of land use types in the Wat Chan area in the far northern portion of the Mae Chaem watershed as a thesis project of an M.Sc. student in the CMU Agricultural Systems Programme. Although basic PFA assessment data from this study has been added to the ICRAF data base, analysis of the wide range of data collected under this study is proving more difficult than originally expected. Findings are expected to be presented in a thesis now due to be completed by late 2001.

3. Wanaree et. al.: Ethnobotany and local forest management

One of the issues commonly raised by those concerned about the potential negative impacts on local communities of shortened rotational forest fallow cycles, and especially of their conversion to fixed field agriculture, is fear that various types of locally important forest products may be lost. The argument is that fallow fields in a rotational shifting cultivation system are important sources of numerous products from plants found at various stages of succession.

In order to gain more insight into the nature of these issues, an ethnobotany study was conducted by an M.Sc. student from the CMU Faculty of Science in two midland villages (one ethnic Karen and one ethnic Lua) where shifting cultivation systems are currently based on a 5-year rotation cycle, as well as in a second Karen village where agriculture is now conducted on fixed fields and remaining fallow areas are being returned to permanent forest. While problems encountered during analysis and writing have also delayed completion of this M.Sc. thesis until late 2001, some preliminary observations are emerging from the field data she has already entered into the ICRAF Chiang Mai database:

(1) **Lua 5-year cycle**. A total of 137 plant species were identified in the forest and upland field areas studied at this village, just over 70 percent of which could be used by local people. Currently cropped swidden fields had 47 species (91% useable), whereas fallow fields had 87 species (76% useable) and village forest areas had 53 species (60 % useable). When one examines which species are unique to particular types of land use, however, it was found that only 8 species (5 useable) were unique to the 5-year fallow, while 24 species (13 useable) were found only in the 3-year fallow.

(2) **Karen 5-year cycle**. A total of 126 plant species were identified in the forest and upland field areas studied at this village, about 67 percent of which could be used by local people. Fallow fields contained 78 species (78% useable), while village forest areas had 93 species (68 % useable). In terms of uniqueness, 4 species (100% useable) were found only in the 5-year fallow, while 10 species (3 useable) were unique to the 3-year fallow.

(3) **Karen fixed fields**. A total of 137 plant species were identified in the forest, fixed upland field and paddy areas studied at this village, about 85 percent of which could be used by local people. Paddy fields contained 38 species (95% useable), upland rice fields 43 species (93% useable), regenerating community forest 44 species (98% useable) and dry deciduous forest 27 species (78% useable).

While confirming the very extensive knowledge that these ethnic communities have regarding utilization of natural plant species, these preliminary findings also suggest that impacts of decreased forest fallows on local forest product availabilities may not be as severe as many have feared. Further analyses are continuing, however, including efforts to further assess the nature of plants and their products that may be available only from fallow fields, or which may be more abundant under those conditions, and the role of these products in local livelihoods.

4. Sittichai et. al.: Biodiversity in home gardens of the lowland Thai

Additional data on biodiversity in complex lowland Thai home gardens was gained from a study of 24 sites, led by Sittichai Ungphakorn of the Royal Forest Department[55].

Findings from these preliminary studies, which are summarized in Figure 23, indicate that:

- Although sample size was still too small to characterize the full range of land use variation found in Mae Chaem, findings do indicate increasing plant functional complexity (PFC) along a series of fallows of increasing age, towards complex forests. These are also distinguished along a seasonality/precipitation gradient separating evergreen from deciduous vegetation.
- Permanent agricultural fields have lower levels of plant functional complexity and species richness. However, rotational forest fallows with 5 to 10 years of growth in hill evergreen zones may approach levels comparable to natural forest, although structural characteristics such as canopy height and basal area are significantly less than more mature forest.
- While confirming the extensive knowledge of these ethnic communities regarding use of natural plant species, findings suggest that impacts of decreased forest fallows on local forest product availability may not be as severe as some have claimed. Further analyses are needed, however, to assess the nature of plants and their products that may be more abundant in fallow fields, and the role of these products in local livelihoods.

Figure 23. Estimates of Plant Biodiversity of Various Land Uses in Mae Chaem

	A Gillison et.al. 28 sites		**S Khamyong** et.al. East Transect		West Transect		**Wanaree** 3 Villages		**Sittichai** 24 sites
	Species	PFC	Species	FCI	Species	FCI	Species	%Useable	Species
Natural Forest									
Hill Evergreen	**48-69**	416-703	**62**	Interm	**65**	Good			
Hill Pine	**39-54**		**37-64**	Interm	**39**	Good	**44-53**	60-98%	
Mixed Deciduous	**40***	490*	**76**	Good	**86**	Good			
Dry Deciduous	**31-50**	287-436	**58**	Interm	**38-45**	Poor	**27**	78%	
Sequential Agroforestry									
-10yr fallow	**63**	513							
- 5yr fallow	**64**	498					**35-42**	86-88%	
-3yr fallow	**43**	445					**40-61**	75%	
-1yr fallow	**40**	292					**30-41**	71-87%	
Simultaneous Agroforestry									
Home Garden									**21-76**
Fruit trees + vegetables									
Coffee/shade AF	**33**	250							
Annual Crops									
Paddy Rice Field	**30**	192					**38**	95%	
Upland Rice field	**33**	249					**43-47**	91-93%	
Maize									
Intensive Vegetables	**7**	58							
Total Landscape			*138*		*180*		*126-137*	*67-85%*	

One further study has taken a still broader approach to local biodiversity and land management in the Wat Chan area of the far northern portion of the Mae Chaem watershed. This doctoral dissertation study conducted by Jim Peters began with a participatory research approach to biodiversity management in Karen communities. Given the nature of this approach, the scope of the research evolved during the two years of field research to include a broad range of issues associated with land use concepts, classifications, and strategies, along with associated livelihoods, social capital, institutions and tenurial arrangements. One portion of preliminary findings has been presented[56], and the full analysis including

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[55] Sithichai Ungphakorn, Pornchai Preechapanya, Siriphusaya Ungphakorn, Nongluk Kaewpoka. 2001. 'Cost and benefit of homegarden systems in lower Mae Chaem watershed'. Unpublished report to ICRAF.

[56] James R. Peters Jr. 2000. 'Trends in land use systems in the Wat Chan area of northern Thailand in the 20th century: development from the inside out'. Paper presented at the International Symposium II on Montane Mainland Southeast Asia (MMSEA): Governance in the Natural and Cultural Landscape, 1-5 July 2000, Chiang Mai. Proceedings available on CD-ROM from ICRAF, Chiang Mai, Thailand.

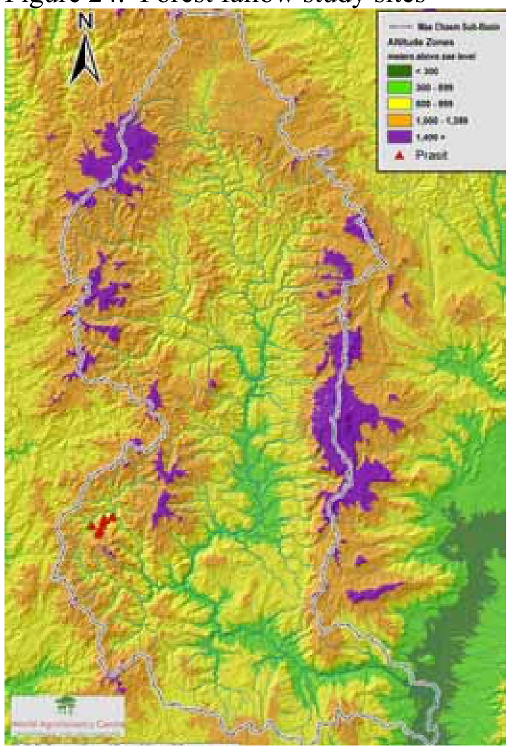
more quantitative biophysical and socio-economic analysis, will be presented in a doctoral dissertation of the University of Wisconsin. Preliminary information includes a summary of how land use practices, patterns and institutional arrangements have evolved in this area since the early 1900's, which is providing many useful insights into how various waves of change have affected Karen land use systems. This is useful since what are considered traditional Karen land use systems have gone through various types of transformations in this area, with some now including high value very intensive production of vegetables and other horticultural products, many in association with the Royal Project Foundation.

B. Agronomic Sustainability of Changes in Sequential Agroforestry

Sequential agroforestry as practiced in rotational forest fallow systems is an extremely important component of livelihoods in many midland minority communities, as well as central subject of much highly contentious debate in the public policy arena. Given its import role in Mae Chaem, additional studies were directed at developing a clearer understanding of the implications of shortened forest fallow rotations on the agronomic sustainability of production by these systems.

Although substantial change in agricultural activities has occurred during the last 20 years, rice remains the single most important component of agriculture in Mae Chaem. At least some area of the watershed have experienced a substantial rice production deficit, largely attributed to the limited area available for paddy establishment in mountainous terrain and the relatively low productivity of upland rice.[57] Given the options available to them, remote ethnic communities such as the Lua and Karen employed and developed traditional rotational forest fallow systems aimed at producing as much upland rice as possible, supplemented with a wide range of additional subsistence foods and products obtained from fallow fields and forests in their mosaic landscapes. Although most evidence indicates that forest fallow rotation cycles were traditionally in excess of 10 years duration, and in a few areas of Mae Chaem examples still exist, various pressures on land use have reduced rotation cycles to about 7 years or less in most areas of the Mae Chaem Watershed, and many government officials are urging further reductions.

Figure 24. Forest fallow study sites



In order to further investigate the implications of shortened forest fallow cycles for the agronomic sustainability of these systems, an intensive study was conducted by Prasit Wangpakapattanawong in an ethnic Karen village employing a 6-year rotation cycle but using otherwise traditional practices (Figure 24). An initial hypothesis underlying selection of this site was that a forest fallow shifting cultivation system operating under these conditions should be under considerable stress, and may not be agronomically sustainable over the longer term. Major research findings have recently been presented in a doctoral dissertation of the University of British Columbia[58] and various publications.

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[57] The Mae Chaem district office reports average rice yields in the area as 3.5 tons/hectare for paddy rice and 1.9 tons/hectare for upland rice, which were very close to average findings of ASB-ICRAF PAM studies in 12 villages: 3.7 tons/hectare for paddy and 1.9 tons/hectare for upland rice. *(see section on economics)*

[58] Wangpakapattanawong, Prasit. 2001. 'Ecological Studies of Reduced Forest Fallow Shifting Cultivation of Karen People in Mae Chaem Watershed, Northern Thailand, and Implications for Sustainability'. Doctoral Dissertation. Department of Forest Sciences, University of British Columbia.

Various researchers and analysts have suggested that forest fallows can assist with one or more of six major ecological functions related to agronomic sustainability: 1) Replenishment of nutrients without outside inputs; 2) Maintenance of soil structure; 3) Minimizing soil erosion in comparison to continuous cropping; 4) Providing useful plants and animals for consumption and medicinal purposes; 5) Control of weeds; 6) Control of crop pests and disease. While this research focused primarily on the first of these functions, some evidence was also obtained regarding other functions. Some of the major conclusions of this research include:

(1) ***Nutrients***. Detailed research findings on nutrient cycling indicated that at least the stress associated with nutrients in shortened fallow periods may not be as great as some researchers have been assuming. Indeed, it appears that the 5-year fallow is sufficient to maintain major soil fertility factors, resulting in fairly low (one ton ha^{-1}) but sustainable upland rice yields with no fertilizer or chemical inputs. During the five years of fallow there was an increase in soil organic matter and total N from the litterfall of fallow species, along with a decline in pH, available P, and extractable K, Ca and Mg due to nutrient uptake by fallow vegetation and decline in the effect of burning. The largest change in soil conditions was when the 5-year fallow was slashed, burned and cropped. Fertilizer trials of the regular 1st year and an experimental 2nd year upland rice crop showed N was the most limiting nutrient in upland rice productivity. Villagers believed 2 to 3 years would be the absolute minimum fallow period, and data indicate that this would likely be associated with increased weed competition and reduced ash from burning.

(2) ***Soil Structure***. Similarly, soil structure appears to be reasonably well maintained under this six-year cycle, with surface soil bulk density in forest fallow fields (about 1.0 gm cm^{-3}) comparing very favorably with those in nearby secondary forest. These findings agree with those from carbon stock assessments, which indicate that although the lowest extremes of soil bulk density are found at sites with fertile hill evergreen forest, bulk density values under forest fallows of 5 or more years of age are comparable to most forest sites, and considerably better than those under dry deciduous forest or fixed agricultural fields. Although Dr. Soonthorn (see biodiversity section) found a bulk density as high as 1.36 gm cm^{-3} in one of his 3 samples of a 5-year fallow field, data from other ASB-ICRAF studies indicate this value is unusually high, since only dry dipterocarp forest or permanent agricultural fields exceeded 1.30 gm cm^{-3}. His additional data on mixed deciduous forest indicate that bulk densities at good sites can also be as low as 0.8, although the average value of his sites would be above 1.0 gm cm^{-3}.

(3) ***Soil Erosion.*** Although no direct measures of soil erosion were made, inspection of shifting cultivation fields indicated only slight to moderate erosion. This, together with the short period of bare soil exposure during a season with low probability of heavy rainfall, and soil bulk density values comparable to nearby forest, were taken to suggest relatively low potential of soil erosion in the forest fallow fields.

(4) ***Useful Plants***. During interviews, farmers cited many plant species as useful for food, medicines or remedial substances. These plants can be found both in the fallow fields and in nearby forest areas. Preliminary analysis of data from the separate ethnobotany study conducted in this village (see biodiversity section) confirm these findings with 61 of 85 total identified useable species found in fallow fields. However, less than 20 useable species were found only in fallow fields; others were also found in the forest or currently cropped fields. Further research will investigate the nature and role of plants found only in fallow fields, as well as the nutritional role of naturally-occurring plants generally.

(5) ***Weeds***. With regard to weed suppression, the fallows at this site were initially dominated by *chromolaena odorata*, which is usually shaded out by other species by the end of the second year. Villagers see *chromolaena* as a desirable species due to its ability to grow fast, shade out grasses and more noxious weeds, produce high biomass (7.1 tons ha^{-1} in the 1st year) and decay rapidly. Indeed, researchers in some areas of Southeast Asia consider this a species for fallow 'improvement'. Although the dominance of *chromolaena* appears to have helped reduce problems associated with grass weed species that are common in many other areas of Mae Chaem, villagers still note that they have increased weeding frequency in their upland rice fields from two to three times per year after their fallow cycle shortened to six years.

(6) ***Crop pests and disease***. Investigation of these complex issues was not an objective of this research. However, an experimental second-year planting of rice in a shifting cultivation field was attacked by soil pathogens resulting in root and lower stem damage, and subsequently much lower total biomass than regular first-year rice, and almost no grain. This provides at least minor support for the role of fallows as an insect/disease break as suggested by some researchers elsewhere, and further direct investigations may be warranted. This may also be related to observations elsewhere in Mae Chaem where upland rice is cultivated on permanent agricultural fields, that even with chemical inputs a minimum crop rotation every third year to a crop like soybeans is necessary to prevent yield decline in upland rice.

C. Contributions to Climate Change

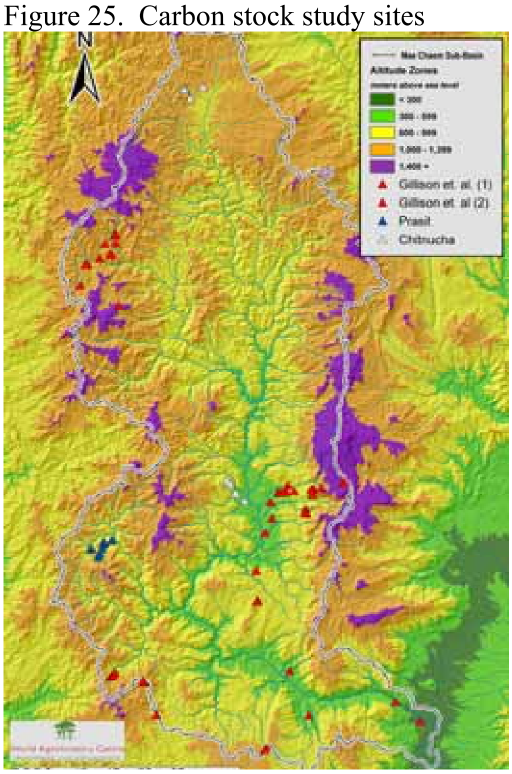
The contributions of changing land use patterns to global climate change are indicated by the manner in which they affect carbon sinks and GHG emissions. The relevance of this area of research relates to international efforts to implement 'carbon off-sets' under the Clean Development Mechanism (CDM). While the Office of Environmental Programs and Policy of Thailand's Ministry of Science, Technology and Environment is urging the government to use extreme caution before entering into any of these types of agreements, various other government units are urging their consideration.

Studies and projects related to carbon stocks are generally focused primarily on the capacity of natural forest ecosystems to sequester carbon in their standing biomass. In order to help broaden the range of issues considered in these policy debates, ASB-Thailand studies have made preliminary assessments of both carbon stocks and methane dynamics in various types of forest, as well as in a range of other types of land use found in the Mae Chaem watershed. We hope these types of studies can serve as prototypes for efforts to make a more systematic assessment of climate change issues in the context of the types of mosaic land use patterns found in northern Thailand and MMSEA.

1. Carbon Stocks

A study of carbon stock levels of various components of land use mosaic patterns in the Mae Chaem watershed was conducted during 1999-2000, and results are presented in a report that is currently being finalized under the leadership of researchers at the Chiang Mai University Faculty of Agriculture.[59] The study was based rapid assessments using standard ASB methods at thirty-five sites, including 9 sites of the methane dynamics study (below), 25 sites of the biodiversity survey conducted by Andy Gillison et.al., 4 sites under a study on agronomic sustainability, and 3 additional sites (Figure 25). In order to facilitate comparison with other land use types, time-averaged values were calculated for forest fallow rotational systems. Basic findings were:

Figure 25. Carbon stock study sites



(1) ***Natural Forest***. Since it is very difficult to locate areas of 'pristine' forest in Northern Thailand, 6 different sites of hill evergreen forest were assessed, resulting in an average total carbon stock value of 212 tons C ha^{-1}, 44 percent of which was stored below-ground. An indicator of the upper end of total carbon storage in Mae Chaem is the 375 tons

[59] K. Pibool, I. Kengnong, D. Muloi, P. Saipotong, and A. Jintrawet. 2001. 'C-Stock of Various Land Uses in Mae Chaem Watershed'. Unpublished report submitted to ICRAF Chiang Mai.

ha^{-1} (33% below-ground) maximum value found in sampled hill evergreen sites. Total carbon storage in other types of natural forest were more modest, and also subject to considerable variation. Pine forest averaged 152 tons ha^{-1} (48% below-ground), while dry deciduous forest averaged 120 tons ha^{-1} (50% below-ground).

(2) ***Sequential Agroforestry***. Rotational forest fallow shifting cultivation systems had time-averaged total carbon stock levels of 158 tons C ha^{-1} (68% below-ground) under a 10-year rotation, 76 tons ha^{-1} (79% below-ground) under a 6-year rotation, and 51 tons ha^{-1} (94% below-ground) under a 3-year rotation. These data assume relatively complete clearing of trees during the slash-and-burn event. Since there are also some systems where various numbers of large trees are left in the swidden field (often after pruning), carbon stored in those trees would need to be added to the data presented here. For example, one observation during this study indicates these trees could add another 38 tons ha^{-1} of above-ground carbon to a 6-year rotation system, increasing the total of that system to 114 tons ha^{-1} (52% below-ground).

(3) ***Simultaneous Agroforestry***. Permanent field agroforestry systems had total carbon stocks ranging from 179 C tons ha^{-1} (71% below-ground) for coffee under forest shade trees, to 157 tons ha^{-1} (97% below-ground) for small sparsely-planted fruit trees undercropped with intensive vegetables.

(4) ***Annual Cropping***. Annual agricultural crop sites ranged from 25 tons C ha^{-1} (91% below-ground) for a permanent upland rice field, to 82 tons ha^{-1} (>99% below-ground) for intensive vegetables, and 99 tons ha^{-1} (93% below-ground) for maize.

Figure 26. Estimated Carbon Storage of Various Land Use Types in Mae Chaem

	Above-Ground Carbon					Soil	Total	Above	surface
	green	litter	tree	dead	Sub-tot	0-30 cm	Carbon	Share	Soil BD
	-- tons hectare^{-1} --							% total	gm cm^{-1}
Natural Forest									
Hill E-G (max)	1.7	6.1	190.9	54.0	252.7	122.4	375.1	67	0.97
Hill E-G (ave)	1.5	3.6	88.2	25.2	118.4	93.7	212.1	56	0.93
Hill Pine	1.3	2.9	69.3	5.3	78.7	73.0	151.7	52	1.08
Dry Deciduous	1.3	1.3	49.0	8.3	59.9	59.9	119.7	50	1.27
Sequential Agroforestry (rotational forest fallow)									
-10yr cycle (time ave)	3.3	3.8	31.0	12.8	51.0	107.4	158.4	32	1.18
-6yr cycle (time ave)	2.7	2.6	10.8	-	16.1	60.1	76.2	21	1.02
-3yr cycle (time ave)	1.9	1.1	-	-	3.0	47.8	50.7	6	1.22
Simultaneous Agroforestry									
Fruit trees + vegetables	1.2	1.0	2.4	-	4.6	152.9	157.5	3	1.19
Coffee/shade AF	0.6	1.7	25.2	23.8	51.4	127.4	178.7	29	1.12
Annual Crops									
Upland Rice field	1.7	0.6	-	-	2.3	22.4	24.7	9	1.33
Maize	6.4	0.3	-	-	6.7	92.0	98.7	7	1.40
Veg	0.2	0.1	-	-	0.3	82.1	82.5	0	1.43

Major implications of these finding include:

- Maximum carbon storage is found in hill evergreen forest generally, and especially in relatively vigorous and undisturbed stands. Forest type estimates in Mae Chaem indicate hill evergreen forest covers a maximum of 30 percent of the total area, with substantial variation in forest conditions. Other pine and dry deciduous forest types appear to store substantially less total carbon, but retain roughly similar partitioning between above and below-ground storage.
- Both a 10-year rotational forest fallow and coffee under forest shade trees appear able to maintain total carbon stock levels roughly comparable to much of the natural forest found in Mae Chaem, including a similar level of partitioning between above and below-ground carbon storage. Data from one site suggest that for systems that maintain some large trees during the cropping phase, rotations could be shortened to 6 years without changing these relative properties of the system.

- As forest fallow rotations are shortened to a 6-year cycle (with full clearing), time-averaged total carbon still remains comparable to pine and dry deciduous forest conditions, but a greater relative proportion of carbon stocks are found below ground. This at least raises the question as to whether the longer-term trend of these systems would be toward a decrease in below-ground carbon. For example, if below-ground carbon were to gradually drop from 80 to 70 percent of total carbon, while above-ground carbon remained constant, total carbon storage would drop to 70 tons ha^{-1}, or about 50 percent of that found in deciduous forest, pine forest or 10-year forest fallow systems.
- Once forest fallow rotations are shortened to a 3-year cycle, time-averaged carbon stocks begin to appear more similar to those found on permanent agricultural lands. In all these systems more than 90 percent of carbon is stored below ground. Lowest carbon stocks are associated with subsistence upland rice production on permanent fields or under a 3-year forest fallow. Higher levels were associated with maize, intensive vegetables and intensive vegetables with fruit trees. In the case of maize, relatively high below-ground carbon storage again raises questions about longer-term trends in below-ground carbon storage. Systems involving intensive vegetable production, on the other hand, are associated with relatively large applications of manure and sometimes mulch, resulting in a carbon import that may help maintain the relatively high levels of below-ground carbon storage found at these sites.

Another finding important for linking this data to other issues is that of the various components of carbon storage, soil bulk density correlates most closely with carbon stored in the litter layer. Three clusters of data indicate:

(1) Highest average levels of carbon in litter (>2.5 tons ha^{-1}) and lowest average soil bulk densities (0.8 – 1.1 gm cm^{-3}) were found in hill evergreen forest, pine forest, and both 10 and 6-year forest fallow shifting cultivation systems. Fertile hill evergreen forest has the extreme values in this category.

(2) Intermediate levels of litter carbon (1-2 tons ha^{-1}) and soil bulk density (1.1 – 1.2 gm cm^{-3}) were found in dry deciduous forest, 3-year forest fallow systems, fruit tree/vegetable agroforestry, and coffee under forest shade.

(3) Lowest levels of litter carbon (<0.6 tons ha^{-1}) and highest soil bulk densities (>1.33 gm cm^{-3}) were found in permanent fields producing upland rice, maize and vegetables.

The significance of these findings relates to associations of low soil bulk densities both with higher rates of methane uptake, and with higher rates of water infiltration. Thus, our findings indicate the 6 to 10 year forest fallow shifting cultivation systems would be expected to have relatively little impact on methane uptake and water infiltration compared to natural forest conditions. Very short cycle (3-year) forest fallow systems and permanent field agroforestry would be expected to have some impact on these processes, but significantly less impact than fields continuously planted to annual crops only.

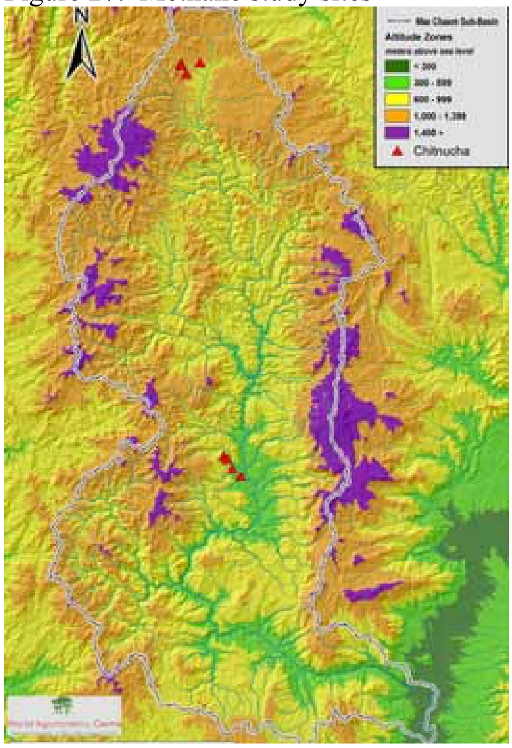
At the broader agroforestry landscape level, shorter forest fallow cycles in the midland zone are resulting in lower overall carbon stock levels than those formerly found in traditional long-fallow systems. In some areas working with the Suan Pah Sirikit and Care-Thailand projects, however, various locally-selected parcels of forest fallow and degraded forest are being returned to permanent forest cover. This process could result in a net increase of carbon stock in the locally-managed landscape, especially to the extent that these parcels can return to mature fertile hill evergreen forest.

The next step in these efforts will be to make landscape-level estimates of carbon storage in different types of mosaic patterns. We are currently in the process of refining our ability to identify and delimit spatial boundaries for various of these types of land use in our GIS. Once these efforts are concluded, we will begin construction of these types of aggregated estimates.

2. Methane Dynamics

Study of methane dynamics associated with various components of land use mosaic patterns in the Mae Chaem watershed were conducted by Chitnucha Buddhaboon, under the guidance of Dr. Attachai Jintrawet, and presented in a M.Sc. thesis under the CMU Agricultural Systems Programme.[60] Part of the findings based on replicated monthly measurements at 12 land use sites (Figure 27) are summarized in Figure 28. Some of the tentative conclusions from this exploratory study include:

Figure 27. Methane study sites



(1) Rates of methane uptake by aerobic upland land uses are more closely associated with soil bulk density than with vegetation type per se, with uptake rates ranging from 1.4 gm CH_4 ha^{-1} day^{-1}on relatively compacted soil (1.40 gm cm^{-3}) to a maximum 5.2 gm CH_4 ha^{-1} day^{-1} on less compacted soils (0.78 to 0.85 gm cm^{-3}) under regenerating forest fallows located on gentle slopes where substantial litter is accumulated and fires are controlled. The most commonly-encountered bulk densities are in the range of 1.0 to 2.5 gm cm^{-3}, and are associated with uptake rates of about 2.5 gm CH_4 ha^{-1} day^{-1}. Thus, we can expect methane uptake to be facilitated by any land use that maintains low soil bulk density.

Figure 28. Preliminary Estimates of the Net Methane Flux in the Mae Chaem Watershed

		Estimated Area		Absorption Rate	Duration	Annual Absorption
		hectares	% area	gm ha-1 day-1	Days	tons year-1
Natural Forest	Hill evergreen	108,605	32.5	2.09	365	82.8
	Hill pine	38,313	11.4	1.61	365	22.5
	Deciduous	154,834	46.3	2.36	365	133.4
Forest fallow fields		11,428	3.4	5.17	365	21.6
Upland fields	fixed field/cabb	6,040	1.8	2.40	365	5.3
	non-cabb swidden	7,996	2.4	2.40	365	7.0
Paddy Rice	flooded	5,818	1.7	(689.2)	195	(781.9)
	non-flooded	5,818		1.44	170	1.4
Other		1,597	0.5	n.a.	n.a.	-
	Total Watershed:	334,631	100.0			(507.9)

Source: Adapted from Chitnucha Buddhaboon (2000) with area estimates from DLD/CMU-MCC

(2) Rates of methane uptake by high altitude forest appear to be somewhat lower than expected from associated soil bulk densities, which is possibly due to lower temperatures at these sites.

(3) Rates of methane emission from flooded paddy fields, which averaged 690 gm CH_4 ha^{-1} day^{-1}, were many times greater than methane uptake rates at any site.

Thus, while factors that influence surface soil bulk density can alter methane absorption rates, it is really the relative area and duration of paddy flooding that most strongly influences the net methane flux at

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[60] Buddhaboon, Chitnucha. September 2000. Methane Emission from Various Land Use Types in Mae Chaem Watershed'. Thesis for Master of Science (Agriculture) in Agricultural Systems. Graduate School, Chiang Mai University, Chiang Mai, Thailand.

broader landscape levels. For example, although paddy covers less than 2 percent of the Mae Chaem watershed, only 35 percent of the methane emissions associated with continuous flooding during the rainy season crop are taken up by the remaining 98 percent of the landscape. These preliminary findings indicate that one hectare of single-cropped paddy rice would require nearly 170 hectares of the types of upland land uses found in Mae Chaem to fully compensate for the paddy emissions.

Given the rapid cessation of methane emissions once paddy land is returned to non-flooded aerobic conditions, these findings are sparking additional interest in the approach to paddy rice production using multiple short periods of flooding under study by Chinese researchers, the International Rice Research Institute and others. If, for example, these practices could reduce the total annual period of flooding by 50 percent, without reducing rice yields, one effect of their use in Mae Chaem paddy lands (1.7% of the total area), would be to reduce net methane emissions of the watershed by 77 percent.

For comparison sake, if improved fire control and forest management were able to double methane uptake rates of natural forest, by effectively reducing surface soil bulk densities, throughout the entire 90 percent of the watershed occupied by various types of natural forest, the overall effect would be to reduce the net methane emissions of the watershed by only 47 percent.

D. Impacts of Mosaic Land Use Patterns on Watershed Functions

This is an issue area of major concern for public policy, both in northern Thailand and across the MMSEA eco-region. Rather than seeking to repeat the standard types of plot-level run-off and erosion studies usually conducted by watershed researchers, ASB-Thailand sought during its first phase of studies to strengthen work in two areas: 1) exploration of potential tools that local communities could use to monitor impacts on watershed functions for themselves, and 2) some more closely structured studies of impacts of mosaic patterns on stream flow.

1. Tools for community-based watershed monitoring

One of the major issues featured in growing debate and conflict of natural resource management in northern Thailand is the perceived impact of changing land use practices and patterns in highland and midland zones on the volume, timing and quality of water in streams flowing to downstream areas. Core arguments of this debate include:

- Advocates of 'downstream' views go as far as calling for forced relocation of all ethnic minority communities from mountain watersheds, so that they can be returned to forest. Growing populations and changing agricultural practices in upper watersheds are claimed to be devastating watershed functions, including increased downstream flooding and heavy sedimentation during the rainy season, drought during the dry season, and water pollution from toxic agricultural chemicals used in highland cash crop production. Loss of forest biodiversity is also now invoked as an associated impact.
- Advocates of 'upstream' views go as far as denying major impacts on these watershed functions, and suggesting downstream water problems are really due to expansion and intensification of downstream land use patterns. Downstream people do not understand minority agroecosystems and practices, and downstream arguments are seen as a cover for state-sponsored expropriation of local community lands in upper watersheds. They counter some of the ethnic overtones of downstream arguments with accusations of ethnocentrism, or even ethnic cleansing of upland forests.

During the first phase of our studies, some of the numerous impassioned presentations and articles advocating one side or the other have been featured in national media, international events and global-level media, and major confrontations have occurred in 'hot spots' such as the Chom Thong area just across the eastern ridge of the Mae Chaem watershed. Awareness of these issues and associated tensions are widespread and continuing to increase in most upper tributary watersheds of northern Thailand.

One rather striking feature of most all major debates and confrontations has been the absence of any systematic efforts to collect and analyze empirical data that could help characterize and more clearly assess the presence and degree of impacts of changing land use practices and patterns on key watershed functions. While there is a modest body of research on soil erosion and some hydrological properties of particular land uses, the net impact of the types of complex mosaic land use patterns found in most areas has generally remained unaddressed. Moreover, pollution from toxic agricultural chemicals is particularly difficult given their invisibility, the range of chemicals used, and the complexity of standard methods used to directly detect and measure their presence at the often very low concentrations at which they may be chemically active. Given the high cost of efforts to conduct systematic analysis of the complex conditions and patterns found in the region using standard scientific approaches employed by most research institutions or government line agencies – especially during the current economic downturn – ASB Thailand researchers decided to explore alternative approaches to bringing more science-based tools to bear on these issues.

Community-based monitoring.

While concerns and tensions are generally rising, in most local areas outside of these 'hot spots' – including various sub-catchments in Mae Chaem – local downstream feelings are still at the level of concern, apprehension or fear. Moreover, the general priority of these concerns are first with chemical pollution, followed by post-rainy season stream flow and heavy sedimentation of downstream water resources and irrigation infrastructure.

Thus, our first effort during 1998-99 was to explore the possible use of biological indicators of water quality that could be used by trained villagers to measure water quality in a manner that would produce results that would be credible beyond their own village area. Considerable preliminary work on the use of aquatic insects was already being conducted by researchers at various faculties of science in Thailand and the Green World Foundation, a Thai environmental NGO, much of it building on principles and techniques developed in the U.K. for use in water monitoring there. Other promising indicators under investigation also included macroalgae, diatoms, riparian plants and animals, etc.

Under collaborative studies led by Dr. Pornchai Preechapanya of the Royal Forest Department and Dr. Yuwadee Peerapornpisal of the CMU Faculty of Science, use of aquatic insects, macroalgae and diatoms as biological indicators of water quality were tested in streams at selected points in Mae Chaem to determine their reliability under local conditions and estimate the feasibility of their use by trained local villagers. While the reliability of all three types of indicators were confirmed under Mae Chaem conditions through comparison with standard physical and chemical analyses, aquatic insects were found to be the most feasible type of indicator for use by local villagers. Results of assessments using macroalgae and diatoms has been presented internationally[61], and a simplified handbook was developed for use of aquatic insect indicator.[62]

Application of the aquatic insect methodology is based on the differential sensitivities of various species to different types and levels of water pollutants. Use of a standardized approach to identifying the presence or absence of a range of selected species with different sensitivities that have already been characterized through scientific study, allows water at a given location to be placed into one of five categories of water quality. A simple hand lens, pan, fish net and identification key are the only tools needed, and most key insects have names in local dialects, indicating an already existing degree of familiarity.

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[61] Yuwadee Peerapornpisal, Pornchai Preechapanya, PhitsanuWanathong, and Sakorn Promkutkaew. 2000. 'Use of macroalgae and benthic diatom for water quality assessing in Mae Chaem stream, Chiang Mai, Thailand'. Paper presented at The 4th Asia-Pacific Conference on Algal Biotechnology, 3-6 July 2000, Hong Kong Convention and Exhibition Centre.

[62] Promkutkaew, Sakorn & Phitsanu Wanathong. 2000. *Khumue truatkhunaphaabnam yangngaingai doaytaneng* [Handbook for easy assessment of water quality by yourself]. Project for study of water quality in the Mae Chaem Valley, Chiang Mai Province. ICRAF-Chiang Mai. [in Thai][photocopied]

In order to more fully test use of this method under local conditions, a trial study was conducted during 2000 at 3 villages in each of 2 sub-catchments. Each sub-catchment trial included a lowland Thai village, a midland subsistence-oriented Karen village and a highland Hmong village cultivating intensive cash crops. In cooperation with local leaders, individuals were selected and trained to monitor rainfall, stream flow, water turbidity, and water quality using aquatic insect indicators. Although these efforts were moderately successful, it also became clear that individual and village-level effort to conduct such monitoring would probably not be very sustainable over the longer term. More effective establishment and management of a local monitoring system would need a clear endorsement and active support by local institutions that included all villages within a local sub-catchment. Thus, expanded and much more systematic efforts to test these methods were conducted during ASB phase 2 in collaboration with pilot multi-village sub-watershed management networks, as described below in chapter VI.

Meanwhile, the Green World Foundation has recently published a series of commercially-available Thai language handbooks packaged under the title, '*Khumue Naksueb sainam samrap kansamroatlaedulae lamnam'* [Stream Investigator Handbooks for surveying and looking after streams]. Very professionally published separate volumes in this series are for stream investigators, stream investigator leaders, and indicator methods for fish, riparian animals, and small freshwater aquatic animals. A kit is now available for less than US$7.00 that includes all volumes, a hand lens, a water resistant key for identifying and classifying insects, and a key for estimating water turbidity, all packaged in a plastic pouch. Particular effort is being made to distribute these materials for use in schools and youth nature camps.

Local Knowledge.

A second component of the study led by Dr. Pornchai Preechapanya involved preliminary study of indigenous ecological knowledge related to watershed management and the underlying interactions of biotic with non-biotic components. Particular focus was on how plants and animals are related to microclimate and processes of water cycling and soil erosion. The study sought to employ techniques for eliciting, recording and accessing indigenous knowledge being developed and refined by a research group led by Dr. Fergus Sinclair of the University of Wales, Bangor, including use of their WinAKT software. Initial findings were submitted[63] and some components were incorporated into a Thai-language publication on folk knowledge about agroforestry systems in mountain watershed areas.[64], which includes discussion of rotational forest fallow agroforestry, 'jungle' tea agroforests, forest livestock raising, and home gardens. Subsequent work under this line of research also contributed to ASB-Thailand phase 2 activities discussed in chapter VI, below. In addition Dr. Pornchai is very actively engaged in efforts to build a network of Thai researchers interested in these topics and tools.

2. Impact of mosaic patterns of land-use on watershed functions

A complementary line of potentially longer-term research was also launched during ASB phase 1 under the leadership of the head of the Royal Forest Department's Watershed Research Group, Mr. Warin Jirasuktaveekul. One of Thailand's leading watershed scientists, Dr. Nippon Tongtham of the Kasetsart University Faculty of Forestry, also serves as an advisor. This study sought to use more standard 'scientific' techniques to begin assessing the relative differences among small sub-catchments with different mosaic patterns of land use. It was also hoped that this data – with which forest hydrologists are much more 'comfortable' – could be used for comparison with more traditional watershed research approaches using small single land use catchments, as well as a cross-check on findings that were anticipated from participatory watershed monitoring activities. They could also serve as sites for developing and testing rapid and/or simple tools for assessing impacts on watershed services.

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[63] Preechapanya, Pornchai, Warin Jirasuktaveekul, David E. Thomas & Nippon Tangtham. 2001. 'Watershed management by communities in northern Thailand'. Unpublished preliminary paper. RFD-ICRAF Chiang Mai.

[64] Preechapanya, Pornchai. 2001. *Phu mi panyaphuenbaan kieokap rabobniwatekaset bon laengtonnamlamthan nai phaknua* [Folk Knowledge about Agroforestry Ecosystems in Watershed Areas of Northern Thailand]. Chiang Mai, Thailand: ICRAF and the Royal Forest Department of Thailand. 127 pp. [in Thai]

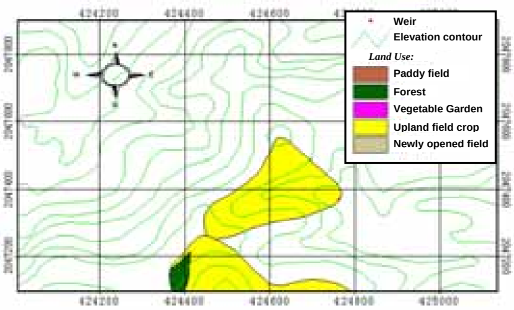
Sites were selected in an effort to start filling gaps in empirical data and our current understanding related to impacts of mosaic land use patterns on environmental services provided by upper tributary agroforestry landscapes. As part of our initial efforts to address this knowledge gap, a set of four small catchments (average area of 0.1 km^2) in Mae Chaem were selected for monitoring using more fully 'scientific' methods than have been used in the community-based watershed monitoring activities described above. The catchments each had a different mix of land use, and are located along an altitudinal gradient up the western slope of the sub-basin to the west of the district town. Catchments represented a small set of mixed of land use patterns:

(1) Highland mosaic dominated by intensive vegetable production
(2) Highland short forest fallow shifting cultivation with cattle grazing
(3) Highland rotational agriculture including upland rice, cabbage and native grass
(4) Midland dry dipterocarp forest

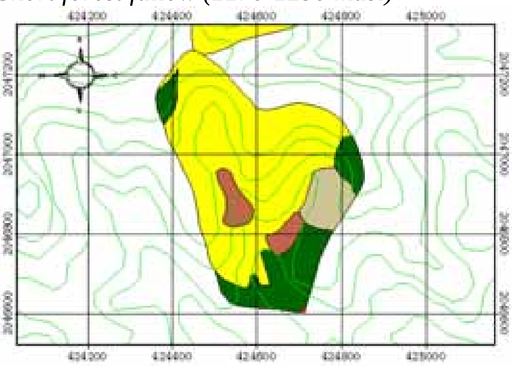
Basic characteristics of the four sites are shown in Figure 29.

Figure 29. Measured sub-catchments

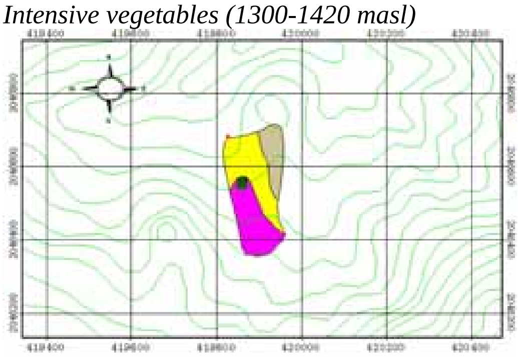
Upland crop rotation (1230-1290 masl)



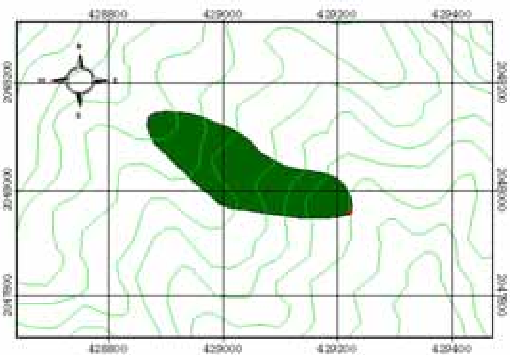
Short forest fallow (1170-1290 masl)



Intensive vegetables (1300-1420 masl)



Dry dipterocarp forest (740-1030 masl)



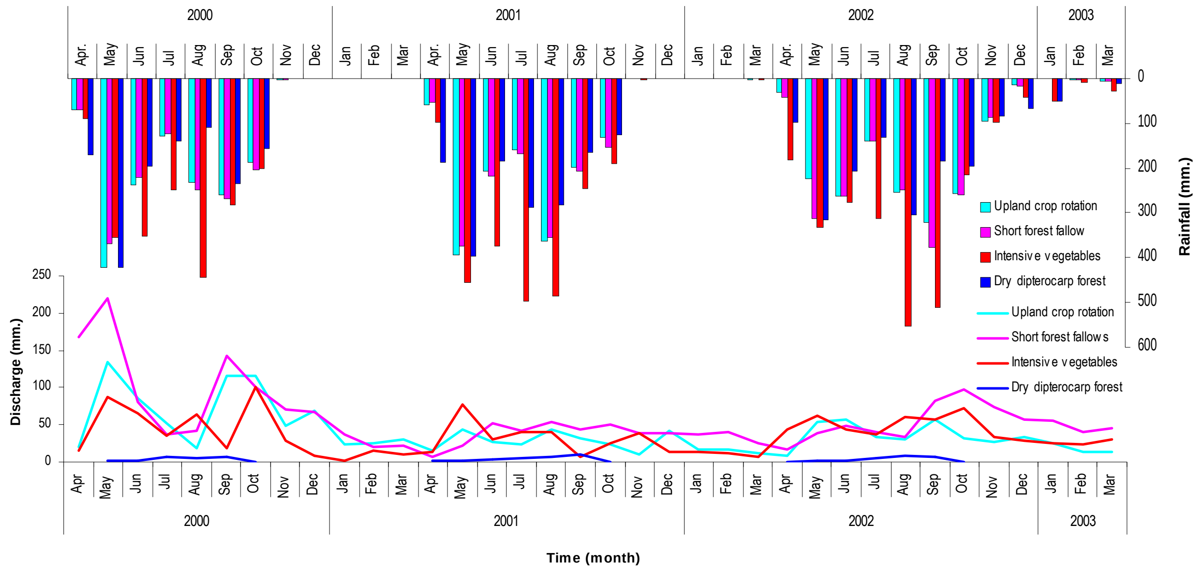
Each of these small sub-catchments was instrumented: 1) with a weir and water level recorder to measure stream flow discharge at the outlet, 2) with data loggers recording rainfall, temperature and relative humidity, and 3) with gypsum blocks to measure soil moisture. Data were collected for a three-year period beginning April 2000. Basic findings are summarized in Figure 61, and detailed in a Thai language report to ICRAF.[65] In order to compare these conditions with the effects of relatively mature hill evergreen forest, comparable climatic and stream discharge data was obtained during the first year from an additional site outside Mae Chaem that is part of longer-term monitoring efforts by the Royal Forest Department at Doi Pui National Park in Chiang Mai.

This approach was basically a reflection of the relatively standard approach to this type of research used in government agencies, but in catchments where land use has more of a mosaic composition than in the types of single land use contexts that are usually sought out for this type of research. The idea was that results might reflect some intermediate type of impacts on stream flow, or perhaps some relatively unexpected types of outcomes relative to what is generally claimed by watershed management officials.

Although three years of measurements at these few sites are not sufficient to be scientifically conclusive, patterns in the data together with previously existing literature, allow us to venture some reasonable preliminary inferences about impacts of land use on:

[65] โสฬัฐ นที, พรชัย ปรีชาปัญญา, David Thomas. 2003. สมดุลน้ำจากการใช้ประโยชน์ที่ดินบริเวณลุ่มน้ำแม่แจ่มตอนล่าง เชียงใหม่. ศูนย์วิจัยวนเกษตรนานาชาติ

Figure 30. Rainfall & stream flow in small catchments, 2000-2003



Stream Flow 2000 - 2003 (mm)												
Land use	Dry dipterocarp forest			Short forest fallow			Upland crop rotation			Intensive vegetables		
altitude	740 - 1,030			1,170 - 1,290			1,230 - 1,290			1,300 - 1,420		
month/year	2000-1	2001-2	2002-3	2000-1	2001-2	2002-3	2000-1	2001-2	2002-3	2000-1	2001-2	2002-3
Apr.		1	1	168	7	16	21	15	8	15	14	44
May	2	2	1	220	22	38	135	44	53	88	77	61
Jun	2	2	2	81	51	49	85	27	57	65	30	44
Jul	7	3	4	37	42	41	52	24	34	34	40	37
Aug	5	4	8	42	54	34	18	44	31	63	41	61
Sep	6	2	6	143	44	82	116	32	57	19	7	57
Oct	0.1	0.1	1	100	51	97	116	24	32	101	24	72
Nov				70	39	73	49	11	27	29	38	34
Dec				68	38	58	69	42	33	9	14	28
Jan				37	38	55	24	16	26	2	13	26
Feb				19	40	40	25	17	14	15	11	23
Mar				22	25	46	30	12	14	10	7	31
Total	22	12	24	1,006	452	630	739	308	385	450	314	518
Average	2	1	2	84	38	53	62	26	32	37	26	43
% of rainfall	2%	1%	1%	67%	30%	36%	48%	20%	24%	23%	13%	20%
Rainfall	1429.8	1629.0	1643.0	1503.5	1526.0	1752.5	1539.2	1512.5	1602.0	1967.6	2342.5	2604.0

(1) ***Fluctuations in stream discharge***. These findings indicate a progression of change in stream discharge patterns from a buffered and smoothed pattern in mature hill evergreen forest (data not shown in Figure 30), through increasing levels of intra-season variability as agricultural activities intensify and become more dominant. There also appears to be a direct relationship between the degree of buffering and relative levels of dry season stream discharge. One would logically expect a longer-cycle forest fallow system to confirm this pattern with a stream discharge curve that resembles even more closely the mature hill evergreen forest.

(2) ***Total quantities of stream discharge***. These findings indicate very substantial variation in total quantities of stream discharge, which appear to be linked with high rates of water loss through evapotranspiration. From data at these sites, evapotranspiration rates appear highest – and total stream discharge lowest -- in dry dipterocarp forest during the growing season, followed by the

intensive vegetable mosaic pattern (where watering and sprinkler irrigation occur), and by the pine plantation with young secondary hill evergreen forests. Low total quantities of stream discharge are also associated with early seasonal cessation of stream flow.

The rather inconclusive results did at least help raise enough questions that it became clear that this type of approach was inadequate to deal with the complex issues and questions we need to address in such work. This helped give rise to the subsequent modeling and associated activities during ASB phase 2 described below in chapter IV, including continuing detailed field work in two sub-watersheds in Mae Chaem.

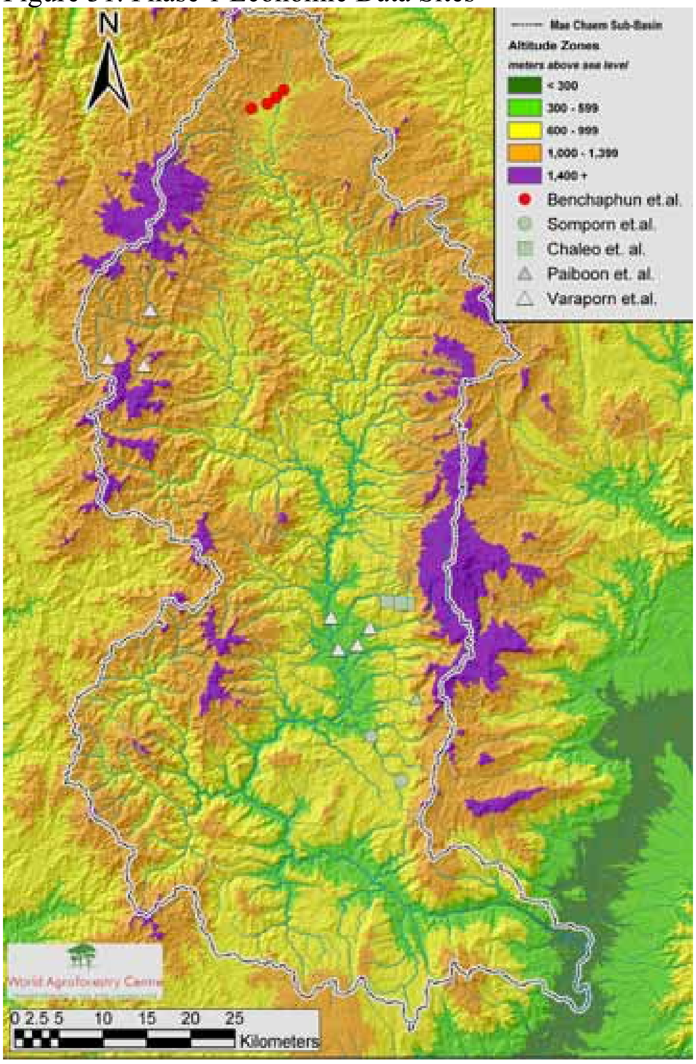
Data from this study has also become very useful for a variety of other activities, including serving as a cross-check on monitoring data collected by local communities, providing input to supplement other weather stations in providing data on variation of rainfall along altitude gradients, and other analyses. Indeed, we have come to see such installations as an interesting complement to village monitoring.

III. Economic and Livelihood Assessments

This chapter presents preliminary findings from a range of research activities conducted at nested sites within the Mae Chaem watershed during 1997-2001. These studies centered on efforts to provide additional primary data and analyses to fill knowledge gaps related to economic and financial aspects of the range of land use practices commonly employed by households in Mae Chaem. An associated study also managed to gain insights into the role of social capital in how villagers responded to impacts that followed from the Asian Economic Crisis.

A. Economic & financial assessments of household land use practices

Figure 31. Phase 1 Economic Data Sites



Core economic and financial research employed the policy analysis matrix (PAM) approach. Initial training in the PAM methodology was conducted during an international training workshop held in Chiang Mai during 1997 under the leadership of Prof. Scott Pearson of Stanford University. Subsequent studies of crop production and profitability using the PAM approach were conducted for various major agricultural land uses under a range of different conditions found in the Mae Chaem watershed (Figure 31). Given the lack of existing data on agricultural practices under conditions in this area, studies included primary data collection using various combinations of survey and rapid assessment methods. For purposes of comparison, the following brief summaries of research findings include standardized calculations of farmer profitability[66] under current conditions, as well as data on estimated farmer profitability and returns to land using international prices without current distortions resulting from policies and market imperfections[67]. Two rounds of PAM-related field studies were conducted:

PAM Round One.

An initial set of studies focused on conditions during the 1997 crop year was conducted by four teams formed during

[66] Farmer Profit (or ‘private’ or ‘financial’ profitability) values in this report all are based on actual prices reported by farmers, and assume a 15% interest rate and a 35 THB/US$ exchange rate, both of which were reasonable assumptions when the field research was conducted. As no real land markets exist and most land was not purchased, results are presented as returns to labor and land, and expressed in terms of US$ person-day^{-1}.

[67] International price profitability (or ‘social’ or ‘economic’ profitability) values differ from farmer profit by use of prices based on international markets for inputs or products that are actually or potentially tradeable in such markets. These calculations assume a 5% interest rate and a 35 THB/US$ exchange rate. Returns to farmer labor and land are expressed in US$ person-day^{-1}, while returns to land are expressed in US$ ha^{-1} and further incorporate a modest THB40 wage rate for labor.

the PAM training workshop. Dr. Benchaphun Ekasingh, chair of the CMU Department of Agricultural Economics, provided overall guidance and assistance in these analyses. Although rainfall was relatively low during 1997 due to an El Nino event, data was from periods prior to impacts associated with the Asian economic crisis. Two major sets of circumstances were studied:

1. **Karen with Pressure and Projects**. These sites are all within the midland zone of the series of small sub-catchments located southeast of Mae Chaem district town, where pressure has been especially strong from national parks occupying the mountain ridge, and from a series of opium eradication, development and conservation projects during the last 20 years. Data were collected using PAM-oriented rapid assessment methods, and a brief summary of some of the main findings are presented in Figure 32. Agricultural production in this area now centers on rice, soybean and maize. Sites include:
   - 1.1. one ethnic Karen site near the lower boundary (600 m) of the midland zone[68]
   - 1.2. one ethnic Karen village near 1,000 m elevation[69]
   - 1.3. one ethnic Karen site in a village cluster located just over 1,000 m elevation[70].

Figure 32. Profitability: Karen with pressure and projects

Midlands		Location		Inputs & Technology							Product	Farmer	Internat'l Prices	
Near Nat Park + Projects		Vill	Eth	Nutritent		Weeds		Pests		Labor	Yield	Profit	Farmer	Land
SE of District Town – 1997		Site	Grp	Ma	Fer	Sa	Her	Ins	Fun	days ha^{-1}	ton ha^{-1}	\$ day^{-1}	\$ day^{-1}	\$ ha^{-1}
Rice	Paddy	1.1	Ka		X		X			191	3.2	1.66	1.16	3
		1.2	Ka		X	X	X			224	3.4	1.48	1.40	58
		1.3	Ka		X					194	3.1	1.76	1.82	132
	Fixed upl field	1.1	Ka		X		X			175	2.0	1.32	0.97	(31)
		1.2	Ka		X	X	X			435	3.4	0.68	0.67	(207)
		1.3	Ka		X					276	1.9	0.86	0.86	(78)
	Rot fields-2-3 yrs	1.2	Ka		X	X	X			349	2.6	0.75	0.72	(148)
Field crop	Soybean – upl	1.1	Ka		X		X	X		56	1.0	1.50	4.51	213
		1.2	Ka		X		X			197	3.3	3.70	4.90	895
		1.3	Ka		X		X			184	1.0	0.42	0.58	(4)
	Maize – feed	1.1	Ka		X		X			47	3.1	(0.17)	7.97	336
		1.2	Ka		X		X			75	1.3	0.61	2.07	113
	Maize – sweet	1.3	Ka		X		X			137	6.9	0.90	1.43	111

KEY: Th=Northern Thai, Ka=Karen, Hm=Hmong, Ma=manure, Fer=fertilizer, Sa=salt, Her=herbicide, Ins=insecticide, Fun=fungicide

As Figure 32 infers, traditional forms of long-cycle rotational forest-fallow shifting cultivation are no longer present in this area. In addition to eradication of opium production in the highland portions of this ridge, agencies and projects have also sought to 'stabilize' or 'sedentarize' agriculture in the midlands, and have now basically succeeded in accomplishing both objectives. Although these efforts have helped expand the area of paddy to some extent, limitations on paddy imposed by geography require that upland rice production continue.

Although retaining their basic emphasis on subsistence rice production, without forest fallows to perform the ecological functions discussed in the above section on agronomic sustainability, villagers have had to adapt and adopt various new practices. While most upland rice producers have one or a few fixed fields, two approaches are employed to prevent yield decline resulting from

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[68] Sangawongse, Somporn, Uthai Jongprasobchai, Chatchai Naktipawan & Brian Cutshall. October 1999. 'Land-use Analysis of Highland Agricultural Systems Using Policy Analysis Matrix: A case study from Ban Pha Phueng and Ban Mong Luang in the Mae Chaem Catchment, Northern Thailand'. Unpublished report submitted to the International Center for Research in Agroforestry, Chiang Mai, Thailand.

[69] Hengsuwan, Paiboon and Pratuang Narintrangkool Na Ayuthaya. July 1999. 'The Farming System of Mae Lu Village in the Mae Chaem Watershed: Using the Policy Analysis Matrix Approach'. Unpublished report submitted to the International Center for Research in Agroforestry, Chiang Mai, Thailand.

[70] Kanjunt, Chaleo, Bradford Withrow-Robinson & Sopon Thangphet. July 1999. 'Economic Analysis of Karen Farming Systems in the Mae Chaem Watershed: Using the policy analysis matrix methodology'. Unpublished report submitted to the International Center for Research in Agroforestry, Chiang Mai, Thailand.

continuous upland rice cultivation: 1) a crop rotation to upland soybean every third year or so, which also helps generate cash income to help cover purchased inputs; 2) an effort to simulate a very short cycle natural fallow system by rotating among fields, resulting in a natural fallow of about 2-3 years. It is also common for villagers to sparsely interplant upland rice with various subsistence vegetables and other plants, as was traditionally done in forest fallow systems. While these approaches appear to have some beneficial effects, possibly related to providing a pest/disease break, they are apparently unable to replace other forest fallow functions. Foremost among these are those related to soil nutrient replenishment and weed suppression, which must now be accomplished through application of purchased external inputs. Although pesticide use is very rare, and some folk approaches are practiced (such as the application of salt to suppress weeds), most all production now employs chemical fertilizer and herbicide. Relatively liberal amounts of labor are also used in rice production, and especially for weeding of upland rice. Despite all these efforts, which can sometimes result in upland rice yields well above average, the overall rice deficit in this area is said to be very substantial, and possibly increasing.

Household Strategies. Few households produce only a single crop, and a range of cropping system combinations are found in this area, based on permutations of the crops and practices in Figure 32. While some soybean is grown as a periodic rotation in fixed upland rice fields, both soybean and maize are also grown in separate permanent fields. In terms of overall household profitability, the cropping strategy with highest financial profits was paddy rice-soybeans. Next were combinations of paddy or upland rice with both soybeans and maize, followed by paddy rice-maize. Lowest profits were associated with strategies employing only combinations of paddy rice, fixed upland rice and/or rotational upland rice. As can be seen in Table 1, it appears that so much labor and purchased inputs are required to push upland rice productivity to relatively high levels that net profitability suffers substantially.

Moreover, evidence obtained since this study indicate relative shifts in profitability, especially among field crops. Since the economic crisis and the THB devaluation, prices of tradeable purchased inputs have increased rapidly, whereas crop prices received by farmers for soybeans and maize appear to have benefited little from the devaluation. Meanwhile, new higher-yielding maize varieties for feed and seed are being introduced in the area, largely in association with contract farming arrangements provided by the Charoen Phokaphand agro-industry group. The result has been a shift from soybeans to maize by farmers in various parts of Mae Chaem, including this area. The Frito-Lay Company also recently introduced contract farming of potatoes, but initial plantings by farmers in this area have not yet been able to demonstrate the viability or desirability of this option. While many fields are shifting out of soybean, it still appears to be retained as a periodic crop rotation in fixed upland rice fields. As this is the only major legume cash crop in this area, if it is not able to retain its economic viability in the future, villagers may need to re-think their strategy for preventing yield decline in fixed upland rice fields.

Although cropping data captures some of the agroecological transformations that have occurred in this area, there are additional elements of persistence and change that proved too difficult to capture in the PAM format using the data collection approaches available. Much of the area formerly used for forest fallow in this set of sub-catchments has now been returned to permanent forest, either within the national park or under unofficial community management in areas within or near village lands. Local Karen communities still draw on their extensive traditional knowledge to acquire a wide range of plant products for normal subsistence use, as a back-up in times of crisis, and occasionally as a source of additional income. For some, the latter also can include forest grazing of cattle, which sometimes serves as an important savings and cash generation component of household strategies.

Despite these subsistence and commercial production opportunities, overall household cash incomes are generally inadequate to purchase necessary production inputs, cover their subsistence rice deficit, and meet other necessities requiring cash, such as expenses associated with education, health care, etc. While off-farm wage employment, primarily within Mae Chaem, had been increasing during the economic ‘boom’ period, opportunities and wage rates have decreased substantially since the economic crisis. Given the great effort – and often sacrifice – most of these communities have made in attempting to adapt to government land use policies, some agencies and projects have sought to provide additional forms of assistance to communities in this general area, including support for development of cottage industry such as weaving, or stable wage employment in government activities such as forest fire protection.

2. **<u>Karen with Paddy and the Royal Project</u>**. This site includes several villages in the Wat Chan area in the far northern reaches of the Mae Chaem watershed, much of which is a plateau-like area where the Royal Project Foundation has a well-established program centered on commercial production of primarily annual horticultural crops. Data were collected using a combination of survey and rapid assessment methods, building on previous and on-going research conducted in this area by Dr. Benchaphun Ekasingh and colleagues at the CMU Faculty of Agriculture's Multiple Cropping Centre. [71]

    2.1. Two ethnic Karen administrative villages (each composed of 2 settlement areas) where villagers had expanded from subsistence rice-centered systems into intensive production of a range of high-value vegetables and horticultural crops. Data from both villages are combined and briefly summarized in Figure 33.

Figure 33. Profitability: Karen with paddy and the Royal Project

Midlands		Location		Inputs & Technology							Product	Farmer	Internat'l Prices	
Paddy + Royal Project		Vill	Eth	Nutritent		Profit		Pests		Labor	Yield	Profit	Farmer	Land
Far North (Wat Chan) – 1997		No	Grp	Ma	Fer	Sa	Her	Ins	Fun	days ha^{-1}	ton ha^{-1}	\$ day^{-1}	\$ day^{-1}	\$ ha^{-1}
Rice	Paddy	2.1	Ka	X	X					106	2.5	2.15	1.97	88
	Upland 'priv' fal	2.1	Ka							83	1.3	1.52	1.47	27
Hort Crop	Taro	2.1	Ka	X	X					259	3.3	0.79	2.23	351
	Ginger	2.1	Ka	X	X				X	205	2.1	(3.72)	0.67	(1)
	Pumpkin	2.1	Ka	X	X				X	142	6.0	8.24	20.11	2,774
	Lettuce	2.1	Ka	X	X		X			219	6.2	5.80	14.88	3,113
	Green pepper	2.1	Ka	X	X		X		X	276	7.9	7.65	11.42	3,033
	Gladiolas	2.1	Ka	X	X				X	672	70 kHd	2.68	3.97	2,524

KEY: Th=Northern Thai, Ka=Karen, Hm=Hmong, Ma=manure, Fer=fertilizer, Sa=salt, Her=herbicide, Ins=insecticide, Fun=fungicide

Again, as these data infer, the type of community-managed long-cycle forest fallow shifting cultivation usually associated with traditional Karen practices is no longer evident in this area. The history of land use system transformation in this area has been complex, and is a major topic covered under a doctoral dissertation research project, the full analysis of which is due to be completed in late 2001 *(see discussion in above section on biodiversity)*. In any event, one important element is that the terrain in this area has allowed development of a rather large area of paddy land, to which most households have at least some access. And while upland rice is also produced using a forest fallow system, the arrangements in this area are generally that each household has its own permanently allocated parcels of land, so that fallow rotation decisions are 'privatized' to the household level, resulting in a wide range of circumstances. For example, when one observes a field with five years of fallow growth, it usually does not imply that household will also have plots with one, two, three and four-year fallow growth.

In terms of individual horticultural crops, ginger is an example of a crop with wide year-to-year variation in profitability. During the study year it was on a down cycle, and resulted in substantial losses for households cultivating it. As data in Figure 33 indicate, three crops produced for marketing through the Royal Project Foundation, pumpkin, lettuce and green pepper, appeared most promising. While gladiola production is also relatively profitable, its high labor requirements result in relatively lower returns to labor. Although many outsiders believe RPF-associated crops are heavily subsidized, data from our PAM analysis indicate that this is not the case. Indeed, it appears that if tradeables were bought and sold in line with international market prices, these crops would be even more profitable for farmers.

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[71] Ekasingh, Benchaphun, Kitiya Suriya and Suwan Vutticharaenkarn. January 1999. 'An Analysis of Land Use Systems Using Policy Analysis Matrix in a Small Watershed in Wat Chan, Northern Thailand'. Unpublished report submitted to the International Center for Research in Agroforestry, Chiang Mai, Thailand.

Household Strategies. Villagers in this area tend to take a low-input approach to both paddy and upland subsistence rice production, resulting in relatively modest crop yields, but relatively reasonable returns to labor. Indeed, fallows appear to be of sufficient duration that sample households with upland rice fields were able to produce their modest yield with no recorded fertilizer or chemical inputs, as was the case in the 6-year rotational system where agronomic stustainability was studied *(see section above)*. This low-risk approach to core subsistence rice production is combined with high-value intensive vegetable and horticultural crops that can yield quite high returns to labor, but pose substantial risks associated with both environmental and market factors. In order to help compensate for risk associated with various crops, participating households tend to mix two or more intensive crops into their land use portfolio.

As the Royal Project Foundation is quite aware of growing downstream concern about pesticide pollution, efforts are made to minimize pesticide applications, and when they are necessary to manage them appropriately; they are also conducting research on both biological control and integrated pest management. Our PAM data confirm that while chemical fertilizer use is almost universal on crops other than upland rice, use of herbicide and pesticide is quite modest considering the intensity of the horticulture in the area.

Fruit tree production is also promoted in the area, but its nature and the relatively young plantings in the area made collection of data for PAM analysis problematic. Livestock are also produced, but analogous difficulties were also encountered in analysis.

As in other Karen areas, villagers continue to use their extensive knowledge of native plants to obtain a wide variety of products that were, again, difficult to capture in a PAM format. An initial supplementary study was conducted as an initial step in longer-term study of these practices (see below section on supplementary studies). The Royal Project Foundation is currently evaluating various ideas about developing additional production opportunities related to some of these forest products.

Despite the range of agricultural production opportunities available, Wat Chan also has developing cottage industries and some wage labor. There have also been some locally quite controversial proposals to develop projects related to tourism and other activities.

PAM Round Two.

A second set of studies on conditions during the 1998 crop year were conducted by a single research team led by Dr. Varaporn Punyawadee of Mae Jo University, based on socio-economic surveys conducted in two additional sub-catchments[72]. This was a particularly bad year in many areas of the Mae Chaem watershed for two reasons: 1) a rather severe El Nino-associated drought resulted in low rainfall and restricted water availability, a condition that was exacerbated by serious widespread insect infestations of brown plant hoppers that severely damaged rice crops in many areas; 2) impacts of the Asian economic crisis began to be felt through changes in input and output prices, as well as on opportunity costs of labor and sources of wage employment. Two major areas including three additional important sets of circumstances were covered by these studies:

3. The upper Mae Yot sub-catchment in the northwest sector of the Mae Chaem watershed, where surveys were conducted in two distinct settings:

    3.1. **Karen with Relatively Traditional Forest Fallow**. This site centered on one ethnic Karen administrative village (composed of 7 settlement areas), in one of the few areas of Mae Chaem where forest fallow shifting cultivation still maintains 8-10 year cycles. Findings on major agricultural activities are briefly summarized in Figure 34.

[72] Punyawadee, Varaporn, Penporn Janekarnkij, Numpet Winischaikule, & Sairung Saopan. April 2000. 'Profitability Assessments of major crops and major agricultural land use systems in the Mae Chaem watershed'. Report submitted to the International Center for Research in Agroforestry, Chiang Mai, Thailand.

Figure 34. Profitability: Karen with relatively traditional forest fallow

High Midlands		Location		Inputs & Technology							Product	Farmer	Internat'l Prices	
Relatively Remote		Vill	Eth	Nutritent		Weeds		Pests		Labor	Yield	Profit	Farmer	Land
Northwest (Mae Yot) – 1998		No	Grp	Ma	Fer	Sa	Her	Ins	Fun	days ha^{-1}	ton ha^{-1}	\$ day^{-1}	\$ day^{-1}	\$ ha^{-1}
Rice	Paddy	3.1	Ka							211	3.6	1.95	1.69	114
	For fallow-8-10yr	3.1	Ka							290	3.2	1.43	1.22	23
Veg Crop	Cabbage	3.1	Ka	X			X	X		261	14.4	2.02	11.58	2,946
	Carrot	3.1	Ka		X					124	21.0	21.87	79.94	9,838

KEY: Th=Northern Thai, Ka=Karen, Hm=Hmong, Ma=manure, Fer=fertilizer, Sa=salt, Her=herbicide, Ins=insecticide, Fun=fungicide

This is one of the last bastions of relatively traditional forms of forest fallow shifting cultivation found in Mae Chaem. For upland rice, forest fallows are still relatively long, the main rice crop is sparsely interplanted with a range of additional subsistence crops, no chemical inputs are used, and yields of forest fallow upland rice are the highest we have observed in Mae Chaem, despite the drought and pest outbreak observed elsewhere during that year. Indeed, some have suggested that the relative remoteness and diversity of a long-cycle forest fallow landscape may have minimized opportunities for the spread and build-up of pest populations, although such issues have not been studied in Thailand. While a quite substantial level of labor is used in this forest fallow production system, the absence of purchased inputs and reasonable rice yields result in a farmer profitability level that is quite competitive among upland rice practices. Moreover, a number of additional products are also obtained from this system that further increase its profitability.

For paddy rice cultivation, again, no purchased inputs are used, yields are slightly above average for Mae Chaem, and returns to labor are reasonable.

A new small area of commercial vegetable production by one Karen household was also studied. Cabbage production used manure and some herbicide and pesticide, resulting in a reasonable yield level, but relatively high use of labor brought farmer profitability down to a level roughly equivalent to paddy rice. In carrots, however, a modest amount of chemical fertilizer was the only purchased input, labor use was quite modest, and yields were impressive, resulting in the highest farmer profitability level for any crop we studied in Mae Chaem so far. One question (of many) regarding the future and potential for expansion of this practice will be whether these productivity levels can be maintained for very long without substantially increasing the level of purchased inputs.

<u>Household Strategies</u>. Given the community coordination upon which this traditional, relatively long-cycle forest fallow system is based, this strategy is quite universal in these villages. Paddy rice is also present in this village, but the nature of the terrain in the area severely limits its extent, so that only some households have limited areas available. A diverse range of subsistence fruit trees and plants with various uses have also been integrated into land use at various locations around the village landscape, and as in other Karen villages, people use their extensive local knowledge of native plants to obtain a wide range of additional products.

While their traditionally-oriented production systems still appear quite viable and productive, at least for subsistence purposes, the influence of high cash returns from intensive vegetable crops in nearby Hmong villages appears to have influenced one household to begin exploring this opportunity. Although cabbage profitability was not too impressive, it will be interesting to see if there is any impact from the rather spectacular profits from carrots. And if this component is expanded, it would be interesting to study what other activities will be forgone, and how sustainable this low-input approach to vegetable production can be.

3.2. **<u>Hmong near a Recently Upgraded Road</u>**. This site centers on two ethnic Hmong villages practicing intensive commercial agriculture. A brief summary of major annual crop production data is presented in Figure 35.

Although this ethnic Hmong site is located in the same sub-catchment, only a few kilometers away from ethnic Karen site 3.1, the contrast is striking. During the last 25-30 years, ridge-dwelling Hmong communities have been a major target of programs related to both opium crop replacement and national security, and this area was no exce ption. Today opium production is no longer observable, and the road from Mae Chaem district town that passes through this area on its way over the ridge to the Mae Hong Son valley has recently been upgraded to a quite high all-weather standard by military engineers.

Figure 35. Profitability: Hmong near a recently upgraded road

Highlands		Location		Inputs & Technology							Product	Farmer	Internat'l Prices	
Near New Road Work		Vill	Eth	Nutritent		Weeds		Pests		Labor	Yield	Profit	Farmer	Land
Northwest (Mae Yot) – 1998		No	Grp	Ma	Fer	Sa	Her	Ins	Fun	days ha^{-1}	ton ha^{-1}	\$ day^{-1}	\$ day^{-1}	\$ ha^{-1}
Rice	Paddy	3.2a	Hm		X		X			77	4.7	6.84	5.18	310
		3.2b	Hm		X					184	5.0	3.57	2.39	230
	Fixed upl field	3.2a	Hm		X		X			169	3.5	3.59	1.26	20
		3.2b	Hm		X		X			110	2.8	4.52	2.56	156
Field Crop	Maize – feed	3.2a	Hm		X		X			103	3.2	1.80	2.10	166
		3.2b	Hm		X		X			87	2.7	2.14	2.22	151
Veg Crop	Cabbage	3.2a	Hm	X	X		X	X	X	126	16.8	7.59	26.84	3,322
		3.2b	Hm	X	X		X	X	X	136	14.4	3.59	20.75	2,720
	Cabbage (dry)	3.2a	Hm		X		X	X	X	81	14.7	7.52	22.62	1,787
		3.2b	Hm		X		X	X		150	13.6	3.72	11.03	1,550
	Carrot	3.2a	Hm		X		X	X	X	130	20.2	20.70	72.42	9,361
		3.2b	Hm		X		X	X	X	212	17.6	7.04	37.40	7,768
	Carrot (dry)	3.2a	Hm	X	X		X	X	X	225	17.3	7.03	35.06	7,795
		3.2b	Hm	X	X		X	X	X	272	15.7	5.98	25.70	6,885
	Potato	3.2a	Hm		X		X		X	185	7.4	3.06	0.53	(2)
		3.2b	Hm		X				X	62	9.2	18.25	21.58	1,312
	Potato (dry)	3.2a	Hm		X				X	138	6.3	3.39	(4.50)	(658)

KEY: Th=Northern Thai, Ka=Karen, Hm=Hmong, Ma=manure, Fer=fertilizer, Sa=salt, Her=herbicide, Ins=insecticide, Fun=fungicide

For rice and field crops, the type of agricultural inputs used differ little from those used by Karen communities under pressure to reduce rotational forest fallow cycles, who eventually need purchased inputs to assist with soil nutrient replenishment and weed suppression once their fallow periods are insufficient to adequately serve these functions. It appears, however, that some combination of the levels used and the effectiveness with which they are employed can result in some very exceptional levels of yield and profitability, including the highest yields we have observed for both paddy and upland rice. Indeed, levels are such that we intend to re-study this village to verify that these productivity levels are real, and if so to understand more clearly how they are achieved.

In vegetable crops, however, they take intensive highland commercial agriculture to levels well beyond anything yet observed in ethnic Karen communities. Use of chemical fertilizer, herbicide and pesticides are extensive in all vegetable crops, as well as simple self-constructed gravity-fed sprinkler irrigation systems, and farmer profitability levels are impressive. Only potato production in one village seems to have encountered serious probl ems, associated with plant disease, and villagers are considering dropping the crop.

There is also some fruit tree production in the village, including persimmons and lychee that bears a valuable off-season crop, but data collection difficulties have so far prevented a PAM analysis of these crops.

Household Strategies. Intensive commercial agriculture and economic development is clearly the dominant theme in villages at this site, and shophouses along the road, numerous pickup trucks, and multiple satellite dishes are some of the material indicators. Individual households and clans produce various combinations of the above crops. Agricultural chemicals are used extensively to increase yields, substitute for labor and push up productivity and profitability. Although crops are cultivated in areas considered to be permanent upland fields, various crop rotations and some short fallowing is used to reduce problems associated with yield decline in continuous cropping of various crops. Specialized marketing networks have been organized among ethnic Hmong communities, with cabbage being the most obvious, and village-owned pickup trucks are used to feed products into both these specialized channels and more conventional outlets in Mae Chaem and other nearby areas. Off-farm wage labor for other ethnic groups is not a popular option.

Hmong communities are also increasingly aware of the growing hostility voiced in many lowland communities and urban areas regarding the nature of their agricultural activities and their perceived impact on upper watershed areas. From their point of view, there often seems to be little recognition of the extensive transformations they have already undertaken in response to government policies against opium production and their previous forms of ‘pioneer’ shifting cultivation. However, as was the case with opium, their response is often that they will seriously consider changing to crops or practices considered to be more ‘environmentally friendly’ to lowlanders, if they can be provided with access to alternatives that have similar levels of farmer profitability. So far, few suggestions of viable alternatives have been forthcoming.

4. **Northern Thai between Town and a National Park.** This site is in the Mae Pan sub-catchment, located just northeast of Mae Chaem district town, in an area where pressure from Inthanon national park and projects has also been very strong. The analysis briefly summarized in Figure 36 is based on surveys conducted in:

   4.1. Two ethnic northern Thai villages in the lower reaches of the sub-catchment, located within the municipal area of Mae Chaem district town.

   4.2. One ethnic northern Thai village located at mid-elevations of the sub-catchment practicing permanent field agriculture

   4.3. One ethnic northern Thai village located at upper elevations of the sub-catchment, near the boundary of the national park, which also includes some ethnic Karen members, one of whom contributed data to this survey.

   This site is quite representative of areas in which lowland northern Thai communities, which respondents claim were established well over a century ago, have been gradually expanding their agricultural activities up watershed slopes from major lowland centers of paddy production. Lands utilized by villages studied at this site now range from lower elevations within the jurisdiction of the Mae Chaem municipal area, up to areas bordering Inthanon national park. A variety of improvements and services have been provided by various government agencies, including concrete weirs, a small reservoir, paved roads, agricultural cooperatives and extension services on crops, fruit trees, animals and soil conservation.

Figure 36. Profitability: Northern Thai between town and a national park

Lowlands – Midlands		Location		Inputs & Technology							Product	Farmer	Internat'l Prices	
Near National Park + Town		Vill	Eth	Nutritent		Weeds		Pests		Labor	Yield	Profit	Farmer	Land
East (Mae Pan) – 1998		No	Grp	Ma	Fer	Sa	Her	Ins	Fun	days ha^{-1}	ton ha^{-1}	\$ day^{-1}	\$ day^{-1}	\$ ha^{-1}
Rice	Paddy (trad)	4.2	Th		X		X			229	3.6	2.05	1.15	2
		4.3	Th		X		X	X		238	3.8	2.19	0.90	(58)
	Paddy (HYV)	4.1a	Th		X		X	X	X	233	3.6	1.39	1.91	180
		4.1b	Th	X	X		X	X	X	161	3.7	2.25	1.29	24
		4.2	Th		X		X			399	4.0	0.97	0.48	(266)
	Paddy 2nd (HYV)	4.2	Th		X		X			81	4.4	10.18	2.14	80
	Fixed upl (trad)	4.2	Th		X		X		X	254	0.8	(0.73)	(0.89)	(516)
		4.3	Th		X			X		94	0.6	0.08	(0.90)	(193)
	Fixed upl (HYV)	4.2	Th		X		X			100	0.6	(0.31)	(0.42)	(156)
		4.3	Th		X		X			157	0.6	(0.21)	(0.39)	(241)
Field Crop	Soybean – upl	4.1a	Th		X		X	X		88	1.2	1.54	1.78	87
		4.2	Th		X		X			139	1.1	0.20	0.89	54
		4.3	Th		X		X	X		100	1.2	1.29	2.51	190
	Soybean – pad	4.1a	Th		X		X	X		120	1.5	1.52	2.34	210
		4.1b	Th		X		X	X		80	1.5	1.49	3.95	275
		4.2	Th		X		X	X		119	1.6	1.24	2.62	234
		4.3	Th		X		X	X		84	1.4	2.17	2.40	145
	Maize – feed	4.1b	Th		X		X			64	3.4	1.47	2.89	162
		4.2	Th		X					62	3.8	1.89	7.34	425
Veg Crop	Cabbage	4.1b	Th		X		X	X	X	108	11.9	6.29	21.07	2,207
	Shallot	4.1a	Th	X	X		X	X	X	111	13.6	13.22	14.54	1,581
		4.1b	Th	X	X		X	X	X	87	12.4	9.37	13.31	1,106
	Shallot (dry)	4.1a	Th	X	X		X	X		150	15.2	5.30	6.43	907
		4.1b	Th	X	X		X	X	X	103	14.2	10.92	22.79	2,279

KEY: Th=Northern Thai, Ka=Karen, Hm=Hmong, Ma=manure, Fer=fertilizer, Sa=salt, Her=herbicide, Ins=insecticide, Fun=fungicide

Associated with all these efforts is a rather diver se set of rice production technologies along an altitudinal gradient, including both traditional and HYV cultivars under both paddy and upland conditions. Since 1998 was a crisis year for rice production due to both El Nino drought and a brown plant hopper outbreak, this area provided an opportunity to observe some of the relative economic performance under such conditions. For paddy at all elevations, main season rice still had sufficient water and use of pesticides at lower and upper elevations was able to help maintain yields near or well above average levels for Mae Chaem; HYV performed marginally better than traditional varieties. But for fixed field upland rice in mid and upper elevations, yields were very low and losses were high, for both HYV and traditional varieties. In addition to higher yields from paddy rice, this example also points out the substantially higher vulnerability of upland rice to conditions such as these.

Moreover, purchased chemical inputs are key elements for nutrient replenishment and weed suppression in most all agricultural production. Pesticides were also widely used in vegetables, field crops and rice, with the latter influenced to some degree by the unusually heavy pest outbreak.

Overall, with the exception of a small area of paddy where a subsidized second rice crop was produced in the mid-elevation village, by far the most profitable cropping activities were vegetable production by lower elevation villages.

Household Strategies. At this site, the diversity of household agricultural crop portfolios appears to decrease with higher elevation in the sub-catchment. Households in lowland villages near town use HYV technology in their paddy rice, which is usually followed by a post-rice crop of soybean. They also engage in both wet and dry season commercial vegetable production, which is currently focused on shallots. Upland fields of one village (4.1b) where maize, shallots and cabbage were planted, are located in the lowland Long Pong area known for its vegetable and field crop produciton, about 20 kilometers south of the village. The profitability data in Table 5 help explain why this decision was made.

In mid-elevations of this site, commercial vegetable production drops out of the picture, and production centers around irrigated paddy (mostly HYV), often followed by post-rice soybean, or for a few even a second HYV rice crop. But for many, rice production also includes upland rice in fixed fields, along with upland soybean and maize. Farmers at higher elevations in this site have the least diversity, focusing on paddy with traditional varieties, but including post-rice soybean, along with fixed upland fields of rice (some HYV) and soybean, but no maize or commercial vegetables. Indeed, the mid to higher village strategies begin to look quite similar to the Karen strategies observed at the first PAM site, which is located in sub-catchments further south along the same ridge of mountains. And, as at those sites, forest livestock grazing, at least some degree of natural plant harvest, and off-farm wage labor are components not yet included in the PAM.

PAM Round Three

As a preliminary step in helping to further improve the information available on crop production in Mae Chaem, and its implications for livelihood and land use patterns, a subsequent study was conducted by Ms. Thitiya Angsajjapong during ASB Thailand phase 2. She collected crop production information from a substantial sample of villages in our pilot sub-watersheds (Figure 37), and conducted a preliminary assessment of profitability using the policy analysis matrix approach.

Production data was collected through interviews using both structured and semi-structured techniques, with a total of 273 households. The sample includes households representing all ethnic groups, and is distributed across nearly half of all the village settlements in both our phase 1 and phase 2 pilot sub-watersheds, as indicated in Figure 58. Data is most complete for annual crops, since perennial crops (mainly fruit trees) pose additional problems that are difficult for this approach to data collection to overcome under conditions such as found in Mae Chaem.

Major commercial annual crops identified in each pilot sub-watershed are indicated in Figure 38, along with the general judgment of their profitability made by Ms. Thitiya based on her PAM analysis. Crops indicated as being ‘profitable’ are those that showed significant profits using local prices, including a wage rate for labor based on local agricultural wage rates and an estimated local value for land. Those that were not profitable at this level are marked as 'marginal' in the table, since their returns in the context of complete commercialization of land and labor would presumably be lower than their opportunity cost. Ms. Thitiya found that those marked with an asterisk would be profitable if world market prices were used – the major distortion on prices associated with inputs and outputs for these crops is a net tax effect that reduces their profitability. No net subsidy 'incentives' for these types of crop production were identified.

The basic data from the survey is also being processed for further analyses to assess returns to land and labor in a format that can be more directly comparable to previous economic data collected by ICRAF – ASB-Thailand studies just before impacts of the Asian economic crisis began to be felt in Mae Chaem. It will also be used as input into some of our modeling activities described in sections below, as well as further studies we plan to begin soon that will center more directly on aspects related to livelihood and land use implications of commercialization and market integration.

Figure 37. Phase 2 Economic Data Sites

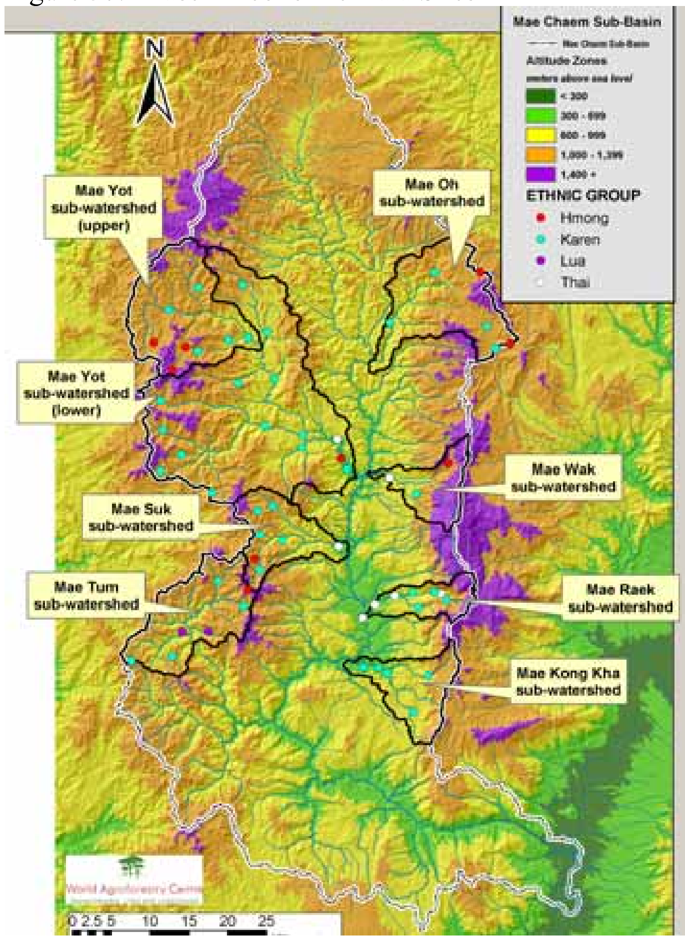

Figure 38. Relative profitability of major annual crops in pilot sub-watersheds.

	Mae Raek	Mae Kong Kha	Mae Wak	Mae Oh	Mae Suk	Mae Yot - lower	Mae Yot - upper	Mae Tum
Rice non-glutinous	*marginal*	*marginal*	*marginal*	*marginal*	*marginal*	*marginal*	*marginal*	*marginal*
Rice glutinous	*marginal*	*marginal*	*marginal*		*marginal*	*marginal*	**profitable**	*marginal*
Maize - feed	*marginal*	*marginal*	*marginal*	*marginal*	*marginal*	*marginal*	*marginal*	
Maize - seed	*marginal*	*marginal*	**profitable**					
Maize - sweet	*	*marginal*				**profitable***		
Soybean	*marginal*	*marginal*			*marginal*	*marginal*		
Garlic	*marginal*	*marginal*				*marginal*		
Shallots	**profitable**	**profitable***			**profitable**	*marginal*		
Pumpkin	**profitable**	*marginal*						
red squash	**profitable**							
cabbage	*marginal*			*marginal*	*marginal*	*marginal*	*marginal*	*marginal*
chinese cabb	**profitable**			*marginal*				
cabbage purlple				**profitable**				
chilli							**profitable***	
tomato					**profitable***		*marginal*	
potato	*				*marginal**	*marginal**	*marginal**	*marginal*
carrot				**profitable**	**profitable**	*marginal*	*marginal*	
beet						*marginal**		
villages	17	9	5	15	14	27	15	19
sampled	8	5	3	6	7	15	8	8
percent	47%	56%	60%	40%	50%	56%	53%	42%
interviews	40	23	15	23	35	71	29	37

B. Exploring the role of social capital in crisis management.

ICRAF staff also provided collaborative support for a doctoral study by Jean Geran on the role that social capital played in helping villagers to cope with the impact of the Asian economic crisis. Study sites included a sample of 12 ethnic lowland Thai and Karen villages in Mae Chaem, some of which overlapped with sites of some of our other studies. Unfortunately, it was not feasible to expand the sample to include highland ethnic Hmong communities. Major funding for this project was provided under a grant from the Ford Foundation to a broader project jointly led by Dr. Ian Coxhead of the University of Wisconsin and Dr. Mingsarn Kaosa-ard of the Thailand Development Research Institute and CMU Faculty of Economics. Key findings of research on social capital and crisis management in Mae Chaem were recently published in a doctoral dissertation[73], while papers on findings under other components of this study are available on a website[74].

This study analyzed effects of the Thai economic crisis that began in July 1997, as well as compounding effects of the 1998 local drought and agricultural pest epidemic, on rural household livelihoods in Mae Chaem. A context-specific definition of social capital provides the basis of the theoretical framework used to link social capital to livelihood strategies and combine different levels of social and economic analysis. Results illustrate the importance of social capital for livelihood resilience and how different endowments of social capital in the form of networks of social relations provide or constrain access to coping mechanisms related to capital, labor, education, markets and employment for rural households. They also reminded us that social capital can bring obligations as well as assistance during times of crisis.

Using a network-based definition of social capital at the household level, the study shows how specific dimensions of social capital – bonding, bridging and linking – played different but important roles in determining the effects of the crisis on rural households and levels of household vulnerability. 'Linking' social capital in the form of social network ties from households to various village-level groups, and 'bonding' social capital in the form of larger informal support networks, were both associated with lower vulnerability for most households. The value of bonding social capital was, however, lower for households in poorer, wage-reliant, ethnic Karen villages where all households were the most severely impacted by both the economic crisis and drought.

Exploration of household social networks as representations of the social capital endowments of rural households revealed sharp differences in the structure of social networks across villages. This village-level heterogeneity in social network structure suggests that different forms of socio-economic integration of villages with the broader Thai society influenced both how the crisis affected households in those villages and how they were able to cope with crisis effects. Categorizing both network ties and coping mechanisms by transactional content around consumption, employment and production also revealed which types of social capital were important for accessing specific coping mechanisms. Bonding social capital was important for consumption-related coping, bridging social capital for employment-related coping, and linking social capital for production-related coping for these rural households.

Circumstances were particularly difficult for midland ethnic Karen communities in a small sub-catchment located just below national park boundaries with conditions and livelihood strategies very similar to those at PAM study site 1. With bonding social capital weakened by the similar situation of all community members, two sources of coping assistance became very important. The first was village-level organizations strengthened or initiated with assistance from the Suan Pah Sirikit and Care-Thailand projects, and the second came through bridging social capital that helped with stable wage employment in forest fire suppression crews of the Royal Forest Department. Without these forms of assistance, conditions would have been far more severe than the already serious difficulties they faced.

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[73] Geran, Jean M. 2001. 'Coping with Crisis: Social capital and the resilience of rural livelihoods in northern Thailand'. Ph.D. dissertation. University of Wisconsin, Madison.

[74] http://www.aae.wisc.edu/coxhead/projects/

C. Summary of Economic Performance and Environmental Concerns.

This section briefly summarizes the patterns of relative financial and economic profitability (drawing on data in the above Tables) of the four major categories of annual agricultural crops found in the Mae Chaem watershed. Environmental concerns were identified by discussions with stakeholders at various levels, biophysical research, and secondary sources.

1. Rice Production

Despite changing land use, rice remains the most prominent component of agriculture in Mae Chaem. Although rice is the mainstay of diets of all ethnic groups, the watershed has long experienced an overall rice production deficit, largely attributed to the limited area available for paddy establishment in mountainous terrain, and the relatively low productivity of upland rice.[75]

Paddy Rice

Since paddy is clearly the rice production approach with highest productivity, in terms of both yield per unit area and returns to labor, it is not surprising that most rice producers use paddies to the extent that their natural, human and financial resources allow. As Figure 39 indicates, profitability is generally somewhat higher than local wage rates. Higher profitability in a subsidized 2nd crop and some small paddy areas acquired by Hmong, may merit further study.

Analysis using international prices indicates that government policy encourages rice production, through both fertilizer subsidies and rice price supports. In contrast to some more profitable crops discussed below, if farm gate prices for paddy were closer to international market prices, profitability of paddy production would decrease rather than increase.

In terms of environmental concerns, paddy production usually uses chemical fertilizer and often herbicide; pesticide use is variable. Since much rainy season stream flow is diverted to flow through paddy lands, particularly in Karen and lowland Thai traditional irrigation systems, varying amounts of water pollution can occur below outlets where water flow returns to the stream. This factor, however, is not yet a major issue in upstream-downstream debate.

Figure 39. Paddy Rice Production

		Location		Inputs & Technology							Product	Farmer	Internat Prices	
		Vill	Eth	Nutritent		Weeds		Pests		Labor	Yield	Profit	Farmer	Land
Crop	Year	Site	Grp	Ma	Fer	Sa	Her	Ins	Fun	days rai^{-1}	kg rai^{-1}	Bt day^{-1}	Bt day^{-1}	Bt rai^{-1}
Paddy Rice Production														
Main	**1997**	**1.1**	**Ka**		**X**		**X**			**31**	**512**	**58**	**41**	**17**
Main	**1997**	**1.2**	**Ka**		**X**	**X**	**X**			**36**	**544**	**52**	**49**	**325**
Main	**1997**	**1.3**	**Ka**		**X**					**31**	**496**	**62**	**64**	**739**
Main	**1997**	**2.1**	**Ka**	**X**	**X**					**17**	**400**	**75**	**69**	**493**
Main	**1997**	**3.1**	**Ka**							**34**	**576**	**68**	**59**	**638**
Main (trad)	**1998**	**4.2**	**Th**		**X**		**X**			**37**	**576**	**72**	**40**	**11**
Main (trad)	**1998**	**4.3**	**Th**		**X**		**X**	**X**		**38**	**608**	**77**	**32**	**(325)**
Main (HYV)	**1998**	**4.1a**	**Th**		**X**		**X**	**X**	**X**	**37**	**576**	**49**	**67**	**1,008**
Main (HYV)	**1998**	**4.1b**	**Th**	**X**	**X**		**X**	**X**	**X**	**26**	**592**	**79**	**45**	**134**
Main (HYV)	**1998**	**4.2**	**Th**		**X**		**X**			**64**	**640**	**34**	**17**	**(1,490)**
Main	**1998**	**3.2a**	**Hm**		**X**		**X**			**12**	**752**	**239**	**181**	**1,736**
Main	**1998**	**3.2b**	**Hm**		**X**					**29**	**800**	**125**	**84**	**1,288**
2nd Crop (HYV)	**1998**	**4.2**	**Th**		**X**		**X**			**13**	**704**	**356**	**75**	**448**

KEY: Th=Northern Thai, Ka=Karen, Hm=Hmong, Ma=manure, Fer=fertilizer, Sa=salt, Her=herbicide, Ins=insecticide, Fun=fungicide

[75] The Mae Chaem district office reports average rice yields in the area as 560 kg/rai for paddy rice and 304 kg/rai for upland rice, which is very similar to average findings of ASB-ICRAF studies in 12 villages.

In terms of soil degradation, paddies are excellent traps (‘filters’) for sediment from upstream, which even adds soil nutrients to paddies, at least up to the point that excessive or poor quality sediment begins harming the paddy environment. Water use is another issue, since significant amounts of water are lost through evapotranspiration during paddy rice production. Thus, water-scarce downstream communities are increasingly critical of increased paddy production in upstream areas. And, to the extent that climate change is perceived as an issue, methane emission rates from flooded paddy are such that zero net emissions would mean that under current practices one hectare of flooded paddy would need to be balanced by more than 160 hectares of the mix of upland landscape of the types currently found in Mae Chaem.

Upland Rice

Given the limited sites for paddy in hilly midland areas, Karen and Lua communities also use traditional rotational forest fallow systems to produce subsistence upland rice and other products obtained from fallow fields and forests in their mosaic landscapes. Although evidence indicates forest fallow rotation cycles were traditionally about 10 years or more, pressures on land use have reduced rotation cycles to six years or less in most areas of the Mae Chaem watershed. Many government officials are urging further reductions, and fixed fields with crop rotations or short fallows are now found in many areas. Hmong communities also produce upland rice, usually in crop rotations or very short fallows with relatively high chemical inputs.

As the data in Figure 40 indicate, relatively high upland rice yields are usually associated with either: a) rotational forest fallow cycles that approach 10 years in length; or b) crop rotations and relatively high levels of chemical and/or labor inputs used to assist with nutrient replenishment, weed suppression and pest management. Net profitability is higher under long forest fallow rotations, which require no chemical inputs. The ‘high tech’ Hmong approach is an exception, but this small area needs further investigation to understand its high profitability. Profitability at international prices shows mild effects of overall rice and fertilizer policies.

Figure 40. Upland Rice Production

		Location		Inputs & Technology							Product	Farmer	Internat Prices	
		Vill	Eth	Nutritent		Weeds		Pests		Labor	Yield	Profit	Farmer	Land
Crop	Year	Site	Grp	Ma	Fer	Sa	Her	Ins	Fun	days rai^{-1}	kg rai^{-1}	Bt day^{-1}	Bt day^{-1}	Bt rai^{-1}
Upland Rice Production														
For fallow-8-10yr	**1998**	**3.1**	**Ka**							**46**	**512**	**50**	**43**	**129**
6-year ‘priv’ fallow	**1997**	**2.1**	**Ka**							**13**	**208**	**53**	**51**	**151**
Rot fields-2-3 yrs	**1997**	**1.2**	**Ka**		**X**	**X**	**X**			**56**	**416**	**26**	**25**	**(829)**
Fixed field	**1997**	**1.1**	**Ka**		**X**		**X**			**28**	**320**	**46**	**34**	**(174)**
	1997	**1.2**	**Ka**		**X**	**X**	**X**			**70**	**544**	**24**	**23**	**(1,159)**
	1997	**1.3**	**Ka**		**X**					**44**	**304**	**30**	**30**	**(437)**
Fixed field (trad)	**1998**	**4.2**	**Th**		**X**		**X**		**X**	**41**	**128**	**(26)**	**(31)**	**(2,890)**
	1998	**4.3**	**Th**		**X**			**X**		**15**	**96**	**3**	**(32)**	**(1,081)**
Fixed field (HYV)	**1998**	**4.2**	**Th**		**X**		**X**			**16**	**96**	**(11)**	**(15)**	**(874)**
	1998	**4.3**	**Th**		**X**		**X**			**25**	**96**	**(7)**	**(14)**	**(1,350)**
Fixed field	**1998**	**3.2a**	**Hm**		**X**		**X**			**27**	**560**	**126**	**44**	**112**
	1998	**3.2b**	**Hm**		**X**		**X**			**18**	**448**	**158**	**90**	**874**

KEY: Th=Northern Thai, Ka=Karen, Hm=Hmong, Ma=manure, Fer=fertilizer, Sa=salt, Her=herbicide, Ins=insecticide, Fun=fungicide

Lowland Thai and international interests have long held strong positions against all forms of shifting cultivation, which are seen as ‘destroying’ natural forests. Indeed, most commercial timber and substantial amounts of carbon stocks are lost. In terms of watershed functions, however, longer-cycle (5-10 year) rotational forest fallow rice production appears to have relatively few negative watershed impacts. As fallows shorten, and at least when they drop to 3-4 years or upland rice production is transformed to a fixed field setting, various mixes of fertilizer, herbicide and pesticide applications appear to become inevitable, and some types of fields may become more susceptible to soil erosion and reduced water infiltration.

2. Field Crop Production

Major field crops produced in the Mae Chaem area include soybean and maize, which are usually sold through lowland markets for agro-industrial use. Profitability of these crops is roughly intermediate between paddy and upland rice, and they are an important source of cash in areas where chemical inputs are needed for subsistence rice production. Since the economic crisis and currency devaluation, crop prices have increased very little, but chemical input costs have risen rapidly. Thus, soybean profitability has dropped, and farmers are shifting to maize, where returns appear better due to new cultivars and contract farming with agro-industry.

Figure 41. Field Crop Production

		Location		Inputs & Technology							Product	Farmer	Internat Prices	
		Vill	Eth	Nutritent		Weeds		Pests		Labor	Yield	Profit	Farmer	Land
Crop	Year	Site	Grp	Ma	Fer	Sa	Her	Ins	Fun	days rai^{-1}	kg rai^{-1}	Bt day^{-1}	Bt day^{-1}	Bt rai^{-1}
Field Crop Production														
Soybean – upland	1997	1.1	Ka		X		X	X		9	160	53	158	1,193
	1997	1.2	Ka		X		X			32	528	130	172	5,012
	1997	1.3	Ka		X		X			29	160	15	20	(22)
Soybean – upland	1998	4.1a	Th		X		X	X		14	192	54	62	487
	1998	4.2	Th		X		X			22	176	7	31	302
	1998	4.3	Th		X		X	X		16	192	45	88	1,064
Soybean – paddy	1998	4.1a	Th		X		X	X		19	240	53	82	1,176
	1998	4.1b	Th		X		X	X		13	240	52	138	1,540
	1998	4.2	Th		X		X	X		19	256	43	92	1,310
	1998	4.3	Th		X		X	X		13	224	76	84	812
Maize – feed	1997	1.1	Ka		X		X			8	496	(6)	279	1,882
	1997	1.2	Ka		X		X			12	208	21	72	633
Maize – sweet	1997	1.3	Ka		X		X			22	1,104	32	50	622
Maize – feed	1998	3.2a	Hm		X		X			16	512	63	74	930
	1998	3.2b	Hm		X		X			14	432	75	78	846
Maize – feed	1998	4.1b	Th		X		X			10	544	51	101	907
	1998	4.2	Th		X					10	608	66	257	2,380

KEY: Th=Northern Thai, Ka=Karen, Hm=Hmong, Ma=manure, Fer=fertilizer, Sa=salt, Her=herbicide, Ins=insecticide, Fun=fungicide

Analysis of profitability using international prices indicates a net tax effect on both soybean and maize, and the effect may actually be getting worse since the economic crisis. Moreover, the longer-term degree of change and scale of impact of new cultivars and contract farming being introduced by large agro-industry operations remain to be demonstrated.

In terms of environmental concerns, chemical usage on field crops appears to usually be limited to fertilizer and herbicide in Karen communities, but insecticide applications also appear widespread on soybean in Thai communities. From a forestry point of view, expansion of soybean has been associated as a key element both in deforestation and in efforts to return forest fallow lands to permanent forest cover. During the mid-1980's, introduction of upland soybeans was associated with a surge in deforestation as lowland Thai villages expanded upland fields up hillsides of major valleys into sloping reserved forest watershed lands. This resulted in much concern by the forest department, and a new generation of projects focused on natural resource management and forest conservation. Upland soybean production began entering midland Karen villages as conservation policies and programs began urging them to stop forest fallow shifting cultivation. A major local response to this situation has been use of upland soybean in crop rotations with upland rice to help prevent rice yield decline in fixed fields and to generate income for chemical inputs; implications of the shift to maize are not yet clear.

3. Vegetable Production

The highest levels of profitability, at both farmgate and international prices, are attained in vegetable production, which is composed of three basic types:

Major Lowland Vegetables

Intensive lowland vegetable production, represented here by shallots grown in both rainy and dry seasons, was the most profitable option for lowland agriculture found in Mae Chaem. However, shallots – along with many other lowland vegetables – have a history of boom-and-bust cycles that over-produce or under-produce relative to available market demand.

Figure 42. Major Lowland Vegetable Crop Production

		Location		Inputs & Technology							Product	Farmer	Internat Prices	
		Vill	Eth	Nutritent		Weeds		Pests		Labor	Yield	Profit	Farmer	Land
Crop	Year	Site	Grp	Ma	Fer	Sa	Her	Ins	Fun	days rai^{-1}	kg rai^{-1}	Bt day^{-1}	Bt day^{-1}	Bt rai^{-1}
Major Lowland Vegetable Crops														
Shallot	**1998**	**4.1a**	**Th**	**X**	**X**		**X**	**X**	**X**	**18**	**2,176**	**463**	**509**	**8,854**
	1998	**4.1b**	**Th**	**X**	**X**		**X**	**X**	**X**	**14**	**1,984**	**328**	**466**	**6,194**
Shallot (dry)	**1998**	**4.1a**	**Th**	**X**	**X**		**X**	**X**		**24**	**2,432**	**186**	**225**	**5,079**
	1998	**4.1b**	**Th**	**X**	**X**		**X**	**X**	**X**	**16**	**2,272**	**382**	**798**	**12,762**

KEY: Th=Northern Thai, Ka=Karen, Hm=Hmong, Ma=manure, Fer=fertilizer, Sa=salt, Her=herbicide, Ins=insecticide, Fun=fungicide

Analysis using international prices indicates that profitability would benefit from prices more in tune with international markets, since the effect of depressed output prices are greater than net fertilizer subsidies. And, since production of these crops involves high levels of chemical use, environmental concern would be expected to focus on stream pollution and water use, although such issues with lowland crops are not yet very visible in the political arena.

Major Highland Vegetables

The most profitable crops are major highland vegetables, represented here by cabbage, carrot and potato, which are primarily grown in ridge-dwelling ethnic Hmong communities, with some spread effects into neighboring higher-altitude ethnic Karen villages. While cabbage has been the most widely produced highland vegetable in recent years, carrots are currently the most profitable, and potato shows promise if disease can be controlled. As substantial market and environmental risks are involved, capital reserves are required to maintain operations.

Figure 43. Major Highland Vegetable Crop Production

		Location		Inputs & Technology							Product	Farmer	Internat Prices	
		Vill	Eth	Nutritent		Weeds		Pests		Labor	Yield	Profit	Farmer	Land
Crop	Year	Site	Grp	Ma	Fer	Sa	Her	Ins	Fun	days rai^{-1}	kg rai^{-1}	Bt day^{-1}	Bt day^{-1}	Bt rai^{-1}
Major Highland Vegetable Crops														
Cabbage	**1998**	**3.2a**	**Hm**	**X**	**X**		**X**	**X**	**X**	**20**	**2,688**	**266**	**939**	**18,603**
	1998	**3.2b**	**Hm**	**X**	**X**		**X**	**X**	**X**	**22**	**2,304**	**126**	**726**	**15,232**
Cabbage (dry)	**1998**	**3.2a**	**Hm**		**X**		**X**	**X**	**X**	**13**	**2,352**	**263**	**792**	**10,007**
	1998	**3.2b**	**Hm**		**X**		**X**	**X**		**24**	**2,176**	**130**	**386**	**8,680**
Cabbage	**1998**	**3.1**	**Ka**	**X**			**X**	**X**		**42**	**2,304**	**71**	**405**	**16,498**
Cabbage	**1998**	**4.1b**	**Th**		**X**		**X**	**X**	**X**	**17**	**1,904**	**220**	**737**	**12,359**
Carrot	**1998**	**3.2a**	**Hm**		**X**		**X**	**X**	**X**	**21**	**3,232**	**725**	**2,535**	**52,422**
	1998	**3.2b**	**Hm**		**X**		**X**	**X**	**X**	**34**	**2,816**	**246**	**1,309**	**43,501**
Carrot (dry)	**1998**	**3.2a**	**Hm**	**X**	**X**		**X**	**X**	**X**	**36**	**2,768**	**246**	**1,227**	**43,652**
	1998	**3.2b**	**Hm**	**X**	**X**		**X**	**X**	**X**	**44**	**2,512**	**209**	**900**	**38,556**
Carrot	**1998**	**3.1**	**Ka**		**X**					**20**	**3,360**	**765**	**2,798**	**55,093**
Potato	**1998**	**3.2a**	**Hm**		**X**		**X**		**X**	**30**	**1,184**	**107**	**19**	**(11)**
	1998	**3.2b**	**Hm**		**X**				**X**	**10**	**1,472**	**639**	**755**	**7,347**
Potato (dry)	**1998**	**3.2a**	**Hm**		**X**				**X**	**22**	**1,008**	**119**	**(158)**	**(3,685)**

KEY: Th=Northern Thai, Ka=Karen, Hm=Hmong, Ma=manure, Fer=fertilizer, Sa=salt, Her=herbicide, Ins=insecticide, Fun=fungicide

Analysis using international prices reveals that if producers of these crops could have access to input and product prices more in tune with international markets, profits would be even higher. This is because the net subsidy seen in the price of fertilizer is dwarfed by the net tax effect on output prices received by farmers. These depressed prices may relate to excessive profits or postharvest losses somewhere in the marketing chain, which is largely independent of ‘normal’ markets and thus fairly difficult to investigate, or more simply to over-production relative to the commodity flows that the marketing system can handle.

Perhaps a more important issue under current circumstances relates to the actual and/or perceived environmental concerns associated with highland vegetable production. Perceived impacts with political importance include: (a) stream pollution by extensive use of pesticides, herbicide and chemical fertilizer; b) reduced dry season stream flow, increased rainy season storm flows, and accelerated downstream sedimentation due to deforestation associated with creation of highland fields in hill evergreen forest zones; c) reduced dry season stream flow due to water use by sprinkler irrigation systems in highland vegetable production areas.

Highland Specialty Vegetables

Specialty highland vegetables are another agricultural option under some conditions, as represented here by lettuce, green pepper and pumpkin produced in Wat Chan for the Royal Project Foundation (RPF). Profitability is quite high by local standards, but production requires transportation infrastructure and fairly elaborate extension, processing and marketing support. Some non-RPF specialty crops, such as taro and ginger, currently show very low profitability.

Figure 44. Highland Specialty Vegetable Crop Production

		Location		Inputs & Technology							Product	Farmer	Internat Prices	
		Vill	Eth	Nutritent		Weeds		Pests		Labor	Yield	Profit	Farmer	Land
Crop	Year	Site	Grp	Ma	Fer	Sa	Her	Ins	Fun	days rai^{-1}	kg rai^{-1}	Bt day^{-1}	Bt day^{-1}	Bt rai^{-1}
Specialty Highland Vegetable Crops – Royal Project Foundation														
Pumpkin	1997	2.1	Ka	X	X				X	23	960	288	704	15,534
Lettuce	1997	2.1	Ka	X	X		X			35	992	203	521	17,433
Green pepper	1997	2.1	Ka	X	X		X		X	44	1,264	268	400	16,985
Gladiolas	1997	2.1	Ka	X	X				X	108	11 kHd	94	139	14,134
Specialty Highland Vegetable Crops – Other														
Taro	1997	2.1	Ka	X	X					41	528	28	78	1,966
Ginger	1997	2.1	Ka	X	X				X	33	336	(130)	23	(6)

KEY: Th=Northern Thai, Ka=Karen, Hm=Hmong, Ma=manure, Fer=fertilizer, Sa=salt, Her=herbicide, Ins=insecticide, Fun=fungicide

As with other vegetable crops, it appears that profitability would be much higher if prices were closer to those in international markets. But the apparent farmgate price depression needs to be examined carefully. These commodities are produced and marketed in association with the RPF, which has a range of retail outlets selling its ‘Doi Kham’ brand name. While this is an operation with extremely interesting potential, the degree to which farmgate prices interact with postharvest losses, grading issues, and its transport, processing and marketing capacity raises some interesting questions regarding further development of these production operations.

In terms of environmental concerns, while fertilizer and some herbicide and fungicide are used on these crops, overall chemical usage appears considerably lower than other vegetable production categories. Nevertheless, some still perceive these activities as using high levels of agricultural chemicals. Thus, as part of their efforts to encourage more environmentally friendly practices, RPF has been encouraging diversification into fruit trees, often in agroforestry style, and is considering other products from native species of plants in local landscapes.

4. Home Gardens & Fruit Tree Agroforestry

In some parts of Mae Chaem, complex home gardens are prominent features of lowland Thai agroecosystems. Since they were too complex for PAM studies, a small study led by Sittichai

Ungphakorn (RFD) investigated a sample of 24 home gardens.[76] Gardens contained from 21 to 76 plant species, and included both cash and in-kind costs. All households received in-kind benefits from their gardens, and 80 percent also received cash income. While cash incomes exceeded cash costs for only 16 percent, in-kind benefits exceeded in-kind costs for 92 percent, with only 8 percent showing a net loss. On average, home gardens accrued a net cash deficit of Bt 1,820 hh^{-1} yr^{-1}, but an in-kind surplus valued at Bt 6,860 hh^{-1} yr^{-1}, resulting in an average net benefit of Bt 5,040 hh^{-1} yr^{-1}.

In order to help build basic knowledge useful for efforts for exploring the potential for further development of fruit tree agroforestry in Mae Chaem, a doctoral study was conducted by Brad Withrow-Robinson in association with the CMU Multiple Cropping Center. Based on study of results of fruit tree promotion in Mae Taeng by the Sam Mun Highland Development Project, a preliminary taxonomy for classifying fruit tree agroforestry practices was developed[77] as one part of a broader analysis. Local approaches to fruit tree agroforestry were along a continuum of gradually changing and overlapping characteristics from expansion of mixed plantings similar to home gardens, to orchards appearing more similar to lowland commercial fruit operations.[78] Development of commercial fruit tree agroforestry appears to go through various stages that may require different types of extension services and support from development programs.

5. Natural Plant Products

Although natural plant use is an important part of livelihoods in mountain communities, the subject was too complex for our core economic assessments. An M.Sc. study[79] conducted by Patcharin Nawichai, under the guidance of Dr. Benchaphun Ekasingh, provided a first step in improving our quantitative understanding of wild plant use, including patterns and sources of gathering, and trends in their abundance.[80] This study of 3 Karen villages in Wat Chan, found numbers of useful plant species consistent with an ethnobotany study in three villages further south (see biodiversity section). Useful wild plant species were grouped into 5 categories: food, fodder, dyes, medicine and fuelwood. Figure 45 summaries findings on species and per capita quantities of products in each category, by gender. Women collected more species and amounts than men in all categories other than medicinals. While food included more species, fuelwood was collected in largest quantities. The most popular locations for wild plant collection by women were near their village, and particularly near streams; men would often travel farther.

Figure 45. Estimated number of species and per capita amounts of wild plants used

	Food		Fodder		dyes		Medicine		Fuelwood		Total
	spp	*amt*	*spp*	*amt*	*spp*	*amt*	*spp*	*amt*	*spp*	*amt*	*amt*
	no.	kg yr^{-1}	no.	kg yr^{-1}	no.	kg yr^{-1}	no.	kg yr^{-1}	no.	kg yr^{-1}	kg yr^{-1}
Women	117	129	9	456	10	13	44	3	17	2,368	2,969
Men	47	50	5	115	3	1	49	8	15	76	250
Total amt:		179		571		14		11		2,444	2,219

While most wild plants are gathered for household use, 40 percent of women and 16 percent of men also reported sales of wild plant products. Women collected and sold wild flowers, mushrooms and nuts, whereas men collected and sold primarily wild vegetables and some mushrooms. Highest incomes were from flowers and mushrooms, which in one village yielded

[76] Sithichai Ungphakorn, Pornchai Preechapanya, Siriphusaya Ungphakorn, Nongluk Kaewpoka. 2001. 'Cost and benefit of homegardens in lower Mae Chaem watershed'. Unpublished report to ICRAF-Chiang Mai.

[77] Withrow-Robinson, B., D.E. Hibbs, P. Gypmantasiri, D. Thomas. 1999. 'A preliminary classification of fruit-based agro-forestry in a highland area of northern Thailand'. *Agroforestry Systems* 42(2): 195-205.

[78] Withrow-Robinson, Bradford. 2000. The Role and Function of Fruit Trees and Fruit Tree-Based Agroforestry in a Highland Watershed in Northern Thailand. Ph.D. Dissertation. Oregon State University, USA.

[79] Nawichai, Patcharin. 2000. 'Use of Wild Plants in Karen Women's Livelihood Systems'. M.Sc. Thesis in Agricultural Systems. Faculty of Agriculture, Chiang Mai University.

[80] Nawichai, Patcharin & Benchaphun Ekasingh. January 2000. 'Use of Wild Plants in Karen Women's Livelihood Systems'. Unpublished report to ICRAF-Chiang Mai.

an average of about Bt 1,260 hh^{-1} yr^{-1}; in the same village total wild plant sales accounted for an average 7% of total household cash income. While collection of food and fodder was unrelated to relative wealth status, poorer households had relatively higher levels of representation in collection of dyes, medicine and fuelwood.

Villagers perceive that the diversity and quantities of wild plants are decreasing because of over-collection and destruction of habitat by fire, cattle and deforestation. They identified 4 species as no longer available near the village, 6 species that are drastically reduced but still present, and 11 more species that have begun to noticeably decrease. At least 16 wild plant species have been domesticated through their integration into home gardens.

IV. Integrating Assessments of Land Use Change

A. Biophysical and Economic Trade-Offs Among Land Use Practices

Findings from the various first phase studies summarized in chapters II and III were compiled into our georeferenced database, so that we could begin analyzing these data to assess trade-offs among the various types of land use found in the Mae Chaem watershed. The primary initial product of these efforts is the preliminary 'ASB matrix' presented in Figure 46. In this presentation, the ASB matrix format used in earlier research at sites in Indonesia, Cameroon and Brazil has been modified somewhat to fit data availability and the policy issue context in northern Thailand. Clearly, enough cells of this matrix have now been filled in to begin seeing some of the major patterns of similarities, differences and trade-offs involved when comparing various land use practices.

1. Land Use Practices.

Drawing on this information, we can now summarize some of the major relative costs and benefits of various land use practices. It appears that mature hill evergreen forest represents maximum values of many of the characteristics deemed most valuable from an environmental point of view. It also appears that this forest type is highly valued as a site for many midland-to-highland agroforestry and agricultural practices. Moreover, hill evergreen forest areas are also some of the most hotly contested areas in current policy debates regarding forest protection and needs of local mountain minority communities.

Thus, the following brief summaries seek to compare characteristics of various land use practices relative to a hill evergreen forest baseline. The order of the first four categories roughly follows a gradient of increasing agronomic intensification, with an accompanying decreasing gradient in the role of natural vegetation and regeneration processes. The fifth category is last because of currently limited data.

Traditionally-Managed Forest Fallow Rotational Cultivation.

- ***8-12-year forest fallow cycle***. It appears this system can be expected to reduce overall hill evergreen above-ground carbon storage by about 50 percent, corresponding with a reduction of basal area of timber stocks and lower average forest canopy height, but there is much less apparent impact on below-ground carbon storage. In return, land users can conduct subsistence rice production that earns modest but reasonable returns to their labor relative to implicit local labor wage rates. A range of other subsistence crops and useful natural plants are also integrated into the system. Relatively little overall impact can be expected on methane absorption rates, water infiltration or stream flow discharge buffering capacity relative to natural hill evergreen forest, although total annual water yield may be reduced somewhat by high evapotranspiration rates of rapidly growing forest during early regeneration stages. Biodiversity of the most mature stages of forest regeneration should be comparable to natural hill evergreen forest. As no fertilizers, herbicides or pesticides are used, pollution from agricultural chemicals should pose no problem.
- ***5-7-year forest fallow cycle***. This system appears to reduce overall hill evergreen above-ground carbon by 50 to 85 percent, depending on the number of large trees left during cultivation of the swidden field, along with a further reduction in average canopy height. There may also be a loss of up to 40 percent of the below-ground carbon storage. Land users obtain subsistence rice, and a range of other subsistence crops and natural plants, and the system appears to remain agronomically sustainable, but it appears returns to their labor would be somewhat reduced relative to longer fallow conditions. There should still be relatively little overall impact on methane absorption rates or water infiltration relative to natural hill evergreen forest, and impact on stream flow discharge buffering should be quite modest. Total annual water yield may be somewhat reduced by the relatively large proportion of the forest area in rapid growth stages. Biodiversity of the most mature stages of forest should still be relatively similar to hill evergreen forest, and the absence of agricultural chemical use should preclude associated water pollution hazards.

- Figure 46. Key Biophysical and Economic Properties of Component Land Use Practices in Mae Chaem (Preliminary ASB Matrix)

	Methane	Carbon Stock		Biodiversity		Agro-Sustainability Factors				Main Crop		Private	Social	
	Absorption	Above	Below	spp	PFC	Soil BDens	Fertility	Weeds	Pests	Yield	Labor	Profit	Profit	Land
	gm/ha/day	ton/ha	ton/ha	no.	index	gm/cc	inputs used			ton/ha	day/ha	$/day	$/day	$/ha
Natural Forest														
Hill E-G max	4.8	253	122	69	703	0.78								
Hill E-G ave	2.1	118	94	56	562	0.93								
Hill Pine	1.6	79	73	55	575	1.08								
Mixed Deciduous				82		1.10								
Dry Deciduous	2.4	60	60	37	359	1.27								
Rice – Traditional Rotational Forest Fallow Sequential Agroforestry System														
10-year cycle	4.9	51*	107*	63**	513**	1.10	-	labor	-	0.3*	29*	1.43	1.22	2*
6-year cycle	5.0	16*	60*	64**	498**		-	labor	-	0.2*				
+ old trees		54*	60*			1.02	-	labor	-					
Rice – Fixed Household Field Systems														
hh 5-year 'priv' fallow	5.7						-	labor	-	0.2*	16*	1.52	1.47	5*
hh 3-year rotate		3*	48*	43**	445**	1.22	fert	herb+lab	-	0.9*	116*	0.75	0.72	(49)*
Perm Field	2.4	2	22	33	249	1.33	fert	herb+lab	±chem	1.4	213	0.24	(0.01)	(203)
Rice – Flooded Paddy	(689.0)			30	192		fert	herb+lab	±chem	3.5	219	1.79	1.38	28
Field Crops														
Soybean						1.33	fert	herb+lab	±chem	1.5	117	1.51	2.65	230
Maize	2.4	7	92			1.40	fert	herb+lab	-	3.5	82	1.23	3.72	209
Vegetable Crops														
Cabbage/Carrot							fert	herb+lab	chem	16.1	166	8.49	33.13	5,107
Lett/GrPpr/Pumpkin		0.3	82				fert	herb+lab	±chem	6.7	212	7.23	15.47	2,973
Taro/Ginger							fert	labor	±chem	2.7	232	(1.47)	1.45	175
Shallots				7	58	1.43	fert	herb+lab	chem	13.9	113	9.70	14.27	1,468
Simultaneous Agroforestry														
Fruit/veg	2.3	5	153			1.19								
Home Garden				47										
Coffee w/shade		51	127	30	216	1.12								

*NOTES: *value for overall system including fallow fields **value of most mature stage in forest fallow cycle*

Household-Managed Fallow Rotations.

- ***5-year 'private' fallow.*** The example of this system studied in the Wat Chan area indicates that the general biophysical properties of the system should be quite similar to those of the community-managed 5-6 year forest fallow cycle summarized above, with the possible exception of potential impacts of increased fragmentation of the landscape. The manner in which the system in Wat Chan is managed results in relatively higher returns to labor, due to the decreased amount of labor employed in the system. Since there is still no effort to use agricultural chemicals to increase nutrients, or suppress weeds or pests, there should be no water pollution hazards from this system.

- ***3-year household rotation***. This system appears to reduce overall hill evergreen above-ground carbon storage by 97 percent, and below-ground carbon by about half. Species richness in the third year also appears bo be reduced by about one-third, although the plant functional complexity index still remains quite high. Soil bulk density appears to be increasing to levels more similar to dry dipterocarp forest, which implies reductions in methane absorption and water infiltration rates, and perhaps soil erosion risk. Evidence also points to at least a modest reduction in stream flow discharge buffering. Land users still obtain subsistence rice and a range of other subsistence crop and natural plant products, but the returns to their labor have dropped to levels at least 25 percent below even modest local implicit wage rates. This is partially due to their need for chemical fertilizers to help maintain soil fertility, and for herbicides to help suppress weeds, which also begin to introduce risks of chemical pollution in local streams.

Fixed field cropping.

- ***Paddy rice***. Benefits of this practice have long been recognized by major lowland societies of the region. Our studies have confirmed once again that production of rice in flooded paddy conditions provides higher returns to producer labor at current prices than any of the forms of upland rice production. With relatively high yields from fields requiring no fallow rotations, this is also the most land-saving form of rice production. There are also, however, several environmental trade-offs associated with this practice. In terms of plant biodiversity, our data indicates paddy fields are roughly similar to upland rice fields, which contain about half the species richness and functional complexity of forest. In terms of watershed issues, impacts are mixed. Although we have not yet conducted direct measurements of paddy water use, paddy rice production is associated with high levels of evapotranspiration from both leaf and standing water surfaces. At the same time, however, paddies function as a physical filter by trapping sediment in streams that are diverted to flow slowly through paddy areas. But since paddy production from our sample of sites in Mae Chaem usually employs chemical fertilizer and herbicides, and sometimes pesticides, it can also be a water pollution hazard if chemicals are not properly managed. From a climate change perspective, very little above-ground carbon storage remains, and flooded conditions result in a relatively massive release of methane – average emission rates are more than 100 times greater than maximum values of methane absorption found in non-flooded upland land uses in Mae Chaem.

- ***Upland rice***. This practice appears to reduce hill evergreen carbon storage by 98 percent above ground, and about 80 percent below ground. In terms of biodiversity, species richness and plant functional complexity both appear to be reduced by at least 50 percent relative to natural forest. Soil compaction appears to have increased soil bulk density to levels comparable to other types of permanent fields, which is associated with relatively low levels of methane absorption, water infiltration and stream discharge buffering capacity. In addition to chemical fertilizers and herbicides, pesticides are sometimes used, resulting in potential water pollution hazards if not managed properly. The combination of relatively low crop yields, use of purchased inputs, fairly high labor use, and high vulnerability to damage in years of low rainfall, result in returns to labor that are well under half the already very modest local implicit wage rate. Moreover, without the modest effects of fertilizer subsidies and rice price supports, it appears this system would have average returns to labor near zero. From financial and economic points of view, this was clearly the poorest performing agricultural practice studied.

- ***Soybeans and maize***. Commercial production of these crops on fixed upland fields appears to have biophysical impacts very similar to those described for upland rice, above. The relatively high below-ground carbon storage in our sample maize field most likely relates to a lag effect from relatively recent establishment of maize production. However, these crops appear to provide returns to labor that are competitive with local wage rates, and returns would apparently be increased from 1.6 to 3 times current levels if farmgate prices were more closely aligned with those in international markets. As with other fixed field production practices, substantial use of fertilizer and agricultural chemicals pose potential water pollution hazards if not managed properly.

Vegetable crops.

- ***Highland major vegetables***. As these crops are usually grown in hill evergreen forest areas, it appears that impacts would include nearly complete loss of above-ground carbon storage, and very major reduction in biodiversity of vascular plants. While losses of below-ground carbon storage, and increased soil bulk density, may depend on the degree to which manure and mulch are used in these crops, our sample sites indicate significant impacts, including a substantial reduction in stream discharge buffering capacity. Total water yield may also be further reduced by sprinkler irrigation. Moreover, substantial use of chemical fertilizers, herbicides and pesticides introduce water pollution hazards if not managed carefully. In return, however, returns to labor are about 4 to 6 times higher than those provided by rice and field crop production. Moreover, if farmgate prices could adjust to the levels in international markets, it appears returns to labor would further increase by nearly a factor of four, making this by far the most profitable major agricultural practice currently found in the Mae Chaem watershed. While significant market risks are also associated with these crops, overall profitability remains very attractive.
- ***Highland specialty vegetables***. General impacts on carbon storage and biodiversity of these practices would appear to be similar to those of highland major vegetables. Impacts on methane absorption and water infiltration are somewhat mitigated, however, by use of manure and mulch, which can help maintain higher levels of soil carbon and lower soil bulk density. In addition, sample fields were located on areas of very gentle slopes or even on terraces next to paddy fields. Total water yield may be reduced by irrigation, often by hand, which we have not yet been able to measure. While use of chemical fertilizer and herbicides appears quite standard, it appears that pesticides are used only occasionally. At current farmgate prices, returns to labor are quite high -- 85 percent of top-earning highland major vegetables -- and it appears they would roughly double if farmgate prices were in line with international markets. Interviews indicate there can be significant fluctuations in returns to labor, however, due to risks associated with both markets and environmental conditions.
- ***Lowland vegetables***. General biophysical impacts appear similar to highland specialty vegetables. The most significant difference appears to be regular pesticide use. Returns to labor at farmgate prices during the study year were about 30 percent higher than highland specialty vegetables, but the increase associated with international market prices would be less than 50 percent. Moreover, these products are often associated with 'boom-and-bust' production cycles. It should be kept in mind, however, that comparison with hill evergreen forest is not really appropriate for this type of land use, since it occurs in zones more likely to have been covered with mixed deciduous forest.

Simultaneous Agroforestry

- ***Complex agroforests.*** While a shortage of comparable data prevents a full relative assessment of this approach to land use, there are indications that above-ground carbon storage in more complex agroforest can be at least nearly 50 percent of average hill evergreen forest levels, with apparently very little reduction in below-ground storage. Biodiversity in our coffee with forest shade example also appears to have been reduced by about 50 percent, but values may vary with other forms of agroforest – some human-structured lowland home gardens have species richness levels similar to hill evergreen forest. Soil bulk density appears to be roughly similar to samples in natural mixed deciduous forest, implying relatively modest impacts on methane absorption, water infiltration and stream discharge buffering capacity. While profitability data is not yet available in a form to allow direct comparison with other land uses, examples of 'miang' type systems modified to include a range of tree crop products that yield high returns to labor are known in areas outside Mae Chaem.

- ***Simple agroforestry***. More simple forms of agroforestry, such as small, fairly widely-spaced fruit trees intercropped with vegetables, appear to offer some mitigation of impacts on soil bulk density and possibly below-ground carbon. Otherwise, biophysical impacts would appear to be similar to the vegetable components of the system. Profitability data is not yet available.

B. Overall Impacts of Local Agroforestry Landscape Management Strategies

While the above type of information begins to help clarify a range of important costs, benefits and trade-offs associated with various land use practices, it does not yet directly correspond with positions being taken in public policy debate associated with these issues.

If we assume arguments to forcibly relocate all mountain minority communities from their current locations into the lowlands are unrealistic and not logistically feasible (or morally reasonable), then debate really centers more on the relative balance of permanent agriculture, forest fallow agriculture and various forms of permanent forest in mountain area agroforestry landscapes.

Thus, the following sections summarize implications of our research findings for four different landscape 'strategy' approaches to upland land management patterns, followed by a brief summary of the overall implications of paddy land as a factor in these strategies.

Landscape Strategy 1: Traditional forest fallow rotations + permanent forest.

This strategy centers on traditional forms of 'sequential' agroforestry that 'integrate' agriculture and forestry components in the landscape. As long as these systems maintain forest fallow cycles between 5 to 10 or more years in length, they appear to offer modest but reasonable returns to producer labor with relatively modest environmental impacts. If cycles on the shorter end of this range maintain some large trees in their cleared and cropped fields, the greatest environmental impact compared to relatively mature hill evergreen forest appears to be a roughly 50 percent overall decrease in carbon storage, with an associated reduction in standing timber stocks and average forest canopy height. As these systems require relatively extensive areas of land, a relatively large portion of the landscape would be affected in this manner. Otherwise, these systems appear to be agronomically sustainable without purchased inputs, and provide watershed and biodiversity services similar to the natural forest. One exception might be a modest loss in total water yield due to higher evapotranspiration rates of forest fallow compartments in stages of rapid growth. Average values of environmental characteristics would increase according to the relative portions and strategic locations of the landscape that are set aside and managed as permanent forest.

As fallow cycle length begins dropping to 3-4 years or less, it appears that these systems begin requiring purchased chemical inputs to help maintain soil fertility and suppress weeds, and returns to producer labor drop below the average implicit local wage rate. Nearly all of the above-ground carbon storage is lost, plant species richness is reduced, and increased soil compaction begins to reduce methane absorption, water infiltration and stream discharge buffering capacity. In principle, most of these negative impacts might be mitigated to the extent that permanent hill evergreen forest occupies an increased proportion of the landscape. Factors that could not be mitigated by increased permanent forest would include low returns to agricultural labor and the need to manage agricultural chemicals to avoid water pollution, but increased use and/or sale of forest products might help reduce overall poverty.

Landscape Strategy 2: Fixed field upland crops + permanent forest.

This approach increases application of the 'intensification hypothesis', wherein agriculture is segregated from the forest and intensified on permanent fields, in order to reduce land use pressure on forest areas. In this situation, we assume that upland rice and field crops are produced continuously on fixed upland fields, which would probably require some rotating of crops among fields to prevent yield decline in upland rice. As all fallow areas would be returned to permanent forest cover, the relative proportion of permanent forest in the landscape would be increased relative to options under the forest fallow rotation scenario, above.

For the lands placed in permanent agriculture, most all above-ground carbon storage and a significant portion of below-ground storage would probably be lost, plant biodiversity would be reduced by about 50 percent, and increased soil compaction would result in relatively low methane absorption, water infiltration and stream discharge buffering, and probably increased risk of soil erosion. Agricultural chemicals would be used to help maintain soil fertility and suppress weeds, and perhaps pests. Overall returns to labor would depend on the balance between upland rice and field crops. Upland rice production under these conditions offers very poor returns to labor, whereas field crops appear to currently offer returns competitive with the current implicit local wage rate. Thus, the larger the relative proportion of agricultural land planted to upland rice, the more that overall returns to labor would be expected to fall below those of other alternatives.

Increased proportions of the area under forest would be expected to offset impacts of agricultural areas on carbon storage, methane absorption, plant biodiversity and watershed impacts, especially if they are strategically well located in the landscape. Agricultural chemical usage would still need careful management, and conservation farming practices may be needed in some permanent agricultural fields. Moreover, this strategy presents the most difficult challenge for mitigating the effects of low returns to agricultural labor, and thus rural poverty. Products from the expanded proportion of the area under permanent forest may be one attractive option to help in this regard.

Landscape Strategy 3: Intensive vegetables + permanent forest.

This strategy is another variation on application of the ‘intensification hypothesis’. The main strategic difference from the above example is that intensive commercial vegetable crops are produced on the permanent agricultural fields, rather than subsistence upland rice and lower-value field crops.

For the agricultural field component of this approach, impacts include loss of most all above-ground carbon storage and plant species diversity, relatively high soil compaction and soil erosion risk, and relatively low methane absorption, water infiltration, and stream discharge buffering capacity. Total water yields may be reduced where use of sprinkler irrigation is extensive. Returns to labor, however, are very attractive in this strategy. At current farmgate prices, all three types of vegetable production (highland major, highland specialty, lowland) appear to offer returns at least four times higher than those of paddy rice. Although if farmgate prices were more closely aligned with international market prices, returns to labor for these crops would surge further, these crops are also subject to significant levels of production risk, associated with both market and environmental variability. Overall, financial incentives for this component appear quite strong.

Examples of practices in some types of vegetable production – especially those conducted in association with the Royal Project Foundation -- that could mitigate some of the potentially negative environmental effects include: 1) use of manure and mulch could reduce soil erosion risk and effects associated with soil compaction; 2) reduced frequency of pesticide use; 3) simple intercropping of fruit trees that could help increase carbon storage and decrease soil compaction; 4) location of vegetable fields on gentle slopes or terraces, and/or integration of conservation farming practices.

As with the previous strategy, increased proportions of the area under forest would be expected to offset impacts of agricultural areas on carbon storage, methane absorption, plant biodiversity and watershed impacts, especially if they are strategically well located in the landscape. Usage of agricultural chemicals, and perhaps irrigation practices, would still need careful management. Moreover, this strategy presents the most difficult challenge for managing environmental impacts of intensive agriculture, and possibly for identifying sufficient incentives to maintain permanent forest components of the landscape.

Landscape Strategy 4: Agroforest + permanent forest.

This strategy provides a 'simultaneous' agroforestry alternative for integrating agriculture and forestry components in the landscape, without a shifting cultivation component. While current examples in Mae Chaem appear limited to coffee under natural forest shade and complex lowland homegardens, examples outside Mae Chaem include 'miang' tea agroforests and their transformed variants, and various mixed fruit-based variations that are locally significant in different areas of northern Thailand. Many 'miang' tea agroforests and some others also integrate a livestock component, usually centered on cattle grazing/browsing.

Although data is still incomplete on examples of this strategy, we could expect above-ground carbon storage to be 50 percent or more of that found in average hill evergreen forest, with perhaps relatively little loss in below-ground storage. Plant species richness would probably be at least half that of natural forest, and possibly more. Soil compaction would probably be rather modest, resulting in only mild effects on methane absorption, soil erosion risk, water infiltration and stream discharge buffering. As there is usually no irrigation or areas where young forest is in rapid stages of growth, impact on total water yield should not be significant. Use of fertilizer and agricultural chemicals is usually absent or modest, but may increase in some cases. While we do not yet have data that can allow us to assess financial and economic profitability in a PAM format, we do have anecdotal evidence that profitability can range from levels reasonably competitive with implicit local wage rates, to quite impressive levels.

The proportion of the landscape occupied by these types of systems would likely vary, but would probably usually be greater than proportions used for at least more intensive forms of segregated permanent field agriculture. This would be mitigated by their relatively lower levels of environmental impact. Moreover, efforts to promote this strategy would need to emphasize land security and other incentives to encourage further expansion and refinement of this approach.

Wild Card: The rice paddy component

Paddy rice production is referred to as a 'wild card' because it can be, and it has been integrated as a component of all the above strategies. The relative proportion of area converted to paddy land is usually limited by terrain and geographical considerations. In areas where paddy has been able to expand, it has been able to reduce needs for upland rice production and its associated environmental impacts. It has also provided a relatively reliable subsistence rice base, from which producers have been able to diversify with more confidence into more risky commercial crop activities.

Although paddy rice provides more attractive returns to labor, while minimizing land area needed for rice production, it may also imply some increase in water use. And, while it can help filter sediment from streams diverted to paddy areas, use of agricultural chemicals can also be a pollution hazard if not managed carefully. Methane emissions are another trade-off that focuses specifically on flooded paddy conditions; mitigation would most likely be through periodic rather than continuous flooding.

While opportunities for major increases in area under paddy may be limited in many areas, some research and development workers are proposing further intensification of paddy utilization as an option. Possible examples of this approach could include various combinations of: 1) increasing main season crop yields; 2) a second rice crop where dry season stream flow is sufficient; 3) other cash crops grown in paddies after rice. Although an obvious trade-off for the second and third approaches would be increased use of water, some are beginning to argue that this could be justified by improved stream discharge buffering and dry season stream flow, at least where increased paddy production would be associated with increased areas under permanent hill evergreen forest. More specific studies of the water use trade-offs associated with these options may be warranted.

The next steps in improving the policy issue focus of these assessments of costs, benefits and trade-offs, involve application of this overall approach in specific areas where the above agroforestry landscape strategies actually occur. This, in turn, requires the spatial integration and aggregation of assessments within various sample areas of the Mae Chaem watershed where ASB-Thailand studies are conducted. These efforts can help us assess, for example, trends over time and actual current proportions of agroforestry landscapes under various agricultural and forestry components in these areas.

C. Impacts of Changes in Sequential Agroforestry on Child Nutrition

A three-year study building on the studies of the agronomic sustainability of changes in sequential agroforestry reported above in chapter II.B. was aimed at further investigation of potential stress in relationships between this 6-year rotational forest fallow agroecosystem and human health and nutrition. Initial research began during 2000 with funding from Canada's International Development Research Centre (IDRC). The study is being jointly conducted by Dr. Prasit in collaboration with Dr. Prasong Tienboon, a leading human nutrition specialist at the CMU Faculty of Medical Sciences. An initial baseline health survey was conducted during late 2000, and findings indicate mild to moderate malnutrition in village children, as well as Vitamin A, B12, folic acid and iron deficiencies. Since most children also have parasite infections, it is not yet clear whether malnutrition is more closely associated with food intake or with sanitation. More detailed studies of food patterns are underway to address this question, and further explorations will build on the ethnobotany study recently conducted in this village *(see above section on ethnobotany).* A major objective of this study is to identify key indicators of both agroecosystem sustainability and child nutrition that can be used in planned comparisons of conditions in other villages in Mae Chaem where circumstances differ, expected to begin during 2002.

This study was motivated by concern about the well-being of mountain minority villages whose agroecosystems are under pressure to undergo substantial transformation in relatively short periods of time. In the context of current circumstances observable in mountain areas of northern Thailand, a sample of three ethnic Karen villages was selected to represent agroecosystems located at key points along a transformation gradient that reflects increasing intensity of agricultural land use per unit of total land area within overall upland rice-centered agroecosystems. The most extensive systems employ 'traditional' long (10+ year) cycles of forest fallow shifting cultivation. In many areas such systems have become more intensified by reducing land allocated to forest fallow, resulting in shortened (3-6-year) rotational cycles. And in some areas, systems have been further transformed into fixed permanent fields for agricultural production mixed with areas of permanent forest, thus totally eliminating forest fallows from the agroecosystem. This transformational gradient is generally perceived as being paralleled by a gradient of increasing social, economic and institutional integration, wherein (1) long-cycle systems prevail in more remote areas; (2) shortened-cycle systems are in areas where populations have grown and land use policies begin responding to perceived threats to the environmental services that these areas provide to downstream and wider societies; and (3) permanent field systems reflect 'settled' agroecosystems more integrated into 'modern' cash economies and societies dominated by worldviews that find shifting cultivation unacceptable.

During recent years, there has been increasing concern about the health and well-being of people living in villages at different points along this transformational gradient. Of particular relevance here is concern about the capacity of agroecosystems at intermediate stages of intensification to provide sufficient nutrition for children, since serious malnutrition could reduce their capacity to adapt to conditions in 'settled' systems and 'modern' society. Indicators of malnutrition previously seen in various poor villages of Karen and other ethnic groups have included anthropometric characteristics and Vitamin A and iron deficiencies.

It is commonly thought that indications of malnutrition in Karen children are due to inadequate food consumption, associated with rice production deficits relative to the increasing consumption requirements of growing populations. Many argue that this should be particularly important in villages at intermediate stages of transformation, where populations have grown, fallow cycles are shortened, and productivity declines. If short fallow cycles reduce soil nutrient replenishment and weed, pest and disease control, but economic integration has not yet brought commercial production and access to input and output markets, then this should be the point of greatest stress on food supplies. Although alternative points of view argue that permanent field commercial agroecosystems increase vulnerability to environmental and economic stress, and are thus more likely to result in child malnutrition, most would still agree that villages with shortened fallow cycles are also under considerable stress and they may not be sustainable.

Figure 47. Summary of Key Findings (1)

		Mae Yot		Mae Hae Tai		Mae Raek	
Agricultural Production							
- upland rice production system		10 yr fallow cycle		5 yr fallow cycle		Permanent fields	
- chemical inputs	*type*	none		none		fertilizer, herbicides	
- yield 2001	*kg/ha*	708-1,953		1,426		1,027	
- yield 2002	*kg/ha*	2,274-3,003		2,826-3,988		2,103-4,186	
- hh with vegetable garden	*percent*	32%		27%		72%	
- hh with fruit garden	*percent*	85%		47%		74%	
- wild plant sources	*locations*	fallows, forest		fallows, forest		forest	
- cash crops	*types*					maize, upland soybeans	
Household Cash Income & Expenses							
- mean gross income	*US$/yr*	110		150		212	
- mean expenses	*US$/yr*	91		208		204	
- mean net earnings	*US$/yr*	19		(58)		8	
Parents Education		*father*	*mother*	*father*	*mother*	*father*	*mother*
- speak Thai	*percent*	26	10	39	4	30	30
- primary education	*percent*	30	15	29	8	40	20
- secondary education	*percent*	13	6	6	-	12	-
Rice Consumption							
- household mean	*kg/hh*	987		1,106		868	
- per capita mean	*kg/per*	155		174		192	

This study has sought to investigate the extent and nature of child malnutrition in villages with shortened forest fallow agroecosystems, relative to villages with agroecosystems at either end of the transformational gradient. Accordingly, our most intensive study was conducted in a village with a short-cycle (5-year) forest fallow system (MHT), with complementary comparative studies in a village with a more traditional long-cycle (10-year) forest fallow cycle (MY) and a third village (MR) where transformation has resulted in permanent agricultural fields and remaining fallow land has become permanent forest. Figures 47 and 48 summarize key study findings described in more detail in previous sections. Mild to moderate malnutrition was generally found in children from all three villages.

1. Food supplies

Despite previous indications that rice production deficits are a chronic problem in the short-cycle village (MHT), during the study year all 3 villages along the intensification gradient were found to be self-sufficient in rice production. Moreover, subsistence shifting cultivation systems were found to provide adequate rice supply during average years, although all upland rice systems experience low productivities in some years due to drought and insect infestation. Data on rice productivity and consumption indicate a rice surplus in all 3 villages during the study. Moreover, ecological studies of the shortened fallow system found no indications that current yield levels are declining or that the system would be ecologically unsustainable. In terms of labor productivity, however, MHT village instituted an additional weeding of upland rice after its last reduction of forest fallow, and some villagers have very recently begun exploring herbicide application. No other fertilizers or herbicides are used in long or shortened forest fallow systems, whereas both types of chemical inputs are standard practice in permanent field systems where there are no forest fallows to assist system replenishment processes.

Home gardens producing vegetables for subsistence consumption are very prominent in the permanent field village (MR), whereas the forest fallow villages depend more on their swidden fields and forest fallows for vegetable production. While fruit trees would be expected to follow a similar pattern, the long-fallow village (MY) has substantially enriched fruit trees in its home gardens with planting materials provided through previous activities associated with the Royal Project Foundation.

In addition to home gardens and various cultivated plants traditionally mixed into upland rice fields, wild plants also form an important part of Karen diets. Indeed, wild plants sampled during this study

Table 48. Summary of Key Findings (2)

		Mae Yot		Mae Hae Tai		Mae Raek	
Child Malnutrition							
Height-for-age (stunting)		*boys*	*girls*	*boys*	*girls*	*boys*	*girls*
mild	*percent*	48	50	48	63	49	47
moderate	*percent*	22	25	37	17	9	11
severe	*percent*	4	6	-	-	-	-
Weight-for-age (wasting)		*boys*	*girls*	*boys*	*girls*	*boys*	*girls*
mild	*percent*	48	50	46	63	70	63
moderate	*percent*	30	38	42	38	15	-
severe	*percent*	-	3	4	-	-	-
Weight-for-height (wasting)		*boys*	*girls*	*boys*	*girls*	*boys*	*girls*
mild	*percent*	39	41	46	63	33	26
moderate	*percent*	-	3	15	13	6	-
severe	*percent*	-	3	-	-	-	-
Consumption of energy & protein		*boys*	*girls*	*boys*	*girls*	*boys*	*girls*
Energy (kcal) - age 1-3	*%RDA*	39	25	32	28	36	41
Energy (kcal) - age 4-6	*%RDA*	27	34	25	19	53	39
Protein - age 1-3	*%RDA*	96	68	83	56	92	99
Protein - age 4-6	*%RDA*	74	98	59	50	128	125
Fat - age 1-3	*g/day*	15.57	10.78	10.89	8.58	19.84	16.70
Fat - age 4-6	*g/day*	11.39	16.79	7.47	8.72	29.38	18.56
Carbohydrate - age 1-3	*g/day*	62.95	39.23	56.83	55.44	49.21	67.00
Carbohydrate - age 4-6	*g/day*	54.09	62.82	59.14	39.25	98.20	71.20
Caloric balance protein/fat/carbohydrate		*boys*	*girls*	*boys*	*girls*	*boys*	*girls*
Diet proportions - age 1-3	*% p/f/c*	14/30/56	15/32/53	15/26/59	11/23/66	14/41/45	14/31/55
Diet proportions - age 4-6	*% p/f/c*	16/27/57	17/31/52	14/19/67	15/28/57	14/35/51	19/30/51
Parasitic Infestation		*boys*	*girls*	*boys*	*girls*	*boys*	*girls*
- Intestinal	*percent*	87	82	52	55	3	5
- Malaria	*percent*	-	-	-	-	-	-
Nutritional Abnormalities		*boys*	*girls*	*boys*	*girls*	*boys*	*girls*
Anemia (Hb<=11.5 g/dL)	*percent*	30	32	27	21	42	37
Iron deficiency (ferritin)	*percent*	5	3	12	4	4	-
- consumption age 1-3	*%RDA*	27	16	23	18	29	36
- consumption age 4-6	*%RDA*	27	31	22	18	53	38
Serum Vitamin A deficiency	*percent*	-	3	67	58	-	-
- SDA & HKI assessment	*category*	medium risk		high risk		low risk	
- consumption age 1-3	*%RDA*	104	50	108	74	107	163
- consumption age 4-6	*%RDA*	76	127	58	44	205	127

were found to have sufficient nutritional values, especially beta-carotene and iron, which have been major nutritional concerns in many rural areas. Moreover, while some observers have expressed concern that settled agricultural cultivation disrupts supply of wild sources of food traditionally obtained from fallow fields, this study found that villagers appear able to obtain sufficient wild plants from permanent fields and forests to maintain overall levels of wild plant consumption similar to villages with long or shortened fallows. Some further investigation appears warranted to further clarify the degree to which domestication of some wild plants into home gardens may also be playing a part in this process.

2. Dietary patterns

Few major differences were found in dietary patterns among children of villages at different points along the land use intensification gradient. Answers to questionnaires administered in study villages revealed that main Karen diets of children across villages with all three types of agroecosystems include mostly rice (carbohydrate) and vegetables (vitamins and minerals). Although meat is only occasionally consumed, often associated with ceremonies, levels of protein consumed by children were closer to recommended levels than most other food categories. Only small amounts of cooking oil are used in their cooking; the long forest fallow cycle village (MY) uses considerably more vegetable oil than the other villages, which use mostly lard in their cooking.

Nevertheless, it does appear that overall consumption levels of energy, carbohydrates, protein and fat are somewhat higher in the permanent field village (MR), and lowest in the shortened fallow village (MHT), which has the highest percentage of caloric consumption provided by carbohydrates, and the lowest provided by fats. While the differences are not very dramatic, this does add some evidence that dietary stress levels may be greatest in the shortened fallow village.

However, socio-economic status and cultural factors also play important roles in determining food consumption patterns. Indeed, it appears that villagers have been able to adapt to various agroecological conditions in order to maintain child dietary patterns that would appear to be more of a reflection of preferences associated with their cultural heritage than the condition of their agroecosystem. As these are all Karen villages with little cash income, but currently able to produce sufficient rice and have access to considerable sources of wild and domesticated vegetables, malnourishment of children could relate more to low consumption of fat and protein than to insufficient consumption of carbohydrate, minerals and vitamins.

3. Energy, fat and protein consumption levels

The generally mild to moderate malnutrition found in children less than 6 years of age across all three villages may be related to relatively low levels of fat and total energy consumption. Total energy consumption levels are generally well under half of recommended allowances. When mean values of age and gender groups are compared across villages, wasting measures (weight-for-age, weight-for-height) show trends similar to fat and total energy consumption. While protein consumption appears closer to recommended daily allowance levels, similar cross-village trends are observed. In all these cases, children from the village with permanent field agriculture (MR) show somewhat higher consumption levels and lower prevalence of wasting. In villages practicing shifting cultivation, children in the village with relatively long cycle forest fallows (MY) appear to consume somewhat more fat and protein, and show somewhat lower prevalence of wasting than the village with a shorter-cycle fallow cycle (MHT).

4. Vitamin A and Iron deficiencies

Even though wild vegetables were found to be plentiful and have significant amounts of beta carotene and iron, more than 60 percent of children in the short forest fallow cycle village (MHT) were found to have serum vitamin A deficiency. Indeed, SDA and HKI assessment methods found children of MHT to be at high risk of vitamin A deficiency. In the permanent field village (MR), on the other hand, the risk of vitamin A deficiency was assessed as low, and no children showed serum deficiency; risk in the long forest fallow cycle village (MY) was medium, with only a very few children showing serum deficiency. This is consistent with dietary data which indicated that vitamin A levels consumed in MR were above recommended daily allowances, whereas some age and gender groups in the other villages had quite low consumption levels, especially in the 4-6 year age group in MHT.

These effects may be exacerbated in MHT children by their low levels of fat consumption, since assimilation of beta carotene (precursor of vitamin A) is impossible if not enough fat is included in their diets. Earlier studies found that after supplementation with vegetable oil there was a 20 percent reduction in the number of children with either diarrhea or respiratory tract infection (Tienboon et al. 1997b), and a 13 percent reduction in abnormal conjunctival impression cytology (CIC, a biophysical assessment of vitamin A deficiency) (Ausayakun et al. 1997). Since supplementation with vegetable oil might increase absorption of fat-soluble vitamins, especially vitamin A (Tienboon et al. 1997b), such an approach may be particularly useful in groups where consumption is marginal.

In terms of iron deficiency, it was children in the permanent field village (MR) who showed the highest prevalence of anemia (low Hb), although they appear to have consumed more iron in their diet and had the least prevalence of low serum ferritin. .

5. Other vitamins and minerals

The 4-6 year age group in the shortened fallow village (MHT) also showed lowest levels of vitamin B2, niacin and vitamin C consumption, as well as the highest vitamin E deficiency in their biochemical assessment. Researchers will continue to examine the dietary data from this group in order to identify particular elements or patterns related to their vitamin consumption levels.

Moreover, general patterns across villages with divergent agroecosystems and levels of economic integration showed consistent patterns wherein consumption levels of vitamins and minerals are substantially below recommended allowances. Further dietary studies may be justified to focus on influence of cultural factors on dietary preferences, in order to develop practical approaches for addressing nutritional issues.

6. The role of intestinal parasites

Parasitic infestations also appear to be an important factor contributing to malnutrition. Both stunting (age-for-height) measures and prevalence of moderate to severe wasting show similar cross-village trends to levels of intestinal parasite infestation. More than half of the children in the short forest fallow cycle village (MHT) were infested with Ascaris lumbricoides, and more than 80 percent of children in the long forest fallow cycle village (MY) with the same parasite, a portion of whom also had Trichuris trichiura. On the other hand, the village with permanent agricultural fields (MR) had only a few children with parasites. Similarly, the prevalence of moderate to severe stunting and wasting was lowest in MR, and highest in MY. Prevalance of mild stunting, however, was more similar across all 3 villages.

While it may be tempting to assume an essential link between parasitic infestation levels and villager agroecosystems, a closer examination of conditions is required. Experience has shown that the key factor here is related to non-hygienic conditions and most closely to children either not wearing shoes or not having ones to wear. Thus, children often walk everywhere in and around the village with bare feet. A related contributing factor may also be that Karen villagers often raise domestic animals such as pigs and chickens under their houses, which are on poles. The animal-raising area may well be a breeding ground for parasites. The medical doctors who assessed in this study provided free anti-parasitic medicines to correct this problem in the short term.

In trying to understand why so few children in the village with permanent field agriculture were infested with parasites, it is useful to note that this village is also considerably more integrated into the wider economy, transport and communication infrastructure, as well as government service systems. Indeed, researchers are recommending to public health authorities that more effort be made to understand how people in villages such as MR have managed to so effectively reduce parasitic infestations, in order to help improve public health services that are now being extended into areas such as MR and MY.

7. Linkages between Agroecosystems and Human Nutrition

In order to help assess this data for linkages between agroecosystems and human health (child nutrition), it is useful to begin with comparison of children in villages with agroecosystems representing the two ends of the transformation/intensification gradient:

- <u>'Traditional' Long-Forest Fallow Shifting Cultivation (MY)</u>. Child health and nutrition in this village appear to be fairly strongly affected by heavy parasite infestations; this is also where the most severe cases of stunting were found. Overall prevalence of weight-for-age wasting was also quite high, and especially in girls. Consumption of energy was less than 40 percent of the Thai RDA in all 4 age and gender categories, but protein consumption approached RDA levels in two of the 4 groups. Children were found to have medium risk of vitamin A deficiency, and serum deficiency was detected only in 3 percent of girls.
- <u>'Modern' Permanent Field-Centered Cultivation (MR)</u>. Children from this village appear to be distinguished by their low levels of parasite infestation, their relatively higher levels of fat/oil

consumption, and protein consumption near or above RDA levels in all 4 age and gender groups. Although their overall energy consumption was somewhat higher than in MY, it was still far short of RDA levels. These patterns were associated with a somewhat lower prevalence of stunting and weight-for-age wasting, and especially in the moderate to severe categories. Children also appear to have a low risk of vitamin A deficiency, and no cases of serum vitamin A deficiency were detected.

Overall patterns in both of these villages indicate that energy consumption levels are very low, that nearly half of all children are mildly stunted, most have at least mild weight-for-age wasting, 25-50 percent show weight-for-height wasting. Consumption of vitamins and minerals is also generally well below recommended daily allowance levels.

Study findings do appear to provide some evidence that could relate to more nutritional stress on children in the shortened fallow village (MHT) than that seen in children from villages at either end of the transformational gradient. Children in this village show the highest prevalence of weight-for-height wasting, as well as somewhat lower total energy consumption, of which there is a somewhat greater proportion from carbohydrates. They also consume somewhat less protein and fats, and have the highest risk of vitamin A deficiency.

For the most part, however, the differences across villages are not great, and the relatively better nutritional status of children in the permanent field village may be related as much or more to their ability to control intestinal parasites as to the condition of their agroecosystem. Movover, investigations of these very different agroecosystems indicate that all three were producing enough rice to meet villagers' perceived consumption needs, and both provide a reasonable supply of vegetables, fruits and other edible products from domesticated and wild plant sources.

What appears more striking is the apparent resilience of Karen villagers in being able to adapt to quite different agroecosystems in providing a fairly similar nutritional regime for their children. While considerable mild to moderate malnutrition was observed, it was fairly similar across agroecosystems, and appears more related to culturally-associated eating habits than to the nature of the agroecosystem per se.

Indeed, it would appear that the priority recommendations for improving nutrition in Karen villages in Mae Chaem, regardless of the type of agroecosystem they employ, would be: (1) control of intestinal parasites; (2) perhaps some increased use of oil, particularly in areas with high risk of vitamin A deficiency; and (3) some more general work with Karen communities on how children's diets might be improved in a culturally acceptable manner, so as to bring consumption patterns closer to recommended allowance levels.

D. Spatial Integration and Aggregation of Assessments.

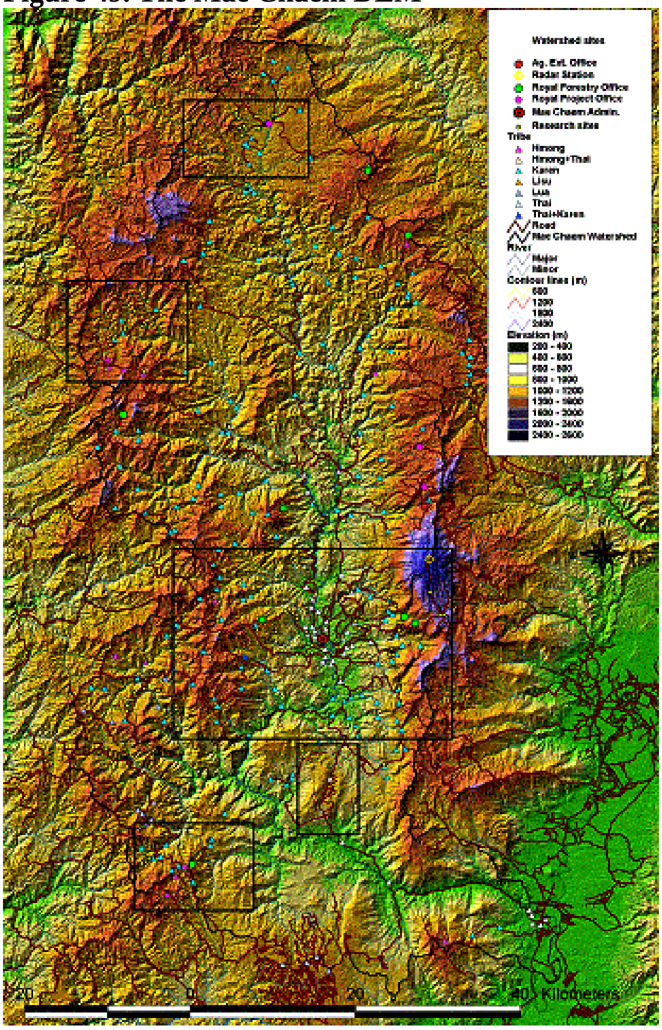
One of the central components of the ASB-Thailand research program has been construction of a geographic information system (GIS) that can serve as a meaningful and useful tool in assessing land use-related policy options and their implications in the context of the Mae Chaem watershed. Thus, we have sought to build a GIS that contains spatial data on as many important types of contextual information as possible, as well as the specific sites of all studies undertaken by ASB-Thailand, ICRAF and our research partners. As this work has progressed, it has also taken some evolutionary turns in response to needs and opportunities that have arisen as part of this collaborative process.

Major objectives of this task have been achieved through continuous effort that has evolved through various steps that can be aggregated into six stages:

1. Establishing the Basic Geographical Context

a. Construction of an overall digital terrain model. In order to begin development of a GIS for the Mae Chaem watershed, we first needed a good digital model of the terrain to serve as a base for locating and interpreting any other information that would be entered. This was particularly important due to the mountainous nature of the area and the various types of ecological, ethnic and land use zonation that was believed to be associated with land use in this region. Thus, in 1996 we began efforts to construct the most accurate digital elevation model (DEM) possible. Given the complexity of terrain in the area, we were very fortunate that our colleagues at the CMU Multiple Cropping Centre's GIS laboratory were able to help us obtain clean contour overlays from the Military Mapping Department for the fifteen 1:50,000 map sheets required to cover the entire Mae Chaem area. After these were digitized with a large-scale scanner at the CMU Computer Services Center, a very large amount of labor was needed to manually join all contour lines at the edges of each map sheet, and enter additional data on spot elevations, sink elevations and stream locations. The Royal Project Foundation helped arrange for us to use a copy of the ANU-DEM software to verify the quality of the overall product, after which we provided them with a copy of the DEM for their use under the RPF-ANU IWRAM Project. Figure 49 provides an image of the DEM.

Figure 49. The Mae Chaem DEM



b. Location of roads and human settlements by population and ethnic groups. We next entered the most basic features associated with human settlements, including roads, government offices, towns and villages. Tables containing data on ethnic group and population were linked to each village, and these are updated annually as data becomes available.

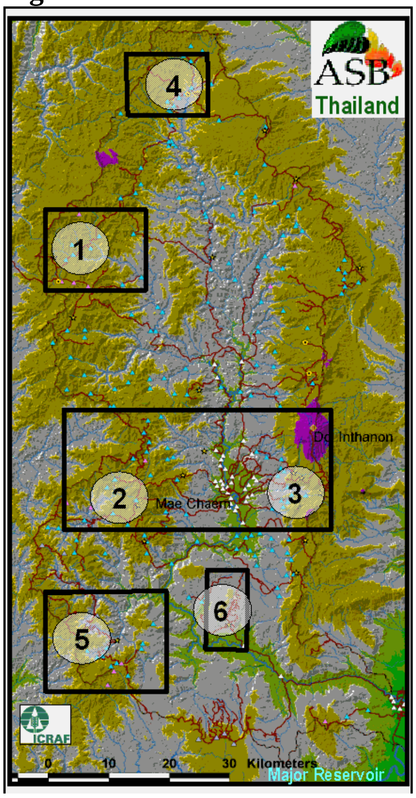
c. Assessment of recent land use change. In order to obtain a spatially distributed overview of land use trends, we next entered overlays of simple categories of land use in 1985, 1990 and 1995, obtained from our colleagues at the Royal Forest Department. These overlays were based on their interpretations of Landsat imagery, conducted in association with the global Land Use and Cover Change (LUCC) project. An earlier 1977 map of land use from the Department of Land Development was also digitized and entered, but its categories and unknown origin eventually limited its utility. We have extended our time series to 2000, however, with a map of more detailed land use categories constructed by the Department of Land Development, and digitized by GIS laboratory of the CMU Multiple Cropping Centre, and have begun work to fill in additional years of the time series.

2. Selection of Nested Areas for more Intensive Research Projects

a. Initial Articulation of Spatial Zonations. Using the above data, we were able to begin mapping various features of Mae Chaem that we hypothesized were associated with patterns of land use change. A major example of this included classifications into lowland, midland, highland and cloud forest zones, which were then crossed with coarse categories of land use and land use change, as well as with village ethnicity and populations. Differential spatial distributions of these characteristics were then used in rapid field surveys and discussions with our colleagues from RFD and Care-Thailand actively working in Mae Chaem to identify important spatial patterns of land use change, and major areas for stratification of further detailed studies to be nested within Mae Chaem.

b. Nested Research Site Selection. The above zones and strata were used to focus further research site selection on areas representative of major patterns and trends in land use change in Mae Chaem, including studies on methane dynamics, carbon stocks, plant biodiversity, agronomic sustainability, watershed impacts, land use profitability, social capital/crisis management, and others. The locations of each study were then geo-referenced as they were initiated, so that subsequently-launched studies could consider the advantages and disadvantages of co-location.

Figure 50. Zones & Nested Sites



3. Broadening Policy-Relevant Contextual Information

a. Locating official constraints on land use under national policies. Examples of these types of data include boundaries of existing national parks, the preliminary boundaries of the new Mae Tho national park in the process of being established, and official boundaries of the 5 classes of land under the national watershed classification system, as well as indications of current government views as evidenced in maps such as the 1993 land use planning map by the Department of Land Development.

b. Strengthening information on natural resource characteristics. As many of the rationales used to justify land use policies are based on biophysical characteristics of natural resource regimes, we also added spatial overlays with data on topics such as geology, soil classification (although the vast majority of the watershed is classified simply as 'slope complex'), and locations of Royal Project weather stations, RID river guaging stations, and other stations under Game-T or our sub-projects.

c. Strengthening links to information on villages and local institutions. In order to strengthen this component of the GIS, we added district and sub-district (tambon) boundaries, as well as linking our geo-referenced village locations with the national rural development database and the special database of the Office of Highland Developlment on villages located above 600 masl. We also began instituting links between villages participating in our partner SPS and Care-Thailand projects with their non-spatially explicit project databases.

4. Conducting Initial Assessments of Spatial Distributions in Mae Chaem

a. Characterizing Zones and Administrative Units. These activities built on initital efforts under 2.a, above, together with additional data obtained under point 3, and gradually sought to include findings from nested studies as they became available. These assessments were useful in helping identify and articulate the manner in which an upper tributary watershed such as Mae Chaem compares with aggregate data on north Thailand, which is usually presented by province, region or major river basin. This information has also been increasingly used to produce custom maps requested by various of our research partners, and especially for use by the SPS project and Care-Thailand. Early characterizations of watershed classifications, land use, population and ethnicity by elevation zone and sub-district were also included in chapter submitted for a special publication on the ASB Programme to be published by ASB and global partner institutions, in which the then Director-General of the Royal Forest Department was lead author.[81] Much of this information is summarized in chapter I of this report.

b. Estimating overall methane dynamics of the Mae Chaem watershed. The first attempt at using the GIS to scale-up findings from nested research sites involved the first-cut preliminary estimates of the net methane flux of the Mae Chaem watershed. As described in the above section on methane research, findings were that although seasonally flooded paddy land covers less than 2 percent of Mae Chaem, the remaining 98 percent is able to absorb only about 35 percent of the paddy emissions. During the process of deriving this estimate, it was also found that most existing land use assessment use categories that may limit these types of calculations with various other types of data being generated by various studies.

c. Integrating findings from biophysical and economic studies. The GIS approach also proved very useful in facilitating integration of research findings from the increasingly diverse range of biophysical and economic studies. While the GIS was useful in site location to assure site co-location for complementary research, it also helped interpret findings, assess similarity of different sites, identify data gaps, and assemble integrated databases for interdisciplinary analyses. The primary initial product of these efforts is the provisional 'ASB matrix' and associated trade-off assessments presented the previous section of this report.

d. Exploring potential for broader integrated assessments of landscape-level agroforestry. As noted at the end of the previous section, policy questions in northern Thailand involve more complex considerations than simple comparisons of different land use practices. The real issues under debate relate to how appropriate are various balances of these different land use practices in alternative mosaic patterns in the broader agroforestry landscape. In order to address these issues, it is clearly necessary to associate data such as that presented in Figure 46 with spatially explicit information on land use patterns.

   As we began exploring approaches for conducting such assessments, however, we soon became aware of some major limitations in the types of spatial data available. These limitations are primarily derived from three factors:

   (1) The resolution of the Landsat satellite imagery on which our land use data from 1985, 1990 and 1995 are based is too coarse to identify some of the very small but important areas of cultivation, and is very limited in its ability to distinguish among some types of crops or forest under various stages of regeneration.

[81] Plodprasop Suraswadi, David E. Thomas, Komon Pragtong, Pornchai Preechapanya, Horst Weyerhauser. 'Northern Thailand: Changing Smallholder Land Use Patterns'. In: C.A. Palm, S.A. Vosti, P.A. Sanchez, P.J. Ericksen, A.S.R. Juo (eds). *Slash and Burn: The Search for Alternatives*. A collaborative publication by the Alternatives to Slash-and-Burn Consortium, the World Agroforestry Centre, the Earth Institute at Columbia University and the Center for Natural Resource Policy Analysis at the University of California, Davis. *(forthcoming 2004).*

(2) The extensive cloud cover in mountain areas during the rainy season make it very difficult to get a 'clear shot' of the landscape from Landsat imagery during the period when most main season crops are growing. Thus, while a number of types of cultivated areas can be identified, it is not clear what crops are being cultivated.

(3) The standard categories used in land use classification exercises do not provide sufficient information to allow identification of some of the important land use categories in the preliminary ASB matrix.

With regard to this third point, although we have very recently been able to obtain a land use assessment conducted by the Land Development Department that has far more detailed categories that previously available, various types of these problems still persist. To illustrate this point, Table 16 contains an aggregation of this detailed DLD data into categories that are as close as we can come through simple aggregation to those in the ASB matrix.

It was particularly encouraging to see that the area of paddy rice in this table corresponds quite well with a detailed assessment of the spatial distribution of all paddy areas in Chiang Mai province conducted by the GIS laboratory of the CMU Multiple Cropping Centre under a Thailand Research Fund-supported project that employed an impressive array of remote sensing techniques supported with field checks. The estimate of area under cabbage is also very useful, and we are planning some field work to cross-check areas in Mae Chaem.

Figure 51. Estimates of Area Under Various Land Uses in Mae Chaem, 2000

Land Use	Area	
	hectares	% total
Secondary Natural Forest		
Hill Evergreen	108,605	32.5
Hill Pine	38,313	11.4
Mixed Deciduous	75,435	22.5
Dry Deciduous	79,399	23.7
Sub-total	301,752	90.2
Regenerating/Disturbed Forest		
Hill Evergreen	5,310	1.6
Deciduous	379	0.1
Bush Fallow	5,740	1.7
Sub-total	11,428	3.4
Rice Crops		
Upland Rice	7,990	2.4
Paddy Rice	5,818	1.7
Sub-total	13,808	4.1
Field & Horticultural Crops		
Field Crops	241	0.1
Field/Truck Crops	1,012	0.3
Veg Crops	417	0.1
Cabbage	4,376	1.3
Sub-total	6,046	1.8
Other Land Uses	1,597	0.5
Total	334,631	100

Source: Dept of Land Development & CMU Multiple Cropping Centre

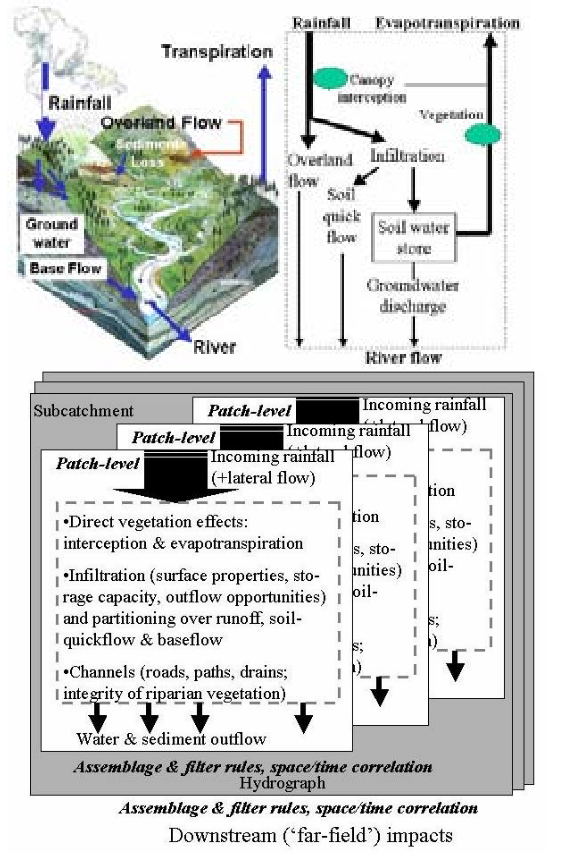
Interpretation of this data is particularly difficult, however, when it comes to understanding the spatial distribution of the distinctly different forms of upland rice cultivation, which are a major point of contention in public debate on land policy issues. It is somewhat instructive that in the more detailed land use categories, all upland rice, field crops and cabbage are indicated as being produced in 'swiddens'. Apparently, the DLD is interpreting any non-paddy form of crop cultivation above 600 masl as 'swidden', thereby rendering the concept meaningless. Ignoring such conceptual signposts, we then come to the question of regenerating forests and forest fallow cycles. With this data, one can try to read between the lines by interpreting 'bush fallow' as early regeneration or very short fallow, 'disturbed forest' as middle-aged fallows, and assume that fallows at some age are for the purposes of such surveys indistinguishable from natural secondary forest. Even if this approach is roughly correct, the problem is that we do not know the age of fallows at which these category transitions occur. As we needed to understand these and similar issues more clearly, we began exploring alternative approaches about how best to conduct some additional nested studies that might help us to more effectively interpret these standard approaches to land classification in the context of actual land use systems and policy issues important in upper tributary watersheds.

E. Exploratory Nested Modeling of Land Use Impact on Watershed Services

Our efforts to move much more seriously into systematic analysis of the impacts of land use change on environmental services, with particular focus on watershed services, were able to increase dramatically from collaborative assistance we received through the Alternatives to Slash-and-Burn Program (ASB), under its project on Functional Value of Biodiversity, which received major support from the World Bank – Netherlands Partnership Programme (BNPP). Most of the work discussed here was conducted during 2002 – 2003, and summarized in much more detail in a quite substantial ASB report[82], upon which materials in this section are based. Numerous references can also be found in that report. Work in Southeast Asia was led by Dr. Meine van Noordwijk at ICRAF's Southeast Asia Regional Office in Bogor, and Dr. Jeff Richey of the University of Washington led collaborative work related to application of the VIC and DHSVM models.

Natural forests are, rightly or wrongly, the global benchmark for both 'watershed functions' and 'biodiversity conservation'. While both these functions can be affected by forest conversion and further intensification of agriculture, the trajectories of both functions are essentially different. 'Watershed functions' can be defined as the way landscapes determine quantity, timing and quality of river flow, by the way they 1) transmit, 2) buffer and 3) gradually release the rainfall that is received, 4) modify water quality and 5) maintain the integrity of the soil capital in the catchment area. For these 5 'criteria' we developed quantitative indicators, applicable in assessments at different scales. There is only a very partial direct overlap between watershed functions in this sense and the ability to conserve, provide habitat and connectivity for biological diversity in landscapes. The relationships between land use change, watershed functions and biodiversity conservation are captured in a series of 10 hypotheses and 5 major questions studied in this project. We tested the hypotheses for internal consistency through the construction and use of quantitative simulation models that can be compared with actual data sets. We concentrated on the first three criteria and indicators in the project report.

Figure 52. Water balance model logic.

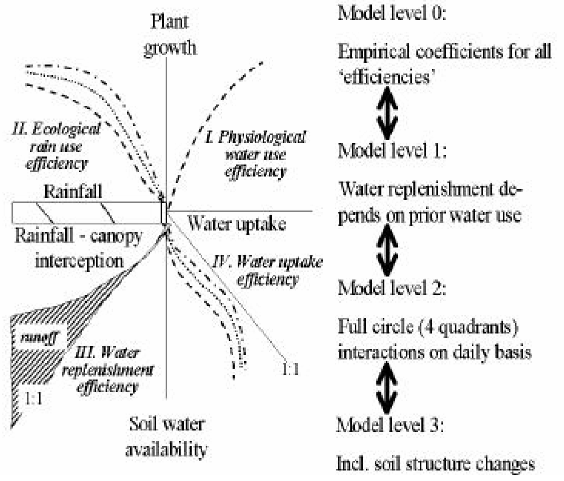


Two ASB benchmark areas in Southeast Asia were the focus of this study, Mae Chaem in northern Thailand and Sumber Jaya (Way Besai) in Lampung in the southern part of Sumatra (Indonesia) have an annual rainfall of about 1.5 and 2.5 m year^{-1}, respectively. Total water yield (after subtraction of an estimated evapotranspiration of 1.3 m year^{-1}) is about 0.2 and 1.2 m year^{-1}, or 15 and 50% of rainfall. These values may broadly represent the hydrology in subhumid and humid tropics. In Mae Chaem the difference between actual and potential evapotranspiration dominates the water balance via total water yield. In Sumber Jaya (Way Besai) changes in soil structure that partition total water yield over quick and slow flows are the main feature that needs to be better understood. An additional line of activity characterized water movement dynamics across the entire Mekong basin.

[82] Meine van Noordwijk, Jeffrey Richey, David E. Thomas. 2003. *Landscape and (Sub) Catchment Scale Modeling of Effects of Forest Conversion on Watershed Functions and Biodiversity in Southeast Asia*. Technical Report for Activity 2. Functional Value of Biodiversity (Phase II). Alternatives to Slash-and-Burn Programme (ASB). World Agroforestry Centre. Nairobi, Kenya. 238 pp.

The basic logic of a water balance that follows water in its passage through vegetation, soil and rivers to either the atmosphere or the ocean is easily captured in quantitative models. All of the models tested under this project are based on a similar 'water balance logic', but they differ in the details of the assemblage and filter rules that are used to predict river flows. Figure 52 diagrams links between patch-level water balance and catchment level hydrological functions.

Figure 53. Water use and model complexity



Models, if correctly implemented, allow for an explicit representation of the consequences of a series of assumptions. No model is correct, no model is wrong – but the assumptions may or may not be sufficient and necessary to reconstruct the phenomena that we can observe. As different modelers may have slightly different interpretations of the same set of assumptions, or differ in the assumptions they make, it is generally relevant to compare between different model implementations, even if they refer to broadly the same set of hypotheses. In the context of this study, we explored a number of models that were initially developed for different sets of circumstances, temporal and spatial scales. All models were used for a comparison of 'natural vegetation (baseline) versus current land use pattern', with current climate. There were also efforts to derive location-specific scenarios of plausible land use change that were evaluated for their bearing on hydrological functions.

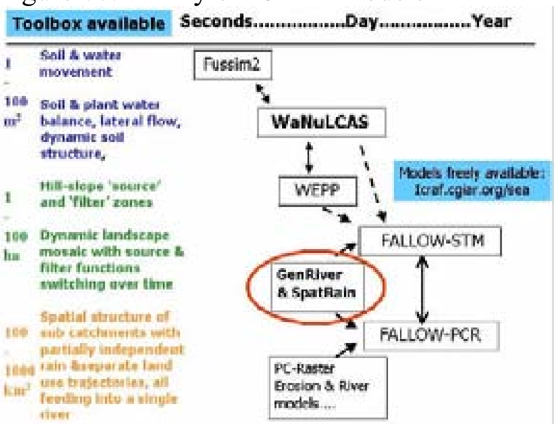
While most models follow a water balance logic, there are substantial differences in model complexity based on the number of feedbacks that are included in the interactions among vegetation, soil and rainfall. Figure 53 shows a four-quadrant representation of the relations involved in water use efficiency, and four model 'levels' depending on the use of interactions between quadrants rather than fixed coefficients; different lines relate to plants with different uptake efficiency and/or transpirational demand.

The simplest models ('null models') work on the basis of 'run-off coefficients' and 'water uptake and water utilization efficiency' and can thus relate total rainfall to both total water yield in rivers and plant production. Models at level 1 acknowledge that infiltration depends on prior water use. Models at level 2 include two-way interactions between all quadrants. Models at level 3, in addition, consider changes in soil structure and infiltration properties over longer time scales. The more complex the model the larger the number of parameters and the easier it is to 'fit' the model to any empirical data set, without gain in confidence for extrapolation to new situations. Yet, a number of the feedbacks are based on solid empirical evidence and their inclusion can enhance the range of model applicability.

For example, changes in land use can affect the various controls on infiltration of rain into soils, through differences in water use of vegetation relative to potential evapotranspiriation (although differences are likely to be bigger during a 'dry season' due to differences in deciduousness), by: (a) providing a protective cover that slows down (and evens out) the rate at which water reaches the soil surface; (b) providing continuous protection of the mineral soil via a litter layer that also stimulate soil biota that increase soil porosity, or expose the soil to sun and rain with opportunity for slaking and sealing; (c) providing more or less temporary water storage opportunities at the soil surface, and thus increasing or decreasing the time available for infiltration; (d) increasing or decreasing macroporosity of the soil, and thus the propensity for 'soil quick flow' rather than overland flow. While nearly all models include means for predicting impacts of land use change on simpler types of infiltration controls, only 'level 2 and 3' models include the full range.

All models predict a 'hydrograph' of the daily (or monthly) rate of flow at specific points in the drainage network, and from this the annual water yield and dry season river flow can be inferred. But in deciding on an appropriate process description for a model of the water balance, choices for spatial and temporal scale need to be linked. Models that describe soil physical details of the infiltration process may need to consider a time scale of seconds, as there are rapid changes in hydraulic conductivity during infiltration into dry soils, and consider spatial units of 1 cm^3 or less as a basic entity, since integrating them over more than one or a few m^2 may put limits on the speed of model execution.

Figure 68. Family of ICRAF models



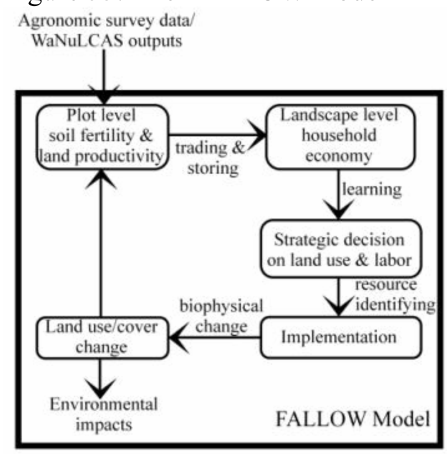
1. Models used by ICRAF

Main relations among the 'family' of models developed and/or used by ICRAF are shown in Figure 54. The models and technical descriptions (except for WEPP) are available on the ICRAF website. Four applications used here include:

FALLOW

The FALLOW model is a spatially explicit landscape dynamics model that considers households of farmers as the change agents and comprises the following main annual dynamic processes (Figure 55):

Figure 55. The FALLOW model



- plot-level soil fertility dynamics in crop and fallow phases affecting agricultural crop production and plot-level productivity of other land uses (e.g. NTFPs, agroforestry, monoculture plantation, etc.);
- food consumption and storing by agents, that may involve exchange of other resources through trading (i.e. food and any other yields), with options along the spectrum from 'full dependence on local food production' to 'fully market-integrated' economy, affecting landscape level household economy;
- agents' learning on expected profitability of various land use options, affecting the decisions on increase or decrease of the area cropped, adopted land use systems and labor allocation;
- plot-level implementation of strategic decisions by agents through resource availability identification, covering labor and preferred sites availability;
- ecosystem succession and growth. FALLOW also provides impact assessment toolboxes on how the resultant mosaic of land cover will affect watershed functions (annual water yield, base flow, net sediment loss), biodiversity indicators and carbon stocks.

Initially developed as a Stella model, FALLOW has now been re-implemented in the spatially explicit modeling environment of PCRaster, making it possible to apply the model to larger landscapes with real spatial data sets. FALLOW can be used for impact assessment and scenario studies, assisting the negotiation process between stakeholders in a changing landscape by visualizing possible/likely consequences of factors such as changes in prices, population density and human migration, availability of new technology, spatial zoning of land use, pest and disease pressure or climate.

Staying essentially at a yearly time step, the FALLOW model differs from the hydrological null-model in that it:

- integrates over a mosaic of patches that each have their own runoff fraction (linked to slope, soil conditions and land cover history) and current water use depending on the vegetation,
- considers spatially explicit changes in land cover in a mosaic context, which have impacts on soil physically quality and thus infiltration and runoff,

- includes human agents' decisions on land use driven by overall targets and a spatially explicit rule set for implementation,
- includes rules for surface erosion and deposition in filter zones,
- allows for estimation of a number of biodiversity indicators, and thus for studying trade-offs between land use intensity, watershed functions and biodiversity.

For the Mae Chaem situation, we began with parameterization of the FALLOW model for a subsistence-oriented sequential agroforestry (rotational shifting cultivation) system that is experiencing a steady reduction in the length of its fallow period, during which soil recovery is associated with regenerating forest vegetation.

GenRiver.

The GenRiver model was designed to bridge between 'parsimonious' (few parameter) models that are essentially fitted to empirical data, and distributed process-based models, by gradually allowing the parsimonious model to be spatially differentiated, as the need arises. The core is a 'patch level' representation of a daily water balance (Figure 56), driven by local rainfall and modified by the land cover and soil properties of the patch. The patch can contribute to three types of stream flow: surface-quick flow on the day of the rainfall event, soil-quick flow on the next day and base flow, via the gradual release of groundwater. The overall water balance of the model is, summed over space and time (Figure 57):

Figure 56. GenRiver

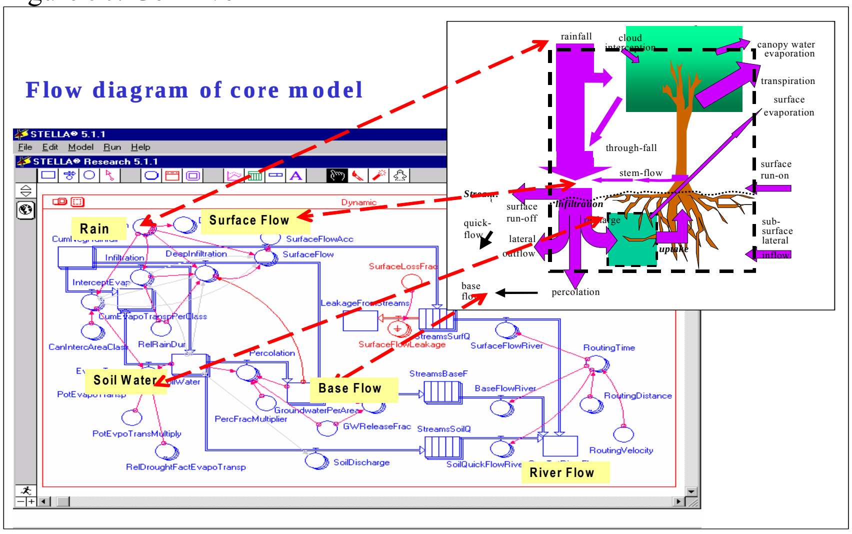
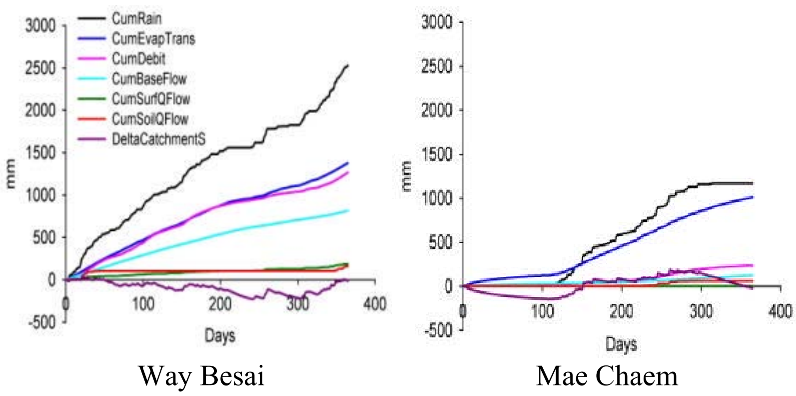


Figure 57. Cumulative water balance of current land use mosaics



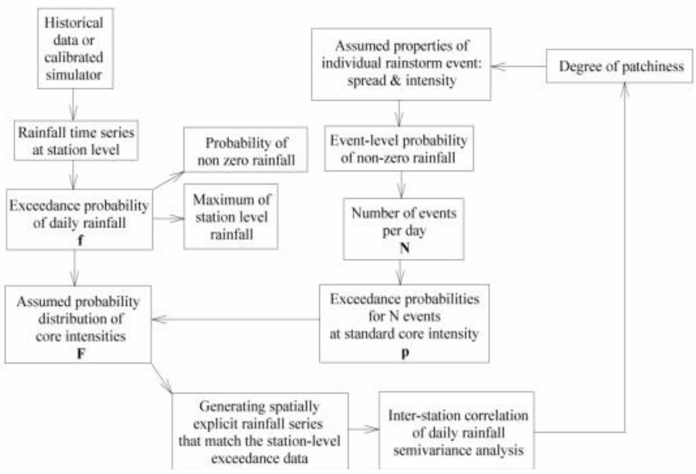
For long-term behaviour the changes in soil and groundwater storage, as well as changes in the volume of streams and rivers will be negligible, while the error term should be negligible at all times if the model is correctly implemented. On shorter time scales, however, the changes in storage in soil, groundwater, streams and rivers are critically important for the variability in (daily) river flow as reflected in the 'hydrograph'. If measured data for river discharge are entered, a direct comparison of measured and simulated river discharges can be made.

In GenRiver, a ***river*** is treated as a summation of ***stream***s, each originating in a ***subcatchment*** with its own daily rainfall, yearly land cover fractions and constant total area and distance to the river outflow (or measurement) point. Interactions among streams contributions to the river are considered to be negligible (i.e. there is no 'backflow' problem). Spatial patterns in daily rainfall events are translated into average daily rainfall in each subcatchment in a separate module. The ***subcatchment*** model represents interception, infiltration into soil, rapid percolation into subsoil, surface flow of water and rapid lateral subsurface flow into streams with parameters that can vary between land cover classes.

SpatRain.

Variations in river discharge tend to decrease with increasing area of consideration, partly due to a decrease in temporal correlation of rainfall events across space. Patchiness of rainfall can contribute to an increase of yield stability over space. Existing rainfall simulators tend to focus on station-level time series, not on space/time autocorrelation. The SpatRain model was constructed to generate time series of rainfall that are fully compatible with existing station-level records of daily rainfall, but yet can represent substantially different degrees of spatial autocorrelation. Calculations start from the assumed spatial characteristics of a single rainstorm pathway, with a trajectory for the core area of the highest intensity and a decrease of rainfall intensity with increasing distance from this core. The model can derive daily amounts of rainfall for a grid of observation points by considering the possibility of multiple storm events per day, but not exceeding the long-term maximum of observed station-level rainfall. Options exist for including elevational effects on rainfall amount. SpatRain is implemented as an Excel workbook with macros that analyze semi-variance as a function of increasing distance between observation points, as a way to characterize the resulting rainfall patterns accumulated over specified lengths of time (day, week, month, year). The SpatRain model starts from the spatial characteristics of a single rainstorm pathway (with a trajectory for the core area of the highest intensity and a decrease of rainfall intensity with increasing distance from this core) and can derive daily amounts of rainfall for a grid of observation points by considering the possibility of multiple storm events per day (Figure 58).

Figure 58. SpatRain model calculation flow diagram



The SpatRain simulator is freely available on our website (http://www.worldagroforestrycentre.org/sea/products/AFmodels/spatrain.htm). The current version of the program is developed using VB macro in an Excel workbook. Application to the Mae Chaem area at a 3 km^2 grid cell resolution proved to be at the edge of the program's capability. To overcome the memory limitations, a standalone version of SpatRain has been developed using Java programming language.

WaNuLCAS,

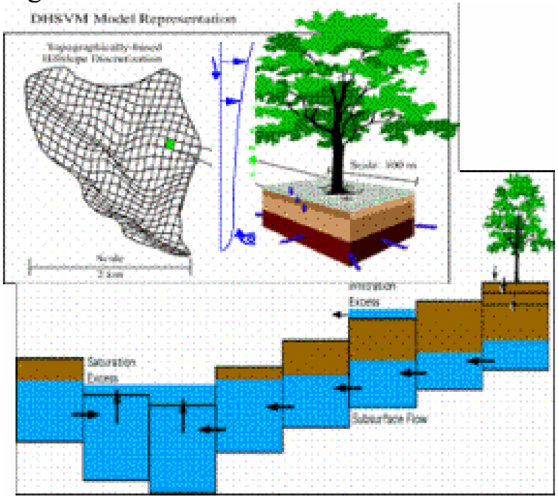
For a number of simulations reported here we made use of the detailed ('level 3') water module of tree-soil-crop interactions in WaNuLCAS (Water, Nutrient, and Light Capture in Agroforestry Systems). The WaNuLCAS model was developed to simulate a range of tree–soil–crop interactions in agroforestry systems, for a wide range of soil, climate and slope conditions. Basic ecological principles and processes are incorporated into the model using modules such as climate, soil erosion, sedimentation, water and nutrient balance, tree growth and uptake, competition for water and nutrients, root growth, and soil organic matter and light capture. Where most models operating at landscape scale need information about infiltration, they are not able to describe this important process at the relevant time-scale. As there is important variation between soils in infiltration rates and there is no direct way to derive such information at the scale required for our models, we need estimation procedures, or 'pedotransfer' functions. Detailed discussions of how WaNuLCAS was applied in these studies are in the project report.

In addition, two broader-scale water balance models were applied through collaboration with Dr. Jeff Richey and his team at the University of Washington and colleagues at Chulalongkorn University. The Variable Infiltration Capacity (VIC) model was applied in an analysis of the dynamics of water movement across the entire Mekong basin, which we will not discuss here. However, we did collaborate directly in supporting their application of the Distributed Hydology, Soil and Vegetation Model (DHSVM) in Mae Chaem.

Deforestation and upland cultivation in the Mae Chaem watershed are believed to be the cause of lowland flooding and lack of dry season water supply. One purpose of this study was to simulate and analyze the historic and current seasonal and annual characteristics of hydrologic response in Mae Chaem. The second objective was to forecast the stream flow regime and annual water yield based on three future scenarios of land-use change, with the focus on the conversion from forest to croplands and *vice versa*. Because the agriculture in this region relies on irrigation, the comparisons of the results both with and without irrigation diversion were considered. The project also aimed to evaluate the far-field effect of stream flow due to the spatial variation in land-use change. This modeling work can be a useful tool for water resource management and flood forecasting for small catchments undergoing rapid commercialization.

DHSVM: The Hydrology Model.

Figure 59. DHSVM



Application of a larger, regional-scale model such as the Variable Infiltration Capacity (VIC) model would not accurately represent the steep topography and finer-scale issues of the Mae Chaem basin. So to examine problems at this scale, we opted to use a higher resolution hydrologic model, the Distributed Hydrology Soil Vegetation Model (DHSVM)

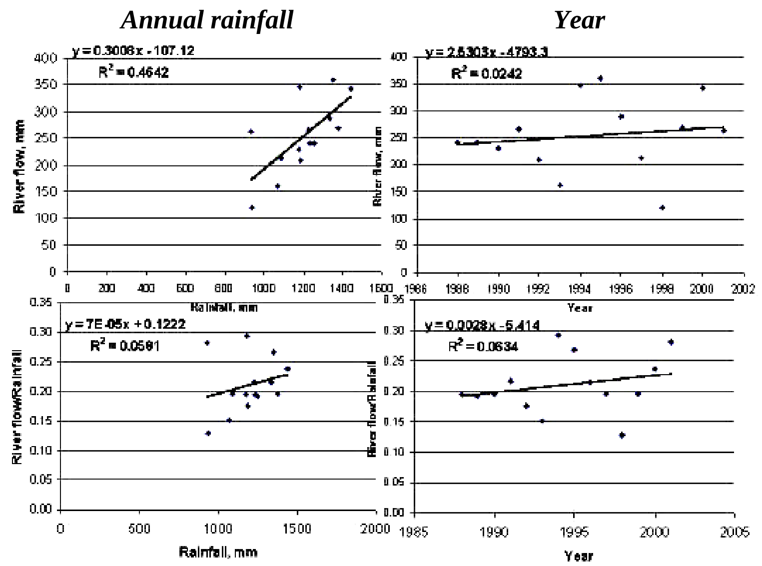
Unlike VIC, DHSVM is intended for small to moderate drainage areas (typically less than about 1000 km^2), over which digital topographic data allows explicit representation of surface and subsurface flow. Like VIC, it represents runoff generation via the saturation excess mechanism. Unlike VIC, it explicitly represents topographic effects, including the formation of perched water tables on runoff generation and incident solar radiation (hence net radiation), as well as vegetation and its properties (like root depth) and soil parameters, on a pixel-by-pixel basis. The model grid resolution typically is 30-150 m, several orders of magnitude higher than VIC. However, because of the large computational burden (and data limitations), DHSVM is restricted to relatively small catchments. Some limited experiments have been conducted comparing the sensitivity of DHSVM and VIC to vegetation change. Although the macro-scale performance of the two models is similar in gross features (e.g., ability to reproduce seasonal fluctuations in runoff), there are important differences in predicted runoff and other surface fluxes, especially at shorter time scales. Details about application of DHSVM in Mae Chaem are provided in the study report.

2. Summary findings on total water yield

Studies confirmed that the total amount of water supplied to downstream users generally increases with forest conversion to upland agriculture, but will be reduced to levels of the original forest or below that if irrigated agriculture or reforestation with fast-growing trees become a major water user. This overall effect of land cover change can be directly predicted by summation over the plot-level water balance, as total river discharge equals rainfall minus evapotranspiration, when considered at time scales where changes in the storage terms can be ignored. As the absolute changes in water use due to land use change are approximately equal across a wide range of annual rainfall values, the relative effects are highest in the driest areas considered.

For the Mae Chaem study area in northern Thailand and for the Mekong river system as a whole, with annual rainfall of around 1.5 m year^{-1}, land-use induced changes in total water yield can lead to a doubling of the total discharge volume (from 13 to 25% of estimated annual rainfall) and to a significant increase in flooding risk for parts of the river where technical control over river flow through reservoirs is limited. For the Mae Chaem study area, river discharge was about 20% of station-level rainfall, but area-averaged rainfall may be considerably higher than the data for the rainfall station suggest. Figure 60 shows relationships between annual river discharge (upper panels) and discharge per unit rainfall (lower panels) of the Mae Chaem river (P14 station) in relation to annual rainfall (left panels) and year (right panels) for the period 1988 – 2000. There was no significant trend with time for either rainfall or river flow.

Figure 60. Relations between river discharge *(upper)* and discharge per unit rainfall *(lower)* of the Mae Chaem River



While the various hydrological models broadly agree on the direction and size of these effects on total water yield, public policy and investment remain often based on expectations of increases in total water yield as effect of 'reforestation'. In the absence of effects of such land cover change on rainfall, there is no known mechanism or empirical data set to support the views underlying such policies.

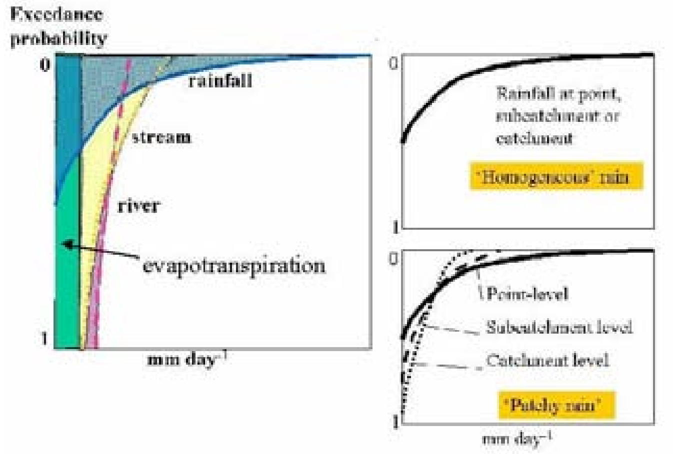
3. River flow fluctuations

More controversial is the impact of land use change on the 'evenness' of river discharge or the degree to which river discharge is buffered relative to rainfall peaks. Both high peak discharge, that leads to flooding of downstream areas and is generally linked to reduced infiltration into the soil and increased channeling of drainage, and low levels of base flow that are the result of reduced infiltration into the soil and/or increased uptake of soil water by trees are generally considered to be undesirable. A newly defined 'buffering indicator' allows the empirical study of changes in buffering. For a watershed in Indonesia a change in forest cover from 60 to 10% and conversion to a coffee dominated agroforestry landscape lead to a decrease in buffering (on a scale from 0 to 1) by 0.15, from 0.85 to 0.7. This means that twice as much water flows in the river as 'above-average flow'. Modeling studies suggest that a conversion to open-field agriculture with ensuing degradation of soil structure could reduce the buffer indicator by a further 0.2, trebling the total amount of 'above-average' river flow relative to the forested condition of the watershed.

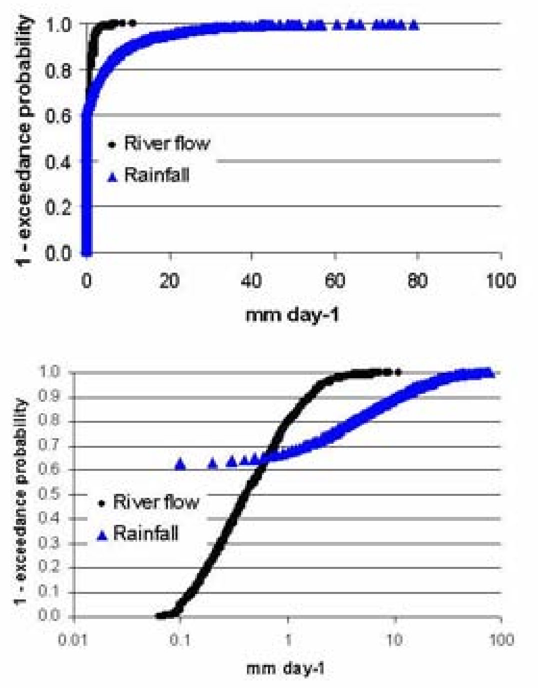
Empirical and modeling studies for Mae Chaem in northern Thailand show only a small change in buffering indicator in response to the land use change in the past decades. With the absence of a trend with time, we can pool the data over the period available and look for the frequency distributions of both rainfall and river flow in the form of exceedence probabilities (Figure 61). When presented in this way, we see that the river flow has a considerably lower maximum and higher minimum, but otherwise similarly shaped distribution. A comparison of the shape of these two curves can lead us to a 'buffering indicator'. For Mae Chaem, this buffering indicator (the above-average river flow per unit above-average rainfall) is about 0.95 for the 1988 – 2001 period, and does not show a clear trend with time or annual total rainfall. The study also explored seasonal effects on buffering and orographical effects on rainfall in Mae Chaem..

As previous studies indicated a lack of empirical evidence for effects of land use change on river flow (except for water quality linked to point-pollution), we explored the hypothesis that spatial variability of rainfall enhances the 'buffering' of river flow and reduces the potential impact of land cover change on the time pattern of river flow. An internally consistent model representation can indeed 'explain' a reduced sensitivity of the buffering indicator to land use change with increasing spatial scale. This effect may help in defining the decreasing degree to which downstream land users are real 'stakeholders' in upland land use, as they live at increasing distance.

Figure 61. Exceedance value as buffering indicator



Mae Chaem exceedance values: linear** (upper) **& logarithmic



(based on data during 1988 – 2001)

4. Water Quality

Water quality, as third category of watershed functions, can be strongly affected by land use change if organic pollution linked to human settlement and agro-chemicals directly reach the streams. Sediment loads of rivers, linked to enhanced erosion, depend strongly on the spatial organization of a landscape, rather than on average degree of forest cover. Model calculations suggest that riparian forests may be more effective per unit of forest cover in reducing net sediment loads of rivers than forests in other landscape positions. Integrity of riparian buffer zones can play an important role in biodiversity conservation and thus there is at least some parallelism between land use patterns that favour watershed functions and biodiversity conservation. But our overall conclusion is that the two function groups have essentially different thresholds and dependencies on specific land use decisions, making them separate domains for policy attention.

5. Plausible scenarios of future change

A set of four scenarios for 'plausible' land use change was developed by Dr. Louis Lebel of the Unit for Social and Environmental Research (USER) of the Chiang Mai University Faculty of Social Sciences, for the Upper Ping River Basin driven by forces in society scenarios that emphasize food production or environmental conservation. The four scenarios, "Fields and Fallow", "Food Bowl", "Parks and Cities" and "Agro-forests", in turn, can be thought of as being nested in larger scale scenarios about national and regional global development (Figure 62). These larger scale scenarios are being developed by the Global Scenarios working group of the Millennium Ecosystem Assessment. In this study the four scenarios for the Ping Basin were applied to the Mae Chaem sub-basin.

This was done in three steps.

- First, an analysis of historical land-use change over the past 10 and 20 years was made using multiple regression techniques.
- Second, 'soft' models were constructed to make explicit some of the main assumptions underlying each of the scenarios and how they could be articulated in a quantitative model of landscape evolution (Figure 63).
- Third, a platform for modeling and visualization landscape evolution was built in Visual C++.

Figure 62. Framework for landscape evolution scenarios

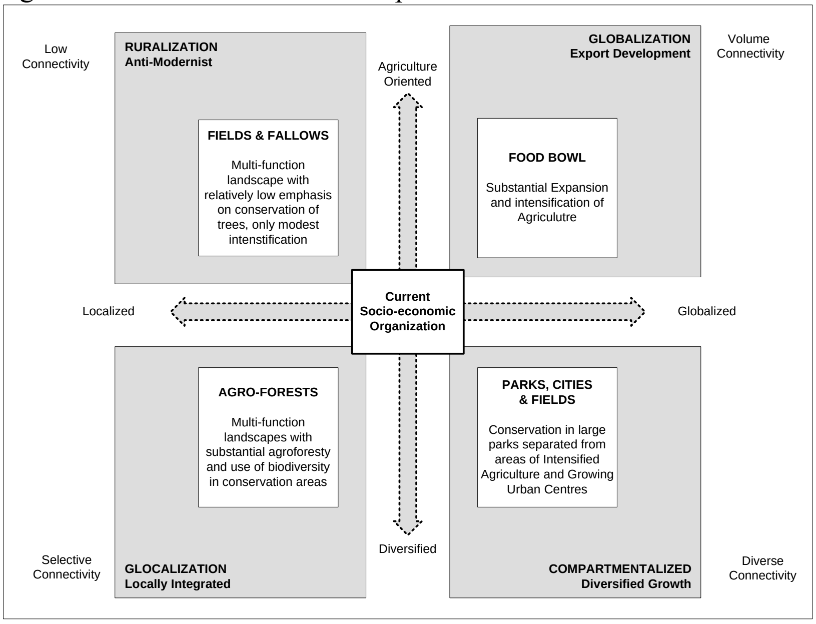
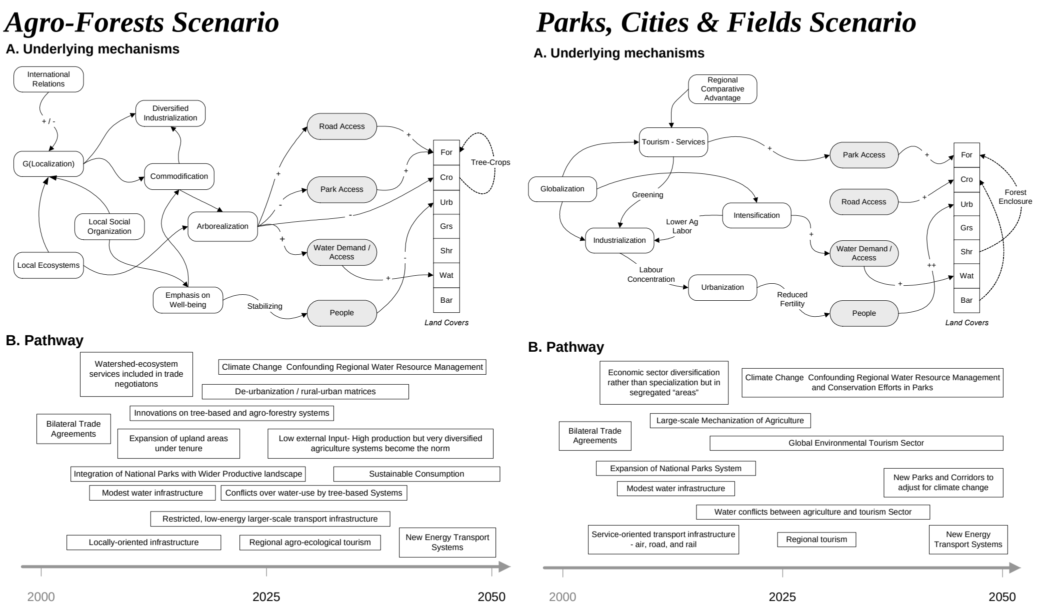


Figure 63. Examples of scenario mechanisms and pathways



This allowed us to include both systems of differential equations based on regressions of land-use change on a set of categorically transformed predictor variables, and rule-based processes. The first version of the model with which the set of simulated landscapes presented here is based largely on modifying small subsets of the underlying regression coefficients guided by the soft models. Land-covers modeled were: orchard, paddy, field crop, hi-value intensified crop, fallow/secondary shrub, human settlements. Other land-uses such as water bodies were assumed to stay constant. Predictor variables were similar to those shown in the soft model diagrams, including, for example, elevation, past land use, estimates of travel times and distance to water. The scenarios differ in the degree of forest cover they predict for Mae Chaem in 50 years time, ranging from 25% for the 'Food bowl' to 50% for the 'Parks' scenario (Figure 64). Hydrological evaluation of these plausible future landscape configurations using GenRiver led to some differences in total water yield, but relatively small changes in predicted buffering (Figure 65).

Figure 64. Projected 50-year land use change under plausible scenarios

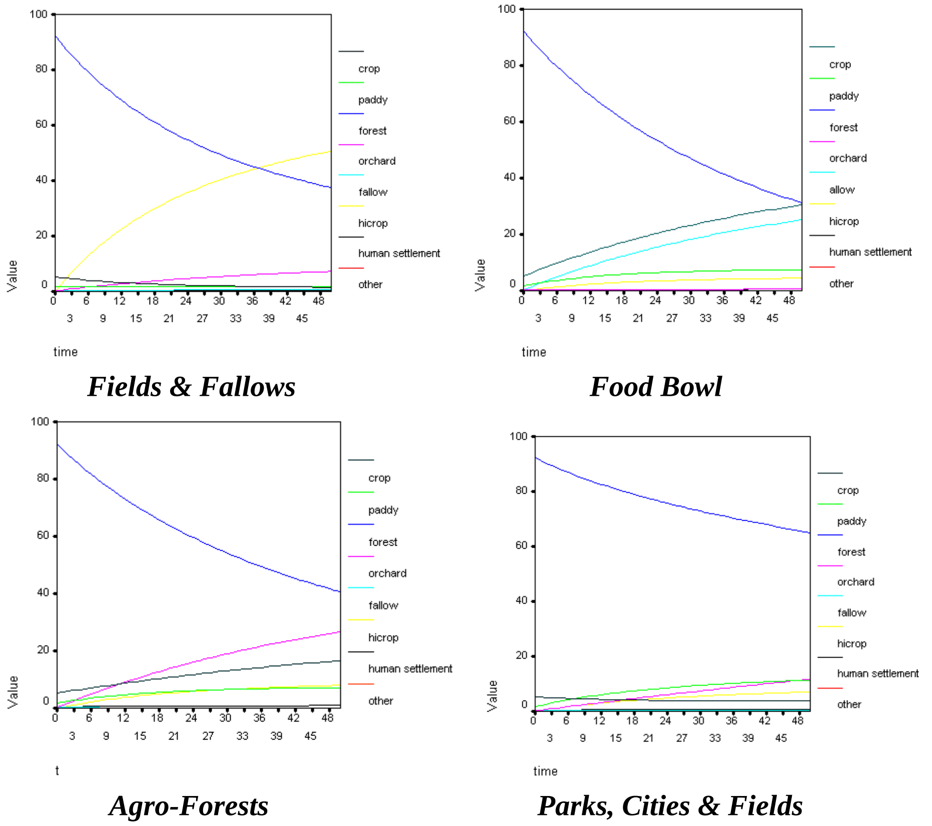


Figure 65. GenRiver estimates of impacts of alternative scenarios on hydrological functions

	Actual Data	GenRiver			Plausible Scenarios (GenRiver)				
Indicators	Current Land Use	Current Land Use	All Forest	All Grass	Current Land Use	Parks	Agro-Forest	Fields& Fallows	Food bowl
Total Discharge Fraction	0.21	0.19	0.13	0.32	0.19	0.25	0.28	0.33	0.38
Buffering Indicator	0.89	0.90	0.93	0.81	0.9	0.86	0.84	0.79	0.8
Relative Buffering Indicator	0.49	0.45	0.54	0.40	0.45	0.46	0.44	0.39	0.48
Buffering peak events	0.91	0.88	0.91	0.79	0.88	0.86	0.84	0.8	0.83
Highest Monthly Discharge relative to mean rainfall	3.16	3.67	3.01	3.37	3.67	3.06	3.12	3.24	2.77
Lowest Monthly Discharge relative to mean rainfall	0.20	0.22	0.27	0.24	0.22	0.24	0.24	0.21	0.25
Overland Flow Fraction	*	-	-	-	0	0	0	0	0.08
Soil Quick Flow Fraction	*	0.08	0.03	0.17	0.08	0.13	0.15	0.19	0.17
Slow Flow Fraction	*	0.14	0.08	0.12	0.14	0.1	0.11	0.12	0.11

6. Conclusions for natural resource management

Based on the overall results of simulations and analyses conducted under this line of activities, the following conclusions were seen as having particular relevance for natural resource management:

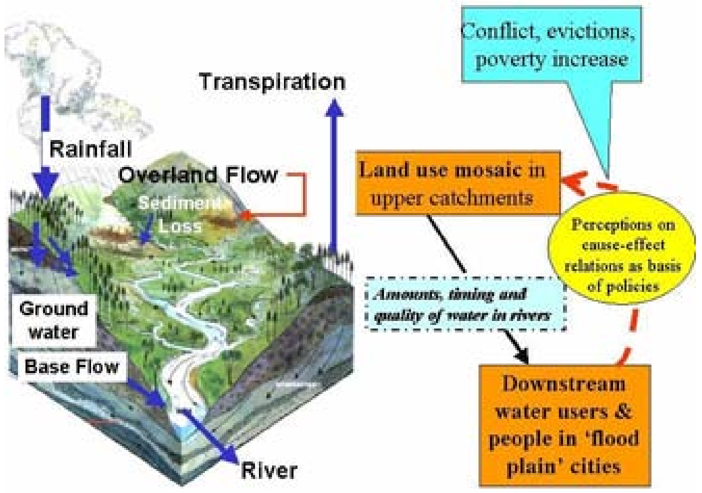
- From a natural resource management perspective ‘watershed functions’ and ‘biodiversity conservation’ are clearly separate issues, as the thresholds for change during land use intensification differ substantially; indicators at plot, landscape, sub-catchment and catchment scale of the historical land use change between ‘natural vegetation’ and ‘current land use pattern’ suggest that watershed functions involved in the transfer, buffering and gradual release of water are maintained (or even improved as far as total water yield is concerned), despite considerable loss in biodiversity value. Only upon further intensification of land use with a dominance of open –field agriculture (or built-up urban areas) will these watershed functions be affected negatively. The separation of ‘watershed functions' and 'biodiversity conservation' agendas at a policy level has important consequences for the overlap in stakeholders. Only in very specific circumstances can we expect local interests in maintenance of watershed functions to lead to the type of land cover that is optimal for biodiversity conservation.

- The empirical scaling rule that relates maximum daily flows (and thus flooding risks) to area to the power 0.75 and mean annual flows to area as such, suggests that flooding risk is a 'local hazard' and total water yield a 'positive far field effect' of forest conversion. The scaling rule can be understood from the spatial pattern in rainfall, only in combination with a (land cover dependent) intercept in the rainfall-runoff relationship. It is thus likely that land cover change cannot only affect the maximum flows at plot level, but also the inherent scaling rule. The scaling rule for species richness (roughly proportional to area to the power 0.25) differs essentially from that for watershed functions, and we can thus expect the trade-off between biodiversity and watershed functions to differ with the area under consideration. For biodiversity values a 'segregate' scenario with areas of high biodiversity value effectively protected in a landscape otherwise optimized for productive functions may be optimal. For watershed functions a more 'integrated' land use mosaic that prevents any area from degradation beyond critical thresholds is preferable. The combination of the two functions, in terms of specific conservation areas in a 'matrix' of an agroforestry mosaic that allows for both productive and protective functions requires separate management and regulatory approach to the two types of areas and specific attention to their interface
- Where earlier summaries of the impact of land use change on watershed functions had found little solid evidence for areas larger than 100 km^2, our data for Way Besai (400 km^2) and Mae Chaem (4000 km^2) provide empirical evidence for an increase in total water yield as well as changes in buffering for the former, for a period of drastic land cover change (60 -> 15% forest cover); for the Mae Chaem the historical land cover change has been less dramatic that that in Way Besai, but simulation models suggest that a significant increase in water yield between natural vegetation and the current land use mosaic has taken place; plausible scenarios of further land use change will continue on this trend towards greater water yield and less tree and forest cover.
- The current evidence from historical change in the benchmarks and from the (validated) models suggests that increases in peak flows are proportional to changes in total water yield; more-than-proportional increases in peak flows only are expected for land use scenarios that lead to substantial soil degradation
- Realistic land use change scenarios for the uplands of Asia have to provide livelihood and income opportunities for substantial rural populations that often include relatively poor and disadvantaged ethnic minority groups. Declaring large areas as 'forest reserves' and expecting farmers to leave is not realistic. Mosaics with tree-based production systems, rather than open-field crops may provide the best way to provide income while maintaining soil conditions conducive to infiltration. The biodiversity value will depend on the opportunity to reserve (segregate) parts of the area for specific conservation purposes, in a socially integrated way. The impacts of land use patterns on biodiversity are likely to exceed the impacts on watershed functions.
- Specific attention to riparian zone forests as landscape elements that can reduce sediment loads of streams as well as play a role in connectivity for plants and animals is warranted; this may be one of the main items where a watershed function and a biodiversity conservation agenda find synergy; a second shared interest is likely to be in the maintenance of wetlands along the river, that can provide a buffer function reducing the risk of flooding downstream, as well as providing important habitat for flora and fauna.
- Ridge top forests can also play an important role as corridors for flora and fauna and thus for biodiversity conservation, especially where human access is primarily linked to the valleys. Ridge top forests (but not their spatial continuity) are relevant for protecting groundwater flows that are tapped for drinking water or other situations where water quality is of specific interest. The emphasis on riparian forests may thus need some nuance.

- While the benefits of forest conversion for total water yield form a positive ‘far field’ effect, the associated higher peak levels require adjustments in the stream bed, depending on the degree to which barrages and dams regulate flows and provide temporary storage
- Local hazards of a change in watershed functions are likely to be more clearly identifiable, both because of the relative size of the ‘insult’ is likely to be larger, and because of intrinsic scaling properties for peak flows. Local stakeholders are likely to have a clear interest in protecting the areas from where they derive their drinking water, as well as areas that stabilize slopes above villages or other vital functions; this type of land use zoning will differ from the broad land use classifications that were developed for many countries in SE Asia, with little implementation on the ground. Where land use zoning is derived from a local negotiation process and supported by local monitoring of water quality and other indicators of watershed functions, local ecological knowledge is more likely to acknowledge the changes in effective infiltration than spatial extrapolation methods based on currently available soil information.
- Protecting existing forests on slopes with soils that allow high infiltration rates makes sense, both for water quality and potentially for supporting dry period/season flows, especially where annual rainfall is more than say 1500 mm $year^{-1}$.
- Expectations of a recovery of infiltration based on planting trees are seldom realistic (except for the direct early effect of planting holes in sealed-surface conditions), and the net effect of rapidly increasing water use and slowly recovering infiltration on dry season flows is likely to be negative for a time frame beyond 'projects' life spans.
  - In the interactions between stakeholders in real landscapes, the tangle of convenient myths, half-baked perceptions, sound experience and valid concerns needs to be acknowledged as such – science-based evidence can only help if it can provide a common platform for discussions.

The main policy problem on ‘watershed functions’ may be in the perceptions that exist in lowland and urban communities about the role of forests in providing such ‘functions’, without specifications of how other land use would actually affect them (Figure 66). A coherent analysis of the local ecological, public/policy and ecological/ hydrological science perspectives on watershed functions, informed by actual observables in case study areas may be needed to move the policy agenda forward and effectively communicate results (that may be contrary to ‘intuition’, current and past support for ‘reforestation’ efforts) to the audiences that negotiate decisions.

Figure 66. Where is the watershed service problem?



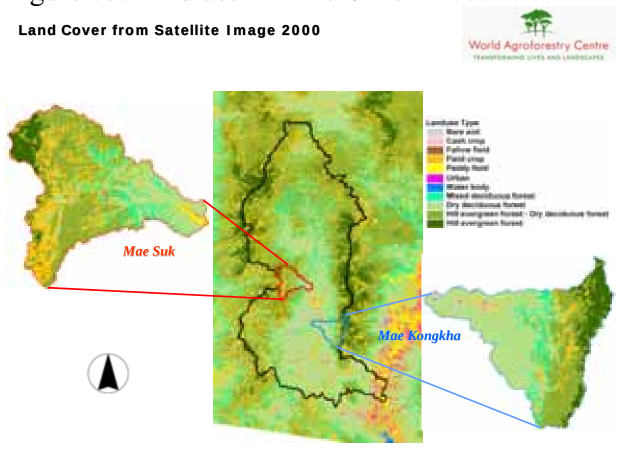
7. Continuing Work on Agroforestry Landscape Impacts on Watershed Functions

This further line of modeling work is still very much in progress, and is allowing us to pursue in considerably more detail various important lines of work begun under activities summarized in the previous section. The following activities are being conducted under a project entitled How do changing agroforestry landscape mosaics in Southeast Asia impact on watershed functions?, which is supported under a grant provided by ACIAR. Again under the regional leadership of Dr. Meine van Noordwijk, these activities also include collaboration with Dr. Barry Croke of the Australian National University (ANU) and Dr. David Post of CSIRO, who also bring additional modeling tools for further exploration of land use impacts on watershed services at our research sites in Mae Chaem and in Indonesia. Most of these more detailed studies are focusing on the Mae Suk and Mae Kong Kha sub-watersheds (see figures in chapter VI). Component studies currently being conducted in Mae Chaem include:

Analysis of recent changes in land use patterns

In order to assist with more detailed analysis of trends in land use change taking place in Mae Chaem during recent years, Dr. Thaworn Ornpraphai of the CMU Multiple Cropping Center is collaborating with Ms. Anantika Ratnamhin and other ICRAF-Chiang Mai GIS staff in conducting image processing and analysis of a time series of satellite data from 1989, 1994, 1996, 1997, and 2000. Analysis of data from 2000 is displayed in Figure 67.

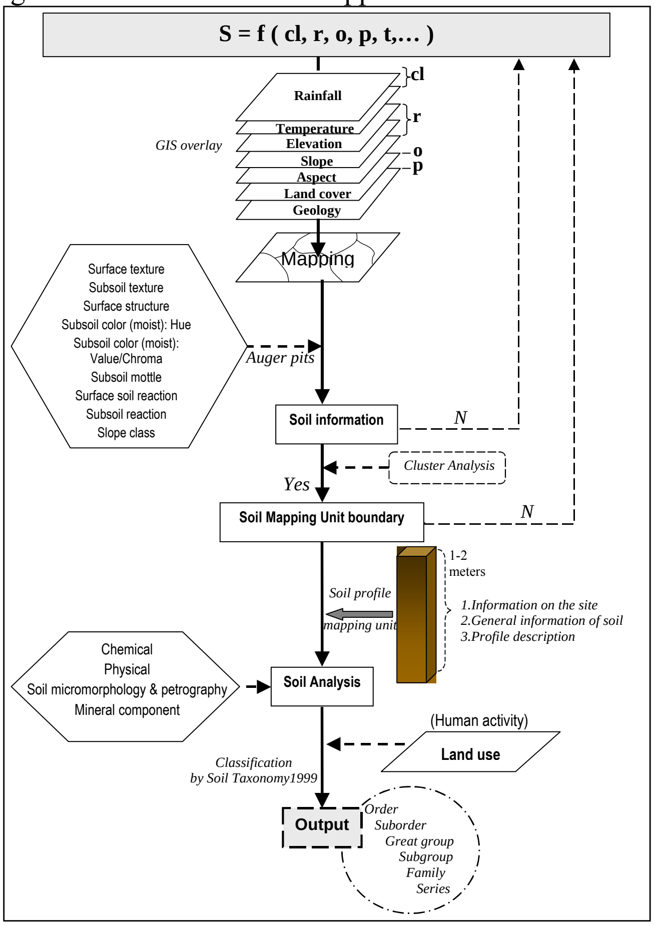
Figure 67. Land use in Mae Chaem 2000



Soil classification in mountain areas

As almost all of Mae Chaem is mapped as ‘slope complex’ in Thailand’s soil maps, we need better estimates of soil information to use in further refinements of the various models we are applying there. Thus, Dr. Niwat Anongrak of the CMU Department of Soil Science and Conservation is collaborating with ICRAF Chiang Mai staff in developing a digital soil map and soil information database. The overall nature of their approach is diagrammed in Figure 68.

Figure 68. Soil classification approach



Water use by mountain area irrigation systems

In order to help improve the level of detail in our watershed models, ICRAF Chiang Mai staff have conducted field surveys in the Mae Suk and Mae Kong Kha sub-watersheds to identify, classify, and georeference all types of irrigation wiers and irrigation systems.

Functions of landscape filter elements

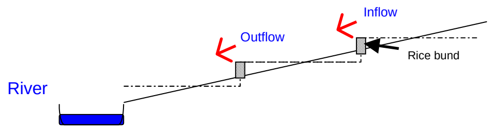
In order to help assess the effectiveness of existing filter elements in the landscape, and incorporate these effects into spatially explicit models of soil and water movement at plot level and in landscape mosaics, studies are being conducted on two types of filter elements found in the Mae Suk and Mae Kong Kha sub-watersheds: Paddy fields are being studied by Chanwit Soonthornmuang of ICRAF Chiang Mai, while riparian vegetation is being surveyed by Dr. Prasit Wangpakapattanawong of the CMU Faculty of Science (Figure 69).

Landscape and river flow models

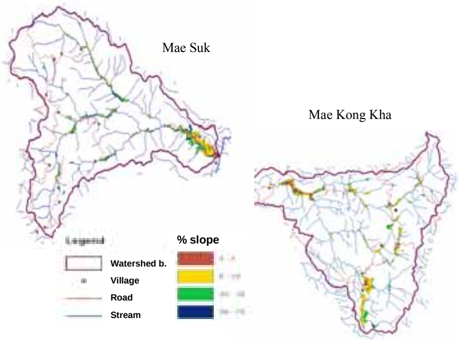
The above activities, together with additional analyses being conducted by our colleagues based at ICRAF-Bogor, ANU and CSIRO, will feed into further refinements of our applications of FALLOW, and GenRiver models in Mae Chaem (see previous section), as well as comparative application of the Variable Infiltration Capacity (VIC) model in Mae Chaem. Dr. David Post and his team is also collaborating with the ICRAF Chiang Mai team to test the SubNet model for application in identifying sources and fates of sediments in Mae Chaem.

Figure 69. Landscape filter studies

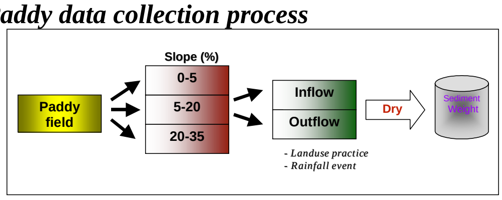
Paddy fields in sloping areas



Paddy fields in Mae Suk and Mae Kong Kha



Paddy data collection process

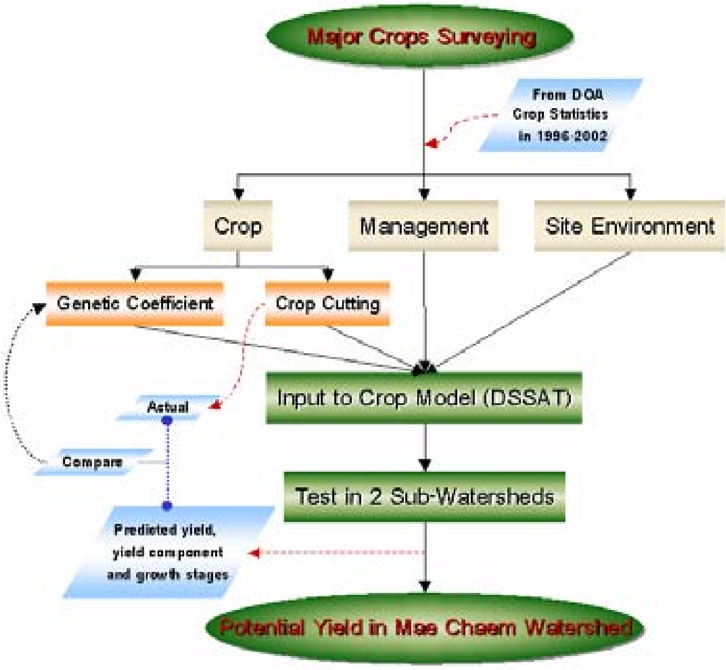


Riparian vegetation survey

Agricultural patch-level studies

This work focuses on crop modeling work in Mae Chaem using DSSAT4 to assess the potential of crop production in agricultural patches within landscape mosaics. Shortly before initiation of this project, ICRAF and ASB-Thailand staff began collaborating with researchers at the Chiang Mai University Faculty of Agriculture's Multiple Cropping Center (MCC) in conducting some crop trials aimed at exploring potential for increasing the productivity of crop production in small areas of irrigated paddy lands nestled in upper tributary sub-watersheds of our benchmark research site in Mae Chaem. While these preliminary trials indicated there are cultivars and management practices that may be able to help increase production from these pockets of paddy lands, and thereby reduce dependence on upland fields, it also became clear that given the wide range in local ecological and locational conditions, we would need a more robust approach to make more significant progress in addressing these issues in a manner that would have more general applicability. Thus, the following line of work on crop modeling was initiated under this project, and is now being continued under support from other sources.

Figure 70. Framework for crop modeling activities.



In order to address questions related to the role of improvements in crop production technology in helping to identify alternatives that could simultaneously improve local livelihoods that are increasingly dependent on commercial agricultural crops, while minimizing pressure to convert forest to upland fields in steeply sloping lands of upper watershed

Figure 71. Crop Modeling Data Sites

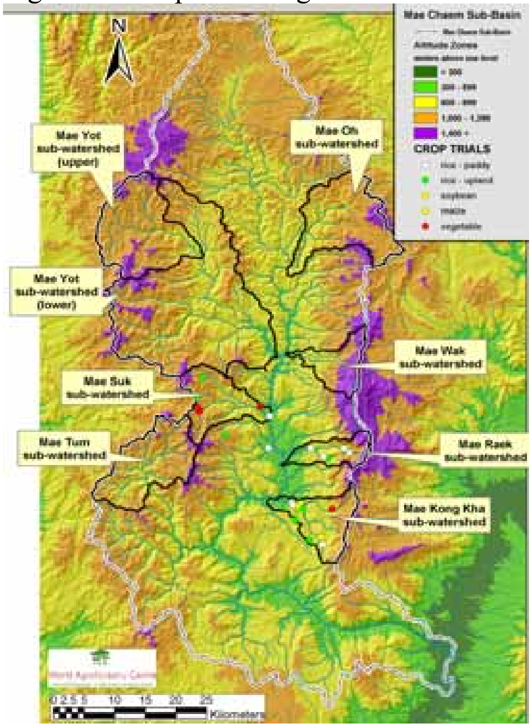


Figure 72. Crop model data collection

areas, we embarked on efforts to apply the DSSAT4 (Decision Support System for Agrotechnology Transfer version 4) crop modeling approach to crops and conditions found in these areas.

The basic framework for this line of activity is outlined in Figure 70. By calibrating DSSAT model modules for each of the major crops involved, we will be able to predict with greater accuracy how changes in crop cultivars, field site location characteristics, or crop cultivation and management practices will affect crop yields. Results can be linked with price information to predict how crop production profitability would be affected by such changes. Moreover, by being able to model crop performance under different environmental conditions, this approach has the potential for greatly strengthening efforts to provide more useful recommendations to communities whose agricultural fields are located in the diverse range of local environmental conditions found at specific locations in the complex terrain of upper tributary watersheds.

Calibration of DSSAT modules for each crop requires rather detailed measurements of plant growth during key developmental stages at sites where specific local environmental conditions and management practices can be documented. Sites for the initial rounds of field research are indicated in Figure 71, and images of some of the major crops being studied at these sites are shown in Figure 72, along with examples of how plant data is being collected. Work with the DSSAT models at ICRAF is led by Ms. Sureeporn Sudchalee, who is consulting closely with her colleagues at MCC where she formerly worked, and various members of the ICRAF GIS and modeling team are assisting with field work. The team is also active in communicating with local communities and local officials in Mae Chaem to explain the nature and potential significance of this work, including through the use of posters such as the example shown in Figure 65.

V. Influence of National Policies, Reform and Local Governance Institutions

This chapter draws on data from previous chapters in summarizing influences of a range of national policies on land use practices, and then turns to examine relationships betwee local governance institutions and natural resource management, and some of their information needs in the context of the Mat Chaem benchmark site.

A. Economic policy distortions

In the overall context of upper tributary watershed conditions, opportunities for economic reforms appear limited. Two overall policy distortions clearly indicated in the first phase PAM analyses were: 1) a net subsidy that reduces the farmgate price of fertilizer; and, 2) rice price support that maintains a farmgate price of rice above current prices in the international market. These policies are obviously established with national considerations in mind, so that it would be difficult to justify proposals for change based solely on the implications for land use in upper tributary watersheds of the northern region. Moreover, the main effect of these distortions is to increase the financial profitability of rice production somewhat, with beneficial impact that reached many of the poorest farmers.

Much larger discrepancies between financial and economic profitability, however, were associated with net tax effects on revenues from field crops, and especially vegetable crops.

1. For field crops, the overall effect was to go well beyond canceling the minor effect of fertilizer subsidies, reducing average financial profits to less than half of calculated economic profits. Indeed, while local input prices began rising rapidly after the major THB devaluation at the onset of the economic crisis, farmgate prices of soybeans and maize appear to have remained stagnant. While it is difficult to argue the case for subsidies to production of commodities that are on the list for trade liberalization under WTO, a more detailed review of marketing channels for these crops in northern Thailand may be appropriate. As a first step in this direction, two graduate students of the CMU Faculty of Economics conducted thesis research on these two industries in collaboration with the University of Wisconsin-TDRI-CMU project discussed in the above section on economics.
2. In the case of vegetable crops, one suspects that the even larger net tax effect on revenues is due more to crop overproduction relative to the capacity of markets to absorb their much more perishable products during peak seasons. Indeed, lowland vegetable production is notorious for its associated boom-and-bust cycles. It is perhaps a bit less clear in the case of specialty vegetables produced for the Royal Project Foundation, but they have recently discussed plans to expand their transportation capacity, which may be a bottleneck. In the case of highland vegetables, given the obvious large expansion of cabbage, and increasingly carrot production during recent years, few would be surprised at saturation of marketing channels. Moreover, the government would be hard pressed to justify efforts to improve prices for major highland vegetables, given the very heated debate going on in the public arena regarding the environmental impact of these operations.

In the case of agricultural chemicals, such as herbicides, insecticides and fungicides, PAM analysis indicated a fairly balanced mix of farmgate prices that were above and below their social prices. It is clear, however, that the THB devaluation has substantially increased the overall cost of these inputs.

B. Rural Poverty and Broader Policy Priorities

This, then relates to PAM assessments of upland rice production. Non-economic policies of the Thai government have consistently either refused to recognize, or overtly opposed the production of upland rice through shifting cultivation practices of any sort. The association of shifting cultivation with opium production in the highlands has helped feed these notions, and a range of programs and projects conducted by a variety of agencies and organizations have sought to 'settle' upland rice production on permanent fields that fit more closely with the lowland (and international) view of agriculture. Yet our PAM data indicate that, at least in areas where cycles still include 5 or more years of forest fallow, both financial and social profitability may be suffering as a result, while at the same time increasing use of agricultural chemicals in upstream areas. Meanwhile, the costs of chemicals needed for this form of subsistence rice production have increased substantially, whereas returns to land calculated at social prices indicate there is certainly no comparative advantage for this type of rice production.

In an effort to explore a more broadly informative approach, we have sought to look at the effects of the current overall policy environment from a rural poverty perspective in each of the major altitudinal zones:

1. Highlands.

The forms of 'pioneer' shifting cultivation observed by earlier researchers has now virtually disappeared from the highlands of Mae Chaem. Opium crop replacement and highland development programs appear to have accomplished most of their major objectives. Relatively stable highland Hmong villages, who were the main targets of such programs, are now engaged largely in production of major highland vegetable crops, or in some areas fruit tree crops. These crops appear to bring relatively high returns to labor, and the impact is evident in observeable indicators of accumulation of material wealth. Many of the areas cleared during their earlier land use practices (or grasslands assumed to have been associated with them) are now planted to highland pines.

What are now perceived as problems in these areas relate to elements that appear to have been given relatively little consideration in these development programs: population growth and environmental externalities. In terms of population growth, major new in-migration of these ethnic groups appears to have been greatly reduced, and very recent evidence indicate that family planning is resulting in a dramatic drop in population growth, as occurred much earlier in lowland society. In terms of environmental externalities, lowlanders appear to find the rate of expansion of vegetable production during the last decade or so to be as worrisome as the current extent of its area. There are some sound biophysical evidence to justify lowland concern about major portions of the hill evergreen forest zone being converted to production of highland major vegetable crops.

This issue is currently difficult to address because most land holdings are officially unrecognized, and therefore 'flexible'. Thus, perhaps one of the most effective means of addressing this issue would be through participatory land use zoning that would define and recognize reasonable areas for intensive horticulture, together with means for monitoring and enforcing compliance with agreements based on these zones. Agreements on water use and maintenance of stream water quality are additional areas that need to be addressed as part of this process, preferably through local institutions that provide a forum for local upstream-downstream interaction, mutual understanding and joint action. Strategies could also be refined for assuring regeneration of hill evergreen forest in remaining areas, with whatever degree of community participation that can be negotiated with these communities.

2. Midlands.

Although their quite sophisticated rotational forest fallow systems for cultivating upland rice, their development of pockets of paddy in small upper valleys, and their extensive knowledge of how to use and manage native plants, have all been the subject of great interest among anthropologists for more than 30 years, times have changed for most of the middle zone ethnic Karen villages in Mae Chaem. While pressure related to demographic change has likely helped decrease the length of their rotational forest fallow cycle somewhat, considerably stronger pressure appears to have come from government policies and various other forces of change. Although biophysical studies indicate these systems may be able to produce sustainable yields without external inputs at cycle lengths as short as 5-6 years, PAM data indicate the yields and profitability tend to decline somewhat with shorter cycle length. But even larger declines in profitability appear to come as purchased inputs are required to maintain fertility and suppress weeds once cycles are shortened to about 4 years or less, or when production is converted to fixed fields. Indeed, it is communities in this situation who appear to be the poorest and most vulnerable component of the population in Mae Chaem.

Three types of policy improvements might be helpful here. First, as in highland communities, is recognition of their land use rights, based on land use zoning developed through participatory processes. Given the land use traditions of Karen communities in many areas, there appears to be a real opportunity here to build on many of the landscape management concepts embedded in their culture, which includes notions of watershed headland protection, protected forest areas, preserved vegetation in gullies and along streams, etc. It would be particularly desirable if these areas had the option of land use agreements that allowed community allocation of agricultural lands in areas where village institutions still operate in this manner.

Second, is support for research and development directed toward improvement of profitability (not just productivity) of rice and field crops under the conditions faced by these communities, possibly including a second rice crop or other crops grown after paddy rice. Alternative, more intensive cash crop approaches being pioneered by the Royal Project Foundation also appear to be potentially attractive options for areas and households willing and able to participate in them.

Third, is clear and effective support for improvement of supplementary sources of income, such as livestock or the weaving groups and other options being explored by the Suan Pah Sirikit project, as well as stable wage employment in state forest management activities such as fire control.

One further area of policy consideration may relate to government forest policies established in 1992 that are still being implemented. The central notion of these policies is that basically all reserved forest lands should be converted either to various categories of protected forest, or else distributed to individual households through the land reform program. While this approach may seem reasonable for areas such as southern Thailand, where the political leaders who established this program are from, in the context of midland tradition communities in northern upper tributary watersheds, this approach forces these communities to abandon many of the central concepts and components of their quite sophisticated landscape management systems and cultural heritage. As we have seen, the major impact that rotational shifting cultivation with forest fallow cycles of 6 to 10 or more years has on environmental services, appears to be a reduction in carbon storage, timber stocks and average forest canopy height – other impacts appear very minimal. These factors are most important to interests concerned with logging and timber production, carbon off-set agreements, and possibly maintenance of habitat for some types of wildlife. For areas where there is clear justification to reserve forest areas for these types of purposes, perhaps there is reason for policies to restrict this type of land use. But policies centered on apparently blind expansion of national parks and wildlife sanctuaries to cover all remaining areas with any type of forest cover would appear both ill-informed and ill-advised. In order to meet as many of both national and local needs as possible, there appears to be a need for more flexibility to localize various aspects of natural resource management, and perhaps action on the long-delayed community forestry legislation will provide an opportunity to develop clear and effective mechanisms for accomplishing this.

3. Lowlands.

Given the variety of institutions and agencies already actively engaged with these communities, together with the various lowland-oriented reforms currently being considered at policy levels, our data thus far indicate only two areas of potential improvement: First, strengthening local institutions which provide a forum for interaction with upstream communities that facilitates mutual understanding of needs, concerns and problems, including cooperation both in maintaining water quality and in conserving and allocating water in areas where scarcity is an issue. Second, helping minimize vegetable and other crop price fluctuations in 'boom-and-bust' cycles, perhaps through better information on production relative to market capacity rather than price support schemes.

In light of these preliminary assessments and public concern over growing upstream-downstream tension and conflict, our colleagues working under the Northern Mountain Area Agroforestry Systems Research and Development Project urged us to focus our second phase ASB efforts on: a) helping develop tools to facilitate strengthening of participatory watershed management by local insititutions, and b) on improving our ability to scale up the types of findings presented in our preliminary 'ASB matrix' (see section A, above) to assist with more clear identification of trade-offs among alternative types of agroforestry mosaic patterns on sub-catchment and larger scales.

C. Local governance and conflict management.

Provisions in Thailand's 1997 national constitution and legislative reforms related to local governance, clearly mandate newly upgraded elected sub-district governments (*tambon* administration organizations – TAO) to play a much more central role in local natural resource management. For many areas in the country, activities to meet this mandate are already beginning. In upper tributary watersheds, however, local TAO find it difficult to act on these mandates, because while local villages and people are legally registered, there is no legal basis for anyone to be using most of the land in areas under their jurisdiction. Meanwhile, tension and conflict over natural resource management in upper tributary watersheds of northern Thailand has become a prominent feature in national public policy and political arenas.

During its second phase of research activities, ASB-Thailand has turned considerable attention to try to more clearly understand the context and needs of formal and informal local institutions related to natural resource management. Based on information gained from studies such as those described in this section, we have undertaken major efforts to help develop relevant and useful science-based tools to help meet their needs. These efforts are described in considerable detail in the following chapter.

1. Institutional Context of Local Natural Resource Governance

As part of our efforts to understand more clearly the manner in which our science-based tools may be able to provide information useful for local governance institutions and initiatives related to natural resource management, the project collaborated with the World Resources Institute's Regional Policy Support Initiative (REPSI) in providing support for a team of Chiang Mai University graduate students to conduct research on local institutions in two of our pilot sub-watersheds in Mae Chaem. The five students are studying for masters degrees at the CMU Faculty of Social Sciences under the Thai University Consortium on Environment and Development - Sustainable Land Use and Natural Resource Management (TUCED-SLUSE) program. The students focused on different, complementary aspects of this subject, under overall team coordination and support provided by staff from CMU, the forestry department, WRI and ICRAF. Funding for field research was provided by World Resources Institute, while information and additional support services were provided under this project.

Studies were conducted in Mae Suk and Mae Kong Kha sub-watersheds. As indicated in previous sections, these two sub-watersheds have quite different land use histories and current configurations that helped provide a comparative context for the study. And, since three of the students have very substantial previous experience in Mae Chaem with Care-Thailand and ICRAF research, they were able to draw various overall conclusions and recommendations that apply widely in the area. An overall synthesis of their preliminary findings has been completed in draft form, and is in the process of being refined for distribution by REPSI and ICRAF.[83]

[83] Pornchai Preechapanya, Chanyuth Tepa, Thanut Promduang, Nonglak Kaewphoka, Sorak Ditthaprayoon, Thitikorn Yawichai, Patarapong Kijkar, David E. Thomas, Natthan A. Badenoch, and Sidthinut Prabudhanitisarn. 2004. Local institutions in natural resources governance: A case study of Mae Suk and Mae Kong Kha sub-watersheds, Mae Chaem District, Chiang Mai Province, Thailand. Summary Report September 2004). REPSI and the World Agroforestry Centre, Chiang Mai, Thailand.

Institutional Complexity

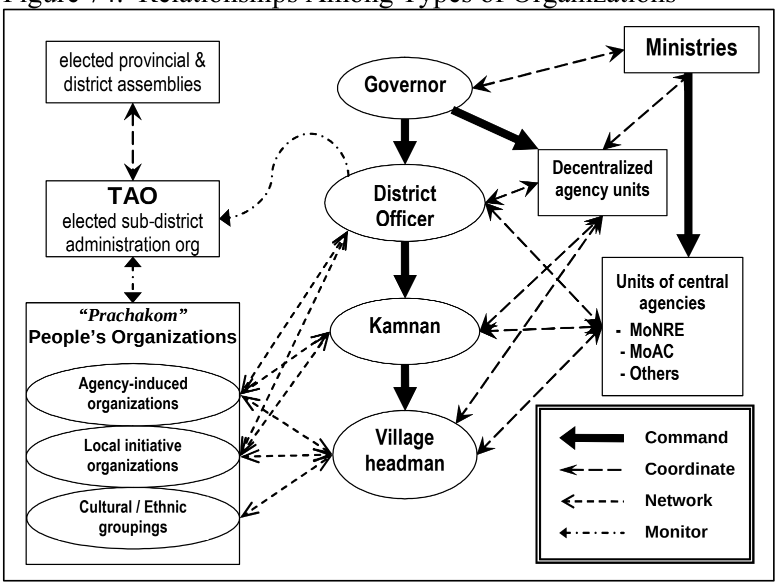
One key element of their findings is the complexity of the institutional environment related to natural resource governance. Major local organizations having roles related to natural resource management in the study sub-watersheds are listed in Figure 73. These 24 organizations are listed under five categories that can help us see more clearly the sources of mandates, authority and initiatives underlying the various organizations. The first column after the organization's name indicates whether or not it has a mandated role in coordinating with others. Thus, it becomes rather clear that local units of centralized government agencies appear to be still quite aloof from other institutional actors, and tend to focus on forest and land resources in relative isolation from other resource management areas. This is one source of difficulty cited by local leaders.

Figure 73. Resource-Related Local Organizations

ORGANIZATIONS	coord	forest		land		water			
		forest	wildlif	land	soil	fish	river	strm	irrig
1. Local Units of Centralized Government Agencies									
Ministry of Natural Resources and Environment									
Watershed Management Unit		√	√	√					
Forest Protection Unit		√	√	√					
Forest Fire Control Unit		√							
Watershed Research Station (not in sites)		√	√	√	√		√	√	√
National Park (not in sites)		√	√	√					
Ministry of Agriculture and Cooperatives									
Land Development Unit		√		√	√				
Royal Irrigation Department Units							√	√	√
2. Decentralized Units of Government Agencies									
Department of Local Administration, Ministry of Interior									
District Office	√	√	√	√		√	√	√	√
- Sub District Office	√	√	√	√		√	√	√	√
- Village Office	√	√	√	√		√	√	√	√
Ministry of Agriculture and Cooperatives									
District Agricultural Extension Office				√	√				√
Centre for Transfer Agricultural Technology	√	√	√	√	√	√			√
District Livestock Development Office		√	√	√					
3. Local Government									
Tambon Administrative Organization (TAO)	√	√	√	√		√	√	√	√
Ping Basin Management Organizations (?)	√	√	√	√			√	√	√
4. Non-Governmental Organizations (NGO's)									
Raks Thai Foundation	√	√	√	√	√	√			
5. People's Organizations *(prachakhom)*									
Agency induced groups									
Agricultural Cooperatives	√			√					
Forest Conservation Group	√	√	√	√	√		√	√	
Local initiative groups									
Irrigation Channel Group (muang fai)							√	√	√
Watershed Management Networks	√	√	√	√			√	√	
Hak Muang Chaem Group	√	√	√	√			√	√	
Cultural/ethnic groupings									
Hmong Clans & Groups		√	√	√	√		√	√	
Karen Groups				√					

In order to help clarify how relationships function among this rather long list of actors, Figure 74 displays the study team diagram of relationships among these different types of organizations. Command and coordination types of relations appear prominent among government agencies and units on the right side of the diagram. This type of coordination is a means for seeking to reconcile common interests and potential conflicts among the various lines of ministerial authority within which command relationships are dominant. One problem with this type of 'official coordination' relationship is that accountability is often unclear. The left side of the diagram includes the elected local government institutions that are continuing to increase their role in local governance under the 1997 national constitution and associated legislation, as well as the box containing 'people's organizations' that includes a variety of less formal groupings that form the core of local components of Thailand's emerging 'civil society'. Relationships among organizations on the left side of the diagram are dominated by network type relationships, which require many actors to cooperate on a peer-to-peer basis, wherein they are laterally accountable to each other. This diagram also helps make clear the key 'bridging' roles played by village headmen and the district officer; roles of kamnan (sub-district head) are important

Figure 74. Relationships Among Types of Organizations



but decreasing as more authority is assumed by TAO. Efforts by government agencies to engage in the 'prachakhom' arena through agency-induced local organizations, as well as efforts by local initiative or cultural groups to engage with agencies about local concerns, are all highly dependent on cooperation by village headmen and the district officer.

Regarding natural resource governance and management, this diagram also helps clarify important differences in overall orientation that are also reflected in the right-side and left-side groupings. Given the nature of organizations on the right side of the diagram, they tend to be very regulation-oriented and most of their interaction with local communities is directive in style, with primary focus on restrictions and measures to mitigate negative impacts of local land use perceived by higher levels of government and national society. In contrast, organizations on the left side of the diagram tend to have a more collaborative and managerial style centered on building local coalitions and alliances based on mutual self-interest. Not surprisingly, their focus tends to be more on strengthening opportunities, at least for members of their coalition, but can also include mobilization to negotiate with or respond to concerns of outside interests, higher levels of governance, and larger society. Both sides receive various types of support and funding from various sorts of government programs, and TAO are now authorized to assess and utilize local taxes initially based primarily on legally-owned land assets.

Increasing Tension and Conflict

Both of the study sub-watersheds have experienced substantial change in land use patterns during recent decades, as discussed in previous sections of this report. Land use in the Mae Kong Kha sub-watershed has been transformed from long cycle forest fallow systems into permanent upland fields producing upland rice and cash crops, through a process similar to what was detailed for Mae Raek. The Mae Suk sub-watershed now has a more diverse range of land use that includes: highland ethnic Hmong communities with year-round intensive commercial vegetable production using dry season sprinkler irrigation, developed in response to opium crop substitution programs; lowland Northern Thai communities with substantial areas of paddy and now upland fields growing commercial maize; and Karen communities with land use systems ranging from subsistence-oriented medium cycle forest fallow to permanent highland fields linked with commercial vegetable production operations. Logging concessions were a prominent feature in mid-to-lower portions of Mae Suk in the past. Government agencies have sought to implement a substantial range of programs in both sub-watersheds.

The study found land use change to have been associated with two major types of driving forces: integration with economic markets, and government environmental policies. Various government programs and projects have sought to promote economic integration as part of their vision for small areas of intensive commercial agriculture embedded in – but segregated from – a matrix of government agency-managed permanent forest lands. In practice, however, it has been difficult to control expansion of areas planted to commercial cash crops as market opportunities have emerged. The absence of any formal land usufruct rights in mountain areas has exacerbated problems with expansion of areas planted to commercial crops, including competition for land among villages, which has sometimes generated disputes between ethnic groups. As expansion of commercial agriculture has also driven increases in demand for water to irrigate intensively cultivated fields, competition for water during dry periods and concerns about water pollution by upstream agricultural practices have brought an additional dimension to resource competition, further increasing tension and conflicts. At the same time, government environmental policies have been adamant in their assertions that rotational forest fallow cultivation is a major cause of forest destruction and soil deterioration, as well as their generally negative attitude toward mountain ethnic minority communities as untrustworthy recent migrants who are expanding rapidly and 'encroaching' on and damaging the nation's valuable forest and watershed resources. Local communities have been actively seeking to adapt to changes inducted by these driving forces by modifying their land use practices in both cultivated and uncultivated portions of the areas within their land use domain, as reflected in the local land use zoning maps presented in a previous section of this report. While land use patterns of Thai and Hmong communities, and Karen communities in Mae Kong Kha now appear reasonably settled, Karen patterns in portions of Mae Suk appear to still be uncertain and possibly in transition. Meanwhile, growing competition over land and water resources remains an issue, both among villages and between communities and government agencies, and increasing levels of natural resource-related tension and conflict is an important concern.

Watershed Management Networks: Responding to complexity, tension and conflict

One of the major institutional innovations that have emerged as part of efforts to address issues associated with complexity, tension and conflict, has been efforts to develop informal local multi-village watershed management networks. Indeed, local multi-village networks, sometimes federated into broader alliances, have emerged as an important institutional innovation seeking to enable and facilitate community-based natural resource governance and management in various parts of the country. Local sub-watershed networks emerged under the Sam Mun project in the Mae Taeng sub-basin under the Sam Mun Highland Development Project, and a substantial range of variations on this theme have occurred around Northern Thailand; they have been encouraged and supported by a range of governmental and non-governmental organizations. Projects in Mae Chaem, including both the Care-Thailand collaborative natural resource management project and the Queen Sirikit forest development project, have actively encouraged local initiative in forming and operating a substantial number of multi-village networks for various purposes, including local sub-watershed management networks. In Figure 39, these networks would fall into the category of local initiative organizations, which are considered a sub-set of people's organizations.

The study traces efforts to form local management networks in both of these sub-watersheds. These efforts have been fairly smooth and quite effective in Mae Kong Kha, but efforts in Mae Suk have been more complex as they had to deal with more local factions and social fragmentation at various levels. Networks often build on related organization at the village level, such as village forest conservation groups that have received encouragement and support from both projects and forest agencies. Functions of emergent networks in both sub-watersheds are dependent on a core set of leaders who communicate with and mobilize broader elements of local communities as various needs arise. Overall, the study found these networks to be promising organizations of key importance for the future, and that they need to be accepted, encouraged, and supported by more formal governance structures, programs and policies.

Tambon Administration Organizations (TAO): The interface with formal local administration

As indicated in Figure 74, the TAO is the most obvious and logical point for emerging sub-watershed management networks to interface with the decentralizing system of formal governance structures. The TAO is seen as an increasingly important focal point for local actors because: (a) it is a highly relevant level of decision making for natural resource management at a scale intermediate between village and district level domains; (b) it is designed to provide a forum for villages to interact as peers on shared issues; (c) it has a mandate to collaborate with a broad range of non-governmental actors, including the range of prachakhom groups.

In situations such as Mae Chaem, however, growth and development potential of TAOs is constrained by (a) budgets that cannot grow from local taxes on land because there is no legal recognition of land usufruct rights in mountain forest areas; (b) limited operational options because of their budget and personnel constraints; (c) ethnic diversity that can make communication and trust more difficult to achieve; (d) administrative boundaries that are often mismatched with important natural resource units such as watersheds.

Despite these difficulties, TAOs are widely considered as having significant potential due to: (a) broad support from outside sources; (b) growing public awareness of environmental and natural resource management issues, including roles and responsibilities for TAO; (c) emergence of provincial and regional networks of TAO that are facilitating assistance from more developed TAOs for those with constraints such as seen among TAOs in Mae Chaem. If linked with sub-watershed management networks and further reforms in the policy environment, TAO would be well positioned to play a major role.

2. Ping River Basin Organization Initiative: multi-level watershed organization

Growing tension and conflict related to natural resource management is a widespread phenomenon that extends far beyond Mae Chaem to all regions of the country. Primary focus has been on watershed services, especially flooding, drought, landslides, water pollution, erosion and sedimentation, and growing upstream – downstream conflict over water use and perceived impacts of land use and other activities, along with increasing concern about natural biodiversity in primarily mountain ridge-oriented protected forest areas. As competing demands for water use continue to expand along with growing environmental awareness, the importance of these issues is expected to continue to increase. In response, the government considers water resources and river basin management a high priority, and the current state of management as a concern for all stakeholders. Thus, the government claims to have begun a process of delegating environmental responsibility to local communities and encouraging their participation in improving environmental quality.

As one of the government's more visible early steps in this direction, the nation has been zoned into 25 official 'river basins', which are sub-divided into a total of 255 official 'sub-basins'. Each region of the country is to now establish a pilot project in one of its major river basins to develop organizational arrangements to implement decentralized integrated basin management. The challenge is how to get communities and other stakeholders within watersheds to collaborate in improving livelihoods and well-being, while at the same time negotiating trade-offs that emerge in the sustainable use of scarce resources. The idea is not to create another layer of bureaucracy, but rather to have province, district, and sub-district governments collaborate with the full range of stakeholders in identifying issues and implementing innovative approaches to address them. In northern Thailand, the Ping River Basin is the first priority pilot area, due to its large size (35,000 km^{-2}) and strategic importance in the context of both the Chao Phraya river system and the nation's overall natural resource endowment. As a major sub-basin of the Ping, Mae Chaem is being given considerable attention by national committees and advisors involved in developing the national river basin approach.

One of the key points emerging from discussions and working groups organized at the Mae Chaem level is the importance of building basin and sub-basin management arrangements on a solid foundation of innovation and work at more local sub-watershed levels. This is particularly important in terms of subsidiarity principles, wherein decisions are best taken at the lowest level at which they can be successfully handled. For example, it is at the sub-watershed level where issues such as flash floods, landslides, and water pollution from intensive highland agriculture usually have their greatest negative impact. Seasonal water shortages, pollution from upland domestic sources, and sedimentation of weirs and irrigation canals can also be important issues. This is also the level where communities involved on different sides of an issue are in relatively frequent and direct contact, and have the same or neighboring local governance units.

Thus, sub-watershed management networks (in partnership with TAO) might best take the lead in managing these issues, including negotiation with and support from higher levels regarding costs or benefits incurred downstream. In cases where local organizations cannot effectively handle an issue, it would be referred to the next higher level for action. Larger scales would be the focus for issues where cumulative impacts of many dispersed minor sources of pollution, sediment or changes in water flow may increase in severity at downstream locations, including emergent problems such as more widespread flooding of larger river channels. Downstream areas with growing demands for water for irrigation, tourism, industry or urban areas could take the lead in negotiations with upstream networks and communities on related issues.

In this regard, local watershed management networks in Mae Kong Kha and Mae Suk are among those to be examined for their experience and ability to serve as examples for similar efforts elsewhere in Mae Chaem and the larger Ping River Basin. While it remains to be seen how these efforts will unfold during the next few years, there may be possibilities for mechanisms to improve the linkages and support systems for institutional innovation that have begun in Mae Chaem, as well as to increase the attention to and support for these efforts by the various stakeholders indicated in Figures 73 and 74.

3. Needs for information and science-based tools

The study found that in both sub-watersheds, problems regarding natural resources were largely linked with processes of market integration and intensified production. There is both tension and conflict over access to natural resources. Tension is characterized by feelings of mistrust and suspicion regarding issues such as chemical agricultural inputs, expansion of agricultural area, illegal activities in forested areas and seasonal stream-flow levels. In situations of tension, there are often varying perceptions of the problem and its source. When tensions are intensified, conflict situations have arisen. Conflicts have involved government authorities, NGOs and communities, and have resulted in closing of roads, destruction of crops and other forms of violence. It is crucial that conflict situations be addressed in fora where communities and other stakeholders can engage with each other as peers. Additionally, there is a need to build a shared base of knowledge and data regarding the watershed issues at hand. Information on water consumption, expansion and management of agricultural and forest land, and use and impacts of chemical inputs is scarce, and is seldom used as a platform for dialog.

Communities, various levels of government and NGOs have responded to this situation.

- From the government policy side, decentralization is trying to empower TAOs to play a more active and efficient role in natural resources management. TAOs are limited by capacity and budgetary constraints, but remain a key focal point for natural resource management, especially in watershed and forest management issues that involve more than one village. Exploring options for recognizing some sort of taxable land tenure rights in agricultural areas could help provide valuable security to farmers, while helping generate important resources that could be channeled back into critical environmental and natural resource management issues. Information tools are needed that can build understanding among communities across ethnic groups, and facilitate communication and effective linkages with outside stakeholders and higher levels of authority.
- Central government agencies have been working to employ more participatory approaches to implementing policy in a manner that is sensitive to the local situation. District Officers, their staff, kamnan, and village headmen are trying to help coordinate government programs at local levels, and to facilitate cooperation among agency personnel, TAO, people's organizations, business interests, and non-governmental organizations. Their information needs reflect this broad range of concerns, and are especially strong in areas that could help them respond to government policies and programs of various ministries.
- At the same time, peoples' organizations, such as watershed management networks, have formed to fill the gaps that appear between state, market and community governance systems. These organizations are based in locally perceived needs (securing resource access rights, inter-community and upstream-downstream dialog and negotiation, alternatives to government-led processes) and are based on local resources (social and cultural capital, local knowledge). While networks have made a large contribution to the expansion of 'space for dialog' among local actors, there is uncertainty regarding how they can enforce decisions and sustain their activities, and they need information and tools that can help build their capacity to engage with other state, community and private actors. In some cases, such as Mae Kong Kha, networks are making good progress in proactively developing concrete activities. In others, such as Mae Suk, there are still some basic attitudes that serve as barriers to building sufficient confidence and trust among communities and across ethnic groups for the networks to realize their potential. In cases such as these, improved information may need to be accompanied by efforts to help open minds of key local leaders.
- Underlying all of these developments is the continuing need for coordination among a diverse range of actors at multiple levels. The degree to which the new Ping River Basin project will be able to help meet these needs still remains to be seen, but it is critical that Ping Basin pilot activities find ways to establish meaningful linkages with local communities and organizations. Leaders of these efforts already recognize their need for a multi-level and multi-sectoral spatial information system and are beginning to actively explore options for its establishment and operation.

VI. Science-Based Tools for Participatory Watershed Management

The second phase of ASB-Thailand research has centered on collaborative efforts to further develop key science-based tools with potential for helping to improve local participatory watershed management and facilitate its integration into higher-level natural resource management policies and programs. Activities conducted under this second phase have built on earlier partnerships, activities, and achievements, while seeking to take the next steps in pushing forward our knowledge and experience in three closely interrelated priority areas:

1) Building a pilot spatial information system capable of linking local land use plans, monitoring and management with sub-basin and higher levels of activity;
2) Developing tools to strengthen local watershed monitoring and management conducted by communities and local networks themselves;
3) Piloting analyses and analytical modelling that provide broader impact assessments and predictive capacity to help improve broader public understanding, set priorities, and better inform policy decision-making at various levels.

Figure 73.

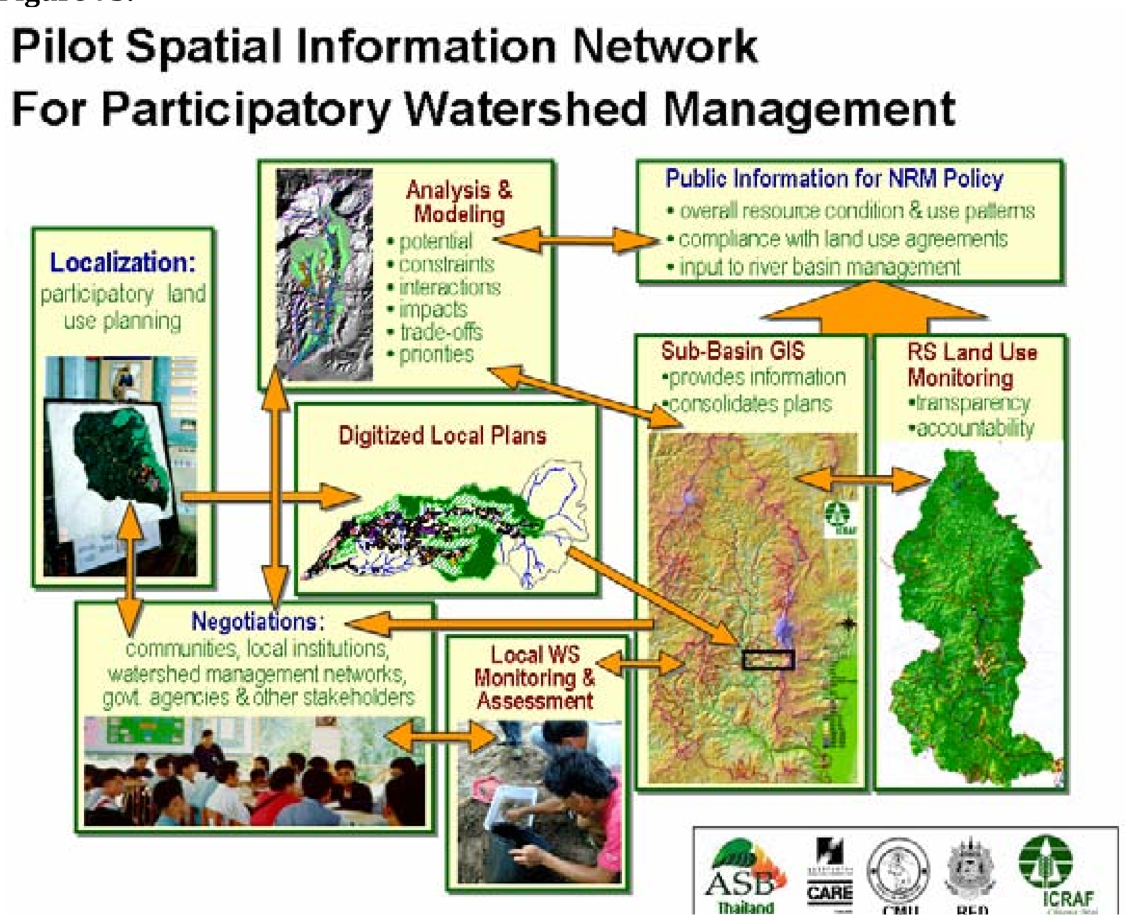


Figure 73 indicates how activities in each of these areas relate to each other and interact in the context of the overall pilot spatial information network that provides the framework for these collaborative efforts.

Details on the activities conducted in each area are provided in following sections.

Study Area

Pilot studies conducted under this grant were located in the nearly 4,000 square kilometer Mae Chaem watershed benchmark research site of the ASB-Thailand program. As mentioned earlier, Mae Chaem is a major sub-basin of the Ping River Basin, which is the largest tributary of the Chao Phraya River system.

Within the Mae Chaem sub-basin, implementation of pilot activities during this phase was conducted through the progressive scaling up of tests to seek to assure that science-based tools that may appear promising at an initial scale are viable and appropriate at the various scales at which they are intended to be applicable. The scaling up process entailed two sub-phases:

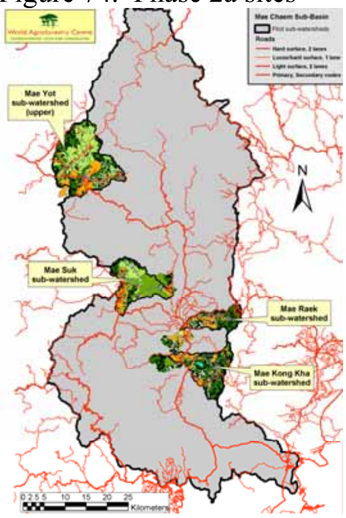
Phase 2a Sub-watersheds:.

For most components, initial efforts focused on a 4 sub-catchments within the Mae Chaem watershed (Figure 74). Selected in collaboration with research and development partner institutions and projects, this initial set of sub-watersheds included a reasonable range of variation in local conditions found in Mae Chaem:

- **Mae Raek**. This is a strategically important sub-catchment where some early work helped shape the nature of this project. It is inhabited by midland Karen and lowland Northern Thai ethnic groups, and upper reaches of the sub-catchment are within the boundaries of Doi Inthanon National Park, which is named after Thailand's highest peak (approx. 2,500 meters above sea level). A strategically important road runs along its northern boundary, providing the shortest route for transportation from Mae Chaem district town to Chiang Mai Valley, and Thai communities in lower areas are subject to urbanization processes associated with the district town. Under pressure from various factors, forest fallow rotational shifting cultivation has all been converted to fixed field cultivation.

- **Mae Kong Kha**. Located to the south of Mae Raek with somewhat similar biophysical conditions, upper portions of this sub-catchment are more remote from major roads, and the population is strongly dominated by members of the Karen ethnic minority. Their traditional rotational forest fallow shifting cultivation systems have also been entirely converted to fixed field cultivation, and upper areas have substantial permanent forest cover.

Figure 74. Phase 2a sites



- **Mae Suk**. This sub-watershed is located to the northwest of the district town, and is similar in size to Mae Kong Kha (90+ sq km). Unlike the above sub-watersheds, however, its inhabitants include highland ethnic Hmong communities, as well as midland Karen and lowland Northern Thai, and administratively it is split among three sub-districts (tambon). Moreover, some of its Karen communities still practice medium-length rotational forest fallow shifting cultivation, while others have effectively merged agricultural areas with intensive vegetable cultivation of the Hmong. Competition for water is growing, as are concerns among lowland Thai communities about water pollution from agricultural chemicals being used in highland vegetable production.

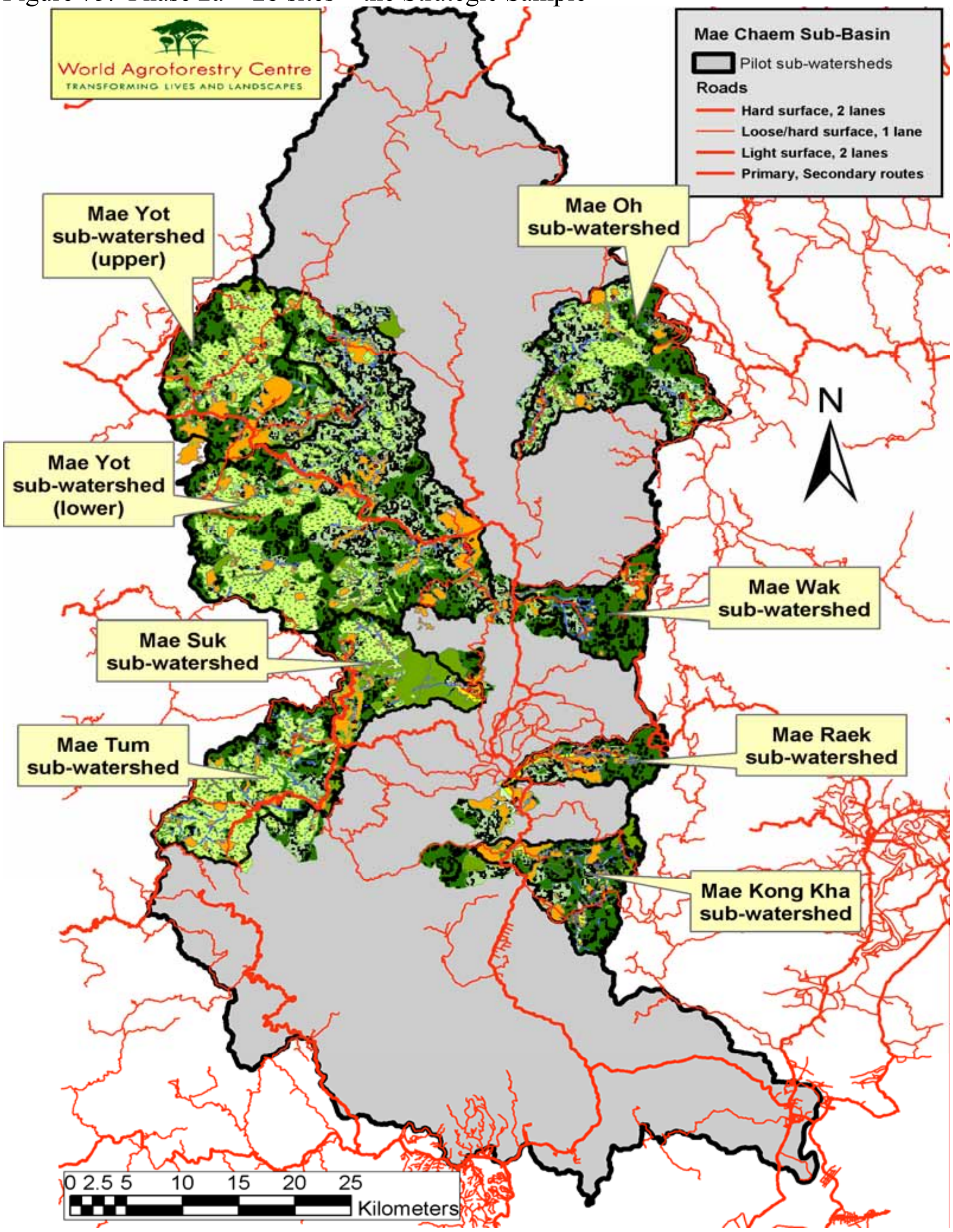
- **Upper Mae Yot**. Located much further to the northwest of the district town, access to this sub-watershed is via the road from Mae Chaem that runs over its western ridge to link with the border province of Mae Hong Son that occupies the next valley. This site included only upper portions of a substantially larger sub-watershed, where communities belong to Karen and Hmong ethnic groups. In this area, intensive commercial vegetable production systems of the Hmong are located very near to Karen communities with rotational forest fallow shifting cultivation systems that still have cycle lengths as long as 12 years.

Phase 2b Sub-watersheds:

After testing in phase 1 sub-watersheds, we sought to scale up key promising components to what we have referred to as a 'full strategic sample' of Mae Chaem, as depicted spatially in Figure 75. The four additional sub-watersheds include:

- **Mae Tum**. This is a substantial western sub-watershed strongly dominated by midland Karen and Lawa ethnic communities operating rotational forest fallow shifting cultivation

Figure 75. Phase 2a + 2b sites – the Strategic Sample



systems, although with somewhat shorter cycle lengths than the longest cycle systems found in upper Mae Yot. Moreover, the vast majority of lands in this sub-watershed fall within the boundaries of a new national park for which forestry agencies have already obtained a preliminary declaration. Forestry officials have established a park office, from which they have begun placing strong pressure on local communities to greatly constrain areas they use for agricultural purposes. Tensions have surged, and efforts to oppose and resist establishment of the national park have been supported by activist non-governmental networks.

- **Mae Wak**. This third eastern sub-watershed is located to the north of Mae Raek, and communities within it all practice fixed field agriculture. Unlike Mae Raek and Mae Kong Kha, however, this sub-watershed includes a Hmong community in addition to Northern Thai and Karen, yet the percentage of area covered by permanent forest remains very high.
- **Mae Oh**. This fourth eastern sub-watershed is located still further to the north, where transport and communication linkages with Mae Chaem district town tend to be weaker than those over the ridge into Mae Wang on the Chiang Mai Valley side. Only Karen and Hmong communities are found in this sub-watershed, with Karen practicing short to medium cycle rotational forest fallow shifting cultivation, and a Hmong community strongly into fruit tree orchard production.
- **Lower Mae Yot**. This site completes coverage of the quite large (nearly 700 sq km) Mae Yot sub-watershed, by adding a substantial number of additional Karen and one lowland Northern Thai communities. This enlargement provides an overall sample of Karen communities within the same sub-watershed that have rotational forest fallow cycles that range from very short to the longest we have found in Mae Chaem. Moreover, they are not yet under severe immediate threat from efforts to expand national parks, or from powerful lowland Thai communities downstream.

Thus, the overall strategic sample was developed to represent a very substantial range of conditions found in Mae Chaem, including: 1) major types of land use systems and patterns; 2) ethnic groups; 3) access, income and participation in the cash economy; 4) tensions related to land and water issues; and thus, presumably, 5) incentives for local participation in pilot activities. The following sections turn to the actual results of efforts to implement pilot activities at these sites.

Moreover, we believe this strategic sample covering more than 1,350 sq km of land area and 125 settlements grouped into 53 administrative villages with a total population of nearly 27,500 people, also covers a significant range of variation found in upper tributary watersheds of North Thailand, as has been depicted by the Thailand Alternatives to Slash-&-Burn (ASB) consortium in Figure 11. Key elements in this depiction are: 1) variation in natural ecological conditions according to altitudinal gradients; 2) ethnic communities and traditional agroecosystems associated with different ecological zones; 3) changes in economic, policy, social, political and institutional conditions that have led to changes in land use, as well as both its actual and perceived impacts on rural livelihoods and environmental services

We have sought to learn from our findings in this large study area to address five key questions related to the use of science-based tools to help strengthen approaches to, and address policy issues associated with, participatory watershed management in the context of upper tributary watersheds of northern Thailand and MMSEA. The report concludes by summarizing progress made toward addressing these questions.

A. Locally-Negotiated Land Use Zoning

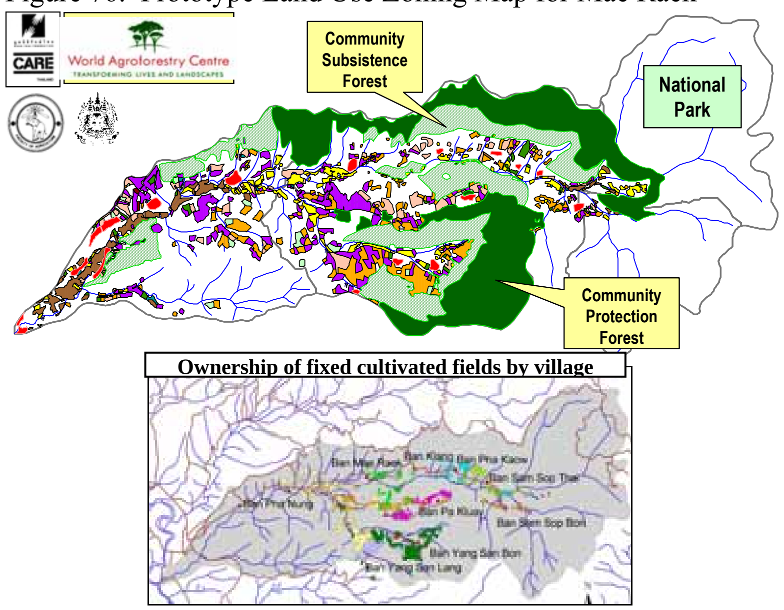
Progress and findings under this set of activities are reported in three areas. The first describes how our approach to working with localized land use planning and zoning unfolded during the project. The second presents results from our extensive collaboration with local communities in bringing their local land use zoning plans into our GIS, summarized primarily at the sub-watershed level, while the third provides examples of how such community-generated land use zoning data can be applied in cross-watershed assessments of current local land use zoning strategies.

Evolving approaches to participatory land use planning

The project sought to maximize its relevance and utility for our development-oriented partners by assessing and responding to evolving adaptations of the approach generally referred to in Northern Thailand as participatory land use planning.

Our initial notions for mapping locally-negotiated land use zoning in Mae Chaem were based on experience in the Mae Raek sub-watershed. In Mae Raek, negotiations between local communities and a range of staff from government agencies, the Queen Sirikit Forest Development Project, and the Raks Thai Foundation (Care-Thailand), had already resulted in a prototype general land use zoning map (Figure 76) for the sub-watershed that all major stakeholders found to be reasonably acceptable. Deeper understanding of local land holding and agriculture patterns was provided through detailed mapping of current agricultural land ownership and use conducted in collaboration with the Department of Geography at Chiang Mai University. ICRAF staff digitized these maps and brought them into our wider GIS for Mae Chaem. Our initial expectations were that a similar set of activities would proceed in other sub-watersheds as they would conduct similar processes with assistance from Care-Thailand field staff.

Figure 76. Prototype Land Use Zoning Map for Mae Raek



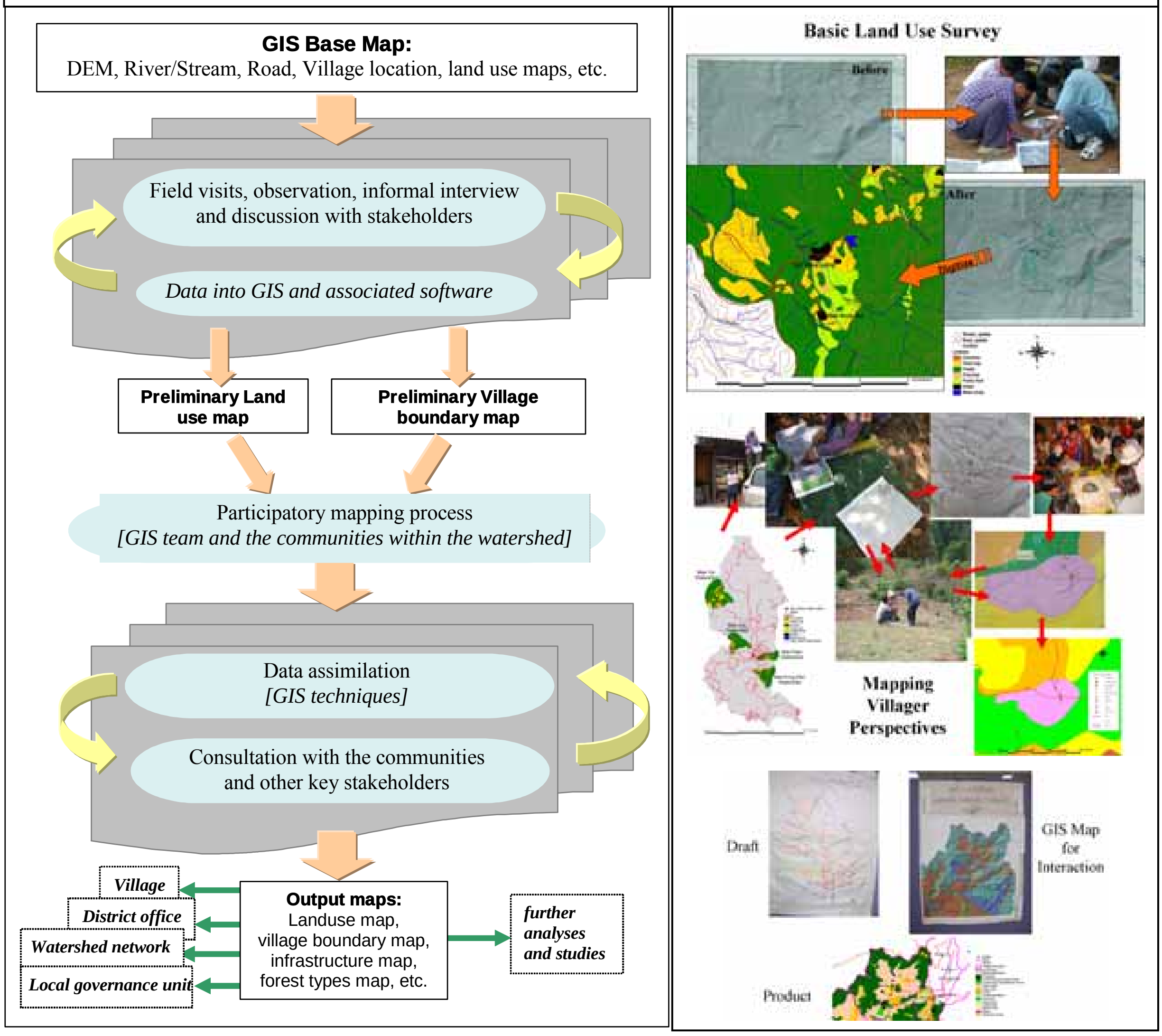
It soon became apparent, however, that the approach and resource allocations under the new phase of the Care-Thailand project were finding this approach too staff and resource intensive to be widely replicated in Mae Chaem. While detailed mapping of each household land parcel in Mae Raek helped increase our understanding of household land ownership patterns under these conditions, the costs of such detailed work reduced the feasibility for its implementation across the much wider areas that need to be covered. Furthermore, it was not very well adapted to the mandate of Care-Thailand's newest approach that focused more on supporting natural resource management initiatives of local communities and elected sub-district governments (TAO - Tambon Administrative Organizations). Fortunately, however, information flowing through the project and a range of other local, NGO and government channels was already stimulating many communities around Mae Chaem to develop and articulate similar types of local land use management categories and zones that respond to pressures, tensions, and emerging conflicts associated with land use issues. Support by Care-Thailand staff for local use of three-dimensional models and related tools provided substantial assistance for these efforts. Given this changing context, it became increasingly clear that we should adapt our approach to land use zoning to make it more clearly centered on articulation of initiatives that local communities are themselves now taking to understand and respond to concerns of other stakeholders involved with issues associated with land use management in Mae Chaem.

Given the lack of any official land tenure or boundaries of village lands in the vast majority of these areas, as well as the watershed orientation of our project mandate, we also faced the challenge of identifying an appropriate basic unit for mapping local land use domains. After considerable consultation with village leaders, colleagues and local officials, we agreed that the administrative village level (*muban*) would be the most appropriate. For a given sub-watershed, then, the challenge was to map the boundaries and community-designated land use zones of administrative village domains that include areas within the target sub-watershed.

Emergent approach for mapping locally-designated land use zones.

Our emergent modified approach centers on use of a small core team of ICRAF project staff to collaborate with local communities in each pilot watershed. As diagramed in Figure 77, beginning with base maps and land use patterns from secondary and fairly recent remote sensing sources, the

Figure 77. Overview of the Project’s Participatory Mapping Process



team developed and implemented an iterative process of collaboration with local communities to create digital maps that reflect current land use and land use zones within community-defined administrative village land use domains. Thus, the nature and location of village boundaries and land use zone categories are dependent on villager perceptions and categories, as they have evolved through changing conditions and in collaboration with Care-Thailand and Queen Sirikit Forest Development Project staff, as well as with efforts by other NGO networks, and interaction with local government and forest department officials. Figure 78 shows images of some of the discussions.

Iterative discussions at multiple levels were necessary to reach local agreement among adjacent communities about the location of boundaries between adjacent domains of village responsibility, as well as to assure that land use maps reflected the common understanding of communities in the area. Given the widely perceived importance of this activity, the participatory land use zoning process was conducted throughout all phase 1 and phase 2 areas, resulting in a total coverage of 125 villages grouped into 53 administrative villages, with land use domains covering just over 1,350 square kilometers of land area.

Outputs from this process resulted in a number of map products reflecting the land use zoning process. One of the most immediately important outputs was individual land use zoning maps for each of the administrative villages participating in this project. After experimenting with a variety of formats, a consensus was reached that each village would be provided with two types of maps – one a simple color coding of land use zones, and a second version where zones are superimposed on shaded relief to better show the terrain of the area. A small 3-D projection was included as an inset on the terrain version. Three examples of village maps with quite different land use practices are shown in Figure 79. Maps actually given to each village were printed in large poster size on flexible white vinyl, so that they would be weather resistant, durable, portable, and suitable for use in group discussions of various size and location. In addition to land use, local place names and important locations are also included in village maps in order to facilitate local and multi-level stakeholder discussions.

Village land use zones were also aggregated at the sub-watershed level, and maps were produced in a similar format at this scale for use by sub-watershed management networks, local government (TAO) and district officials. An example for the Mae Tum sub-watershed is shown in Figure 80.

Impacts of participatory mapping of boundaries and land use zones

A comparative study of Raks Thai Foundation (Care-Thailand) work with 3-D models and this project's work with GIS-based participatory mapping has been conducted by a joint Care-Thailand and ICRAF team of researchers in collaboration with the East-West Center in Honolulu, Hawaii, as part of a regional EWC study on impacts of participatory mapping.[84] Under the leadership of Ms. Pornwilai Saipothong (ICRAF) and Wutikorn Kojornrungrot (Raks Thai), the study combined formal interviews, group discussion and a stakeholders workshop to gather a range of views on these processes and their impacts in areas of Mae Chaem where they have been employed. Villagers of different ethnic groups and land use systems were represented, along with members of relevant governmental and non-governmental institutions at both local and policy levels. Particular attention was given to impacts of the introduction of boundary concepts in relation to particular types of land use on local natural resources management and awareness, and to exploration of potential negative or undesired impacts and/or possible opposition by various stakeholders

The study found that both the 3-D model and GIS-based approaches are complementary and are viewed by a wide range of stakeholders as an increasingly important tool for land use management under conditions in Mae Chaem. These processes clearly have had impacts on ways in which community members think about land use and land use management, both within and among communities. Indeed, the participatory processes themselves were seen as helping strengthen local

[84] Pornwilai Saipothong, Wutikorn Kojornrungrot, David Thomas. 2004. Comparative Study of Participatory Mapping Processes in Northern Thailand. Draft report submitted to East-West Center, Honolulu, Hawaii.

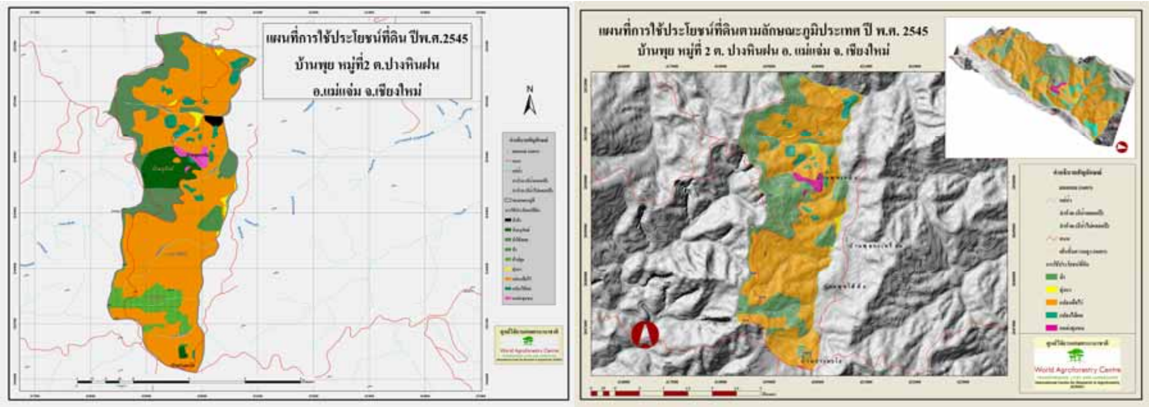
relationships, particularly among communities and stakeholders where communication had been low and tensions were growing. Villagers are interested and willing to engage in mapping processes that can produce maps with accurate and fair information, and are aware that maps with inaccurate information can damage their lives. Moreover, most all agreed that such maps are useful because they make it easier to generate mutual understanding, and that maps are most useful when they are of a quality that is acceptable to neighboring villagers, outsiders, and especially officials and government organizations. The need for such efforts has grown greatly during recent years.

Figure 78.

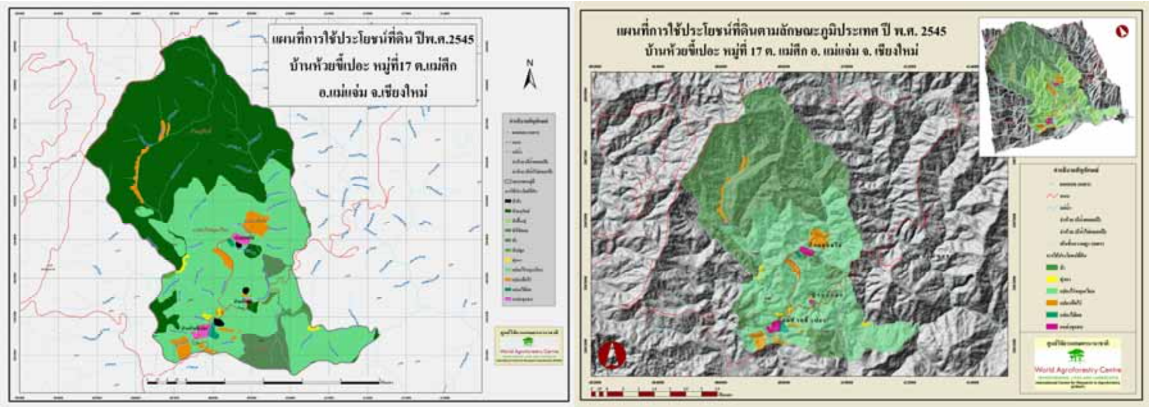
Group, Village & Sub-Watershed Discussions

Figure 79. Examples of Land Use Zoning Maps for Administrative Villages.

(a) Ethnic Hmong village practicing intensive vegetable cultivation.



(b) Ethnic Karen village practicing long-cycle rotational forest fallow cultivation.



(c) Ethnic Northern Thai village practicing paddy and upland field cultivation

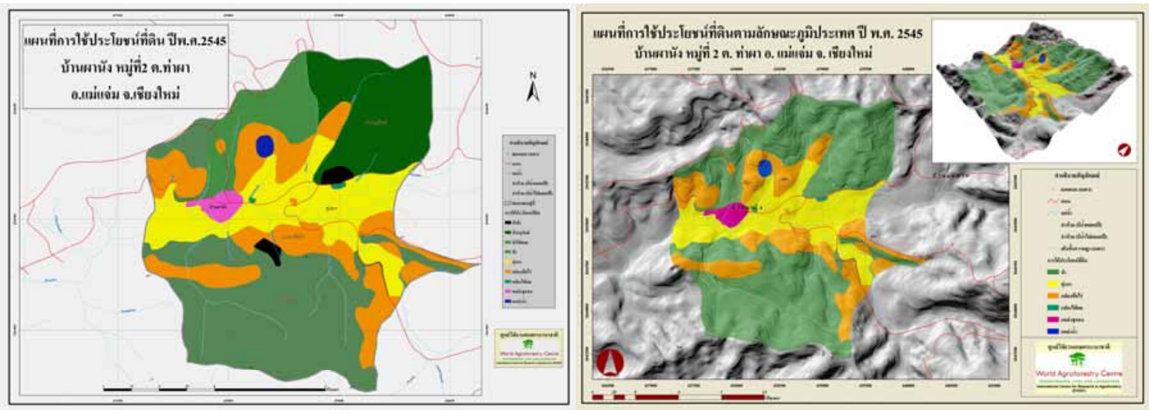
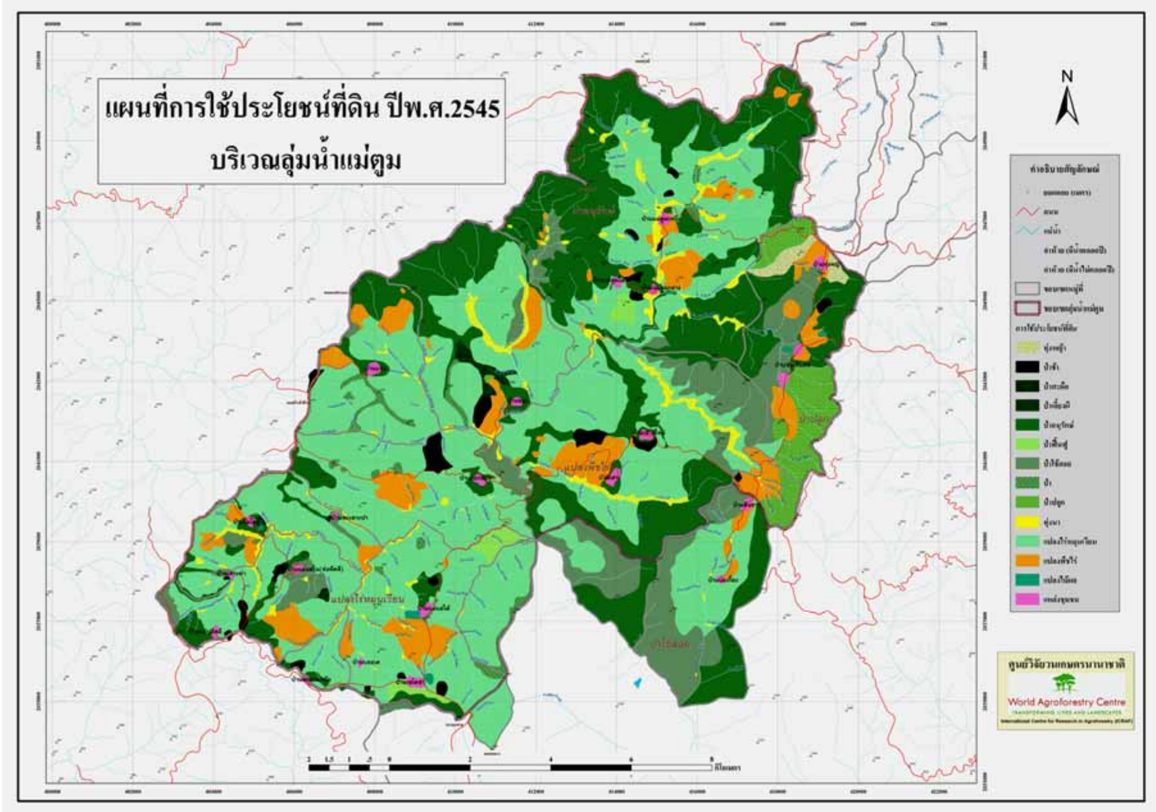
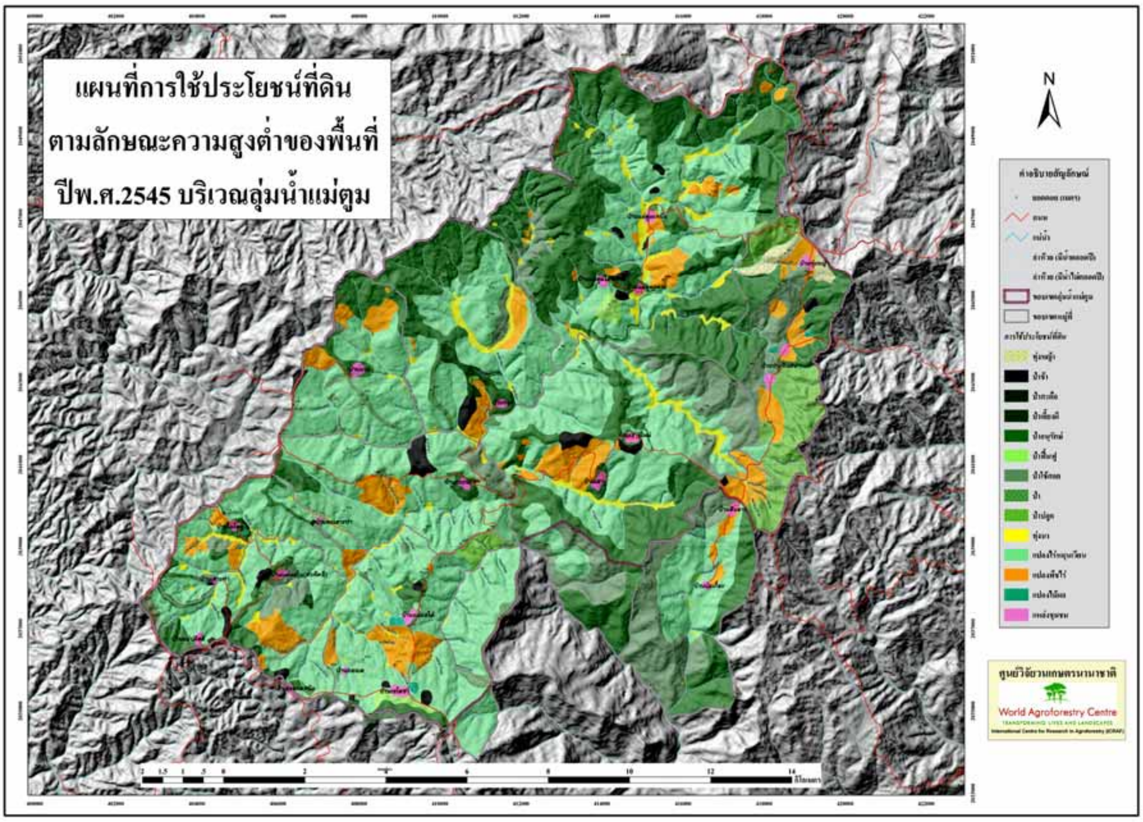


Figure 80. Watershed-Level Land Use Zoning Map for Mae Tum Sub-Watershed





B. Local Land Use Zoning Patterns in Pilot Area Sub-Watersheds

Results of the project's extensive participatory land use mapping activities are summarized in two parts. The first explains how specific local zone information is aggregated for further policy-relevant analyses, and presents overall summary data for each sub-watershed. The second displays and discusses distributions in each sub-watershed, according to groupings derived from overall summary data.

1. Overview of Aggregate Land Use in Pilot Area Sub-Watersheds

Somewhat surprisingly, the local land use zones identified by local communities included a quite limited set of categories. This no doubt reflects the widespread discussions about land use that are occurring in Mae Chaem in association with various types of networks, projects, government programs, and mass media. The 18 local land use categories identified are listed as local categories in Figure 81. Notice the particular attention that is given to effort to articulate the different types of zones for forest land. While most (but not all) of the concepts and beliefs underlying these categories are based in traditional systems, there has been clear widespread effort to articulate why and how non-cultivated forest lands are included in village land use domains.

Figure 81. Land Use Zoning Categories

aggregate	local categories	
Forest Areas		
Planted + other		
	900	forest without further designation
	940	government forest plantings
	930	village forest rehabilitation areas
Community Protected		
	910	community protected forest
	911	birth spirit forest groves
	912	cemetery forest groves
	913	other spiritual groves
Subsistence Use		
	920	community subsistence use forest
	950	community forest
	914	'food bank' forest
Other Uncultivated Areas		
Fallow		
	320	regenerating forest fallow areas
Grass		
	330	grassland areas
Cultivated Fields		
Orchards		
	242	fruit tree gardens and orchards
Upland fields		
	220	current cultivated field crop areas
	230	specific upland vegetable areas
Paddy fields		
	210	bunded paddy fields
Settlement Areas		
	500	village 'urban' housing areas
Other		
	400	areas of mining operations
	600	water

As indicated, these local categories have been combined into aggregate categories in order to simplify and improve the clarity of presentations and discussion of data in the following sections of this report:

- In order to address major forest land use policy concerns, permanent forest zones are aggregated into three major categories: (1) community protected forest where trees are not harvested; (2) community subsistence use forest where trees may only be harvested for subsistence use with prior permission from a village forest management group; (3) other forest areas includes areas planted by forestry department projects, areas communities have designated for forest rehabilitation, and areas locally viewed as simply 'forest' with no further designation.
- Forest fallow is one of the most contentious types of land use at the policy level. Fallow indicates forest areas that are temporary in nature, in that they are composed of various smaller units at different stages of forest regeneration. Upland fields in areas with forest fallows will shift from one unit to another after they are cropped (usually for 1 year). The number of fallow units and the duration of forest regeneration on each is associated with the length of the forest fallow cycle. A rough indication of the forest fallow cycle length in a system with single year cropping can be obtained by dividing the overall area currently in fallow by the area currently in upland crop cultivation. The resulting ratio is an indicator of the number of years that forest vegetation can regenerate in the system, and ratio +1 indicates the system's overall cycle length.

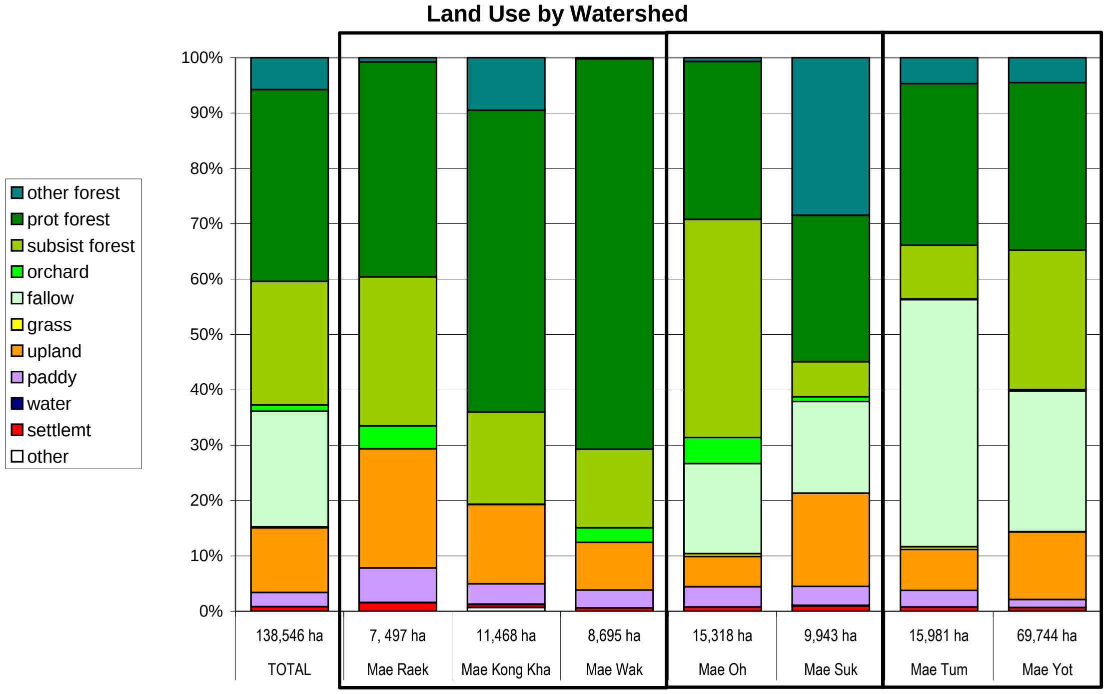
- Grass lands may result from a variety of factors, but here they are usually associated with long duration intensive cultivation of land, or sometimes with major events such as intense forest fires. In any event, they are generally cause for concern by natural resource management authorities.
- Three categories of cultivated land are also associated with land use policy concerns: (1) bunded, and in sloping areas terraced, paddy fields are generally the most acceptable type of cultivated land use from the national policy perspective. But terracing is costly and difficult to justify if irrigation is not available; terrain considerations limit establishment of irrigated paddy in mountainous upper tributary watersheds. (2) upland fields are those planted to upland field crops, in Mae Chaem usually varieties of rice, soybean or maize, or to various types of vegetables or other annual crops. Concern about the environmental impacts of upland crop cultivation is a major issue in the national land use policy arena. (3) orchards of fruit trees or other perennial plants are seen by many interests in larger society as a more benign land use practice than upland fields, although the degree to which this is influenced by the types of management practices employed is now becoming more apparent to various elements of the public policy arena.
- Remaining categories include only village settlements where housing is clustered in small parcels with various types of small gardens and livestock, as well as areas of standing water and areas occupied by mining operations, which are usually beyond the control of local communities.

The relative distributions of these aggregate categories of land use are shown in Figure 82 for the overall study area and each of its seven component sub-watersheds (upper and lower Mae Yot are combined for analytical purposes). It is worth noting in this figure that the three types of permanent forest use cover more than 60 percent of the overall study area, and this pattern holds true for all sub-watersheds except Mae Tum. If the regenerating forest in forest fallow areas is counted as forest, however, Mae Tum then becomes one of the two sub-watersheds where overall forest cover approaches 90 percent, and Mae Raek, where no forest fallows are present, becomes the sub-watershed with the least forest cover. Percentage of land area in currently cultivated upland fields appears to be inversely related to the portion of land in forest fallows, although the relationship does not appear to be very strong. Similarly, relationships are not clear between relative distribution of land among aggregate categories and either population density or average amounts of land per household. This is the type of inclusive evidence that is typical from tables of aggregate data at this scale, even when increased efforts are made to improve articulation of locally-relevant land use categories such as forest fallows. Fortunately, our data is also in a spatially explicit format, which allows us to further disaggregate distributions according to other data that are not necessarily directly observable.

Forest fallow lands are clearly one of the most contentious land use issues in upper tributary watersheds across the entire Montane Mainland Southeast Asia eco-region (see Figure 2). Since forest departments were first established, they have always seen these areas as degraded forest lands, whereas local communities have seen them as areas of forest regrowth that are an essential component of their agroecosystems, restoring productivity without chemical inputs from external sources.

Thus, as an example of how our land use zoning database can help improve understanding of patterns underlying these aggregate land use distributions, let us first group study watersheds according to the presence and relative extent of forest fallow lands per household. Using this criteria, 3 groupings of sub-watersheds are clearly discernable from the data in Figure 13 – those where: (1) average forest fallow is more than 10 hectares per household (Mae Yot, MaeTum); (2) average forest fallow is less than 6 hectares per household (Mae Suk, Mae Oh); and (3) no forest fallow is present (Mae Raek, Mae Kong Kha, Mae Wak). These groupings are also indicated by bold lines in Figure 82.

Figure 82. Land Use in Community Delineated Zones of Study Area Sub-Watersheds



	units	Overall	Mae Raek	Mae Kong Kha	Mae Wak	Mae Oh	Mae Suk	Mae Tum	Mae Yot
Study Area									
Administrative Villages	*no.*	53	7	6	4	5	6	10	15
Ethnic Groups	*symbol*	KTHL	TK	KT	TKH	KH	KTH	KLTH	KHT
Settlements	*no.*	125	20	11	6	13	14	20	41
Population	*persons*	27,435	3,307	2,533	1,340	3,026	3,088	3,613	10,528
	percent	*100*	*12*	*9*	*5*	*11*	*11*	*13*	*38*
Land Area	*hectares*	138,546	7,497	11,468	8,695	15,218	9,943	15,981	69,744
	percent	*100*	*5*	*8*	*6*	*11*	*7*	*12*	*50*
Population Density	*per / sq km*	19.8	44.1	22.1	15.4	19.9	31.1	22.6	15.1
Average Population Data									
settlements/admin village	*no.*	2.4	2.9	1.8	1.5	2.6	2.3	2.0	2.7
settlement size	*households*	36.9	40.6	50.2	40.8	32.5	43.1	32.6	32.3
household size	*persons*	6.0	4.1	4.6	5.5	7.2	5.1	5.5	7.9
Average Land per Household									
house plot	*hectares*	0.2	0.1	0.1	0.2	0.3	0.2	0.2	0.3
cultivated land	*hectares*	4.6	2.9	3.8	5.1	5.0	3.5	2.6	7.3
- paddy land	*percent*	*17*	*19*	*20*	*22*	*26*	*16*	*28*	*11*
- upland crops	*percent*	*76*	*68*	*79*	*60*	*40*	*80*	*70*	*87*
- orchard	*percent*	*7*	*13*	*0*	*18*	*34*	*4*	*1*	*2*
forest fallow	*hectares*	6.3	-	-	-	5.9	2.7	11.0	13.4
- fallow / upland crops	*ratio*	*1.8*	-	-	-	*3.0*	*1.0*	*6.1*	*2.1*
permanent forest	*hectares*	18.9	6.2	16.8	30.1	24.7	10.1	10.7	31.5
- subsistence use	*percent*	*36*	*41*	*21*	*17*	*57*	*10*	*22*	*42*
- community protected	*percent*	*55*	*58*	*68*	*83*	*42*	*43*	*67*	*50*
- plantation & other	*percent*	*9*	*1*	*12*	*0*	*1*	*46*	*11*	*8*

2. Distributions of Aggregate Land Use Zones within Pilot Area Sub-Watersheds

We can now look at how these aggregate categories of land use are spatially distributed within sub-watersheds in each of these groupings. And, since we know that different types of agroecosystems are supposed to be associated with different ethnic groups, we can further re-aggregate data from each sub-watershed according to villages and ethnic group. These data are shown in Figures 83 through 89.

Sub-watersheds where average forest fallow is more than 10 hectares per household.

The sub-watersheds with relatively large average holdings of forest fallow land per household include Mae Yot and Mae Tum. Spatial and numerical data for these sub-watersheds are presented in Figures 83 and 84. One would expect that when such large areas of fallow are present that it would reflect a large presence of ethnic groups practicing rotational forest fallow shifting cultivation with relatively long fallow cycles. From the overall data in Figure 82, this appears to hold true for Mae Tum, which appears to have enough fallow for 6 years of forest re-growth, but in the case of Mae Yot relatively large fallow lands appear to be associated with quite large areas of currently cultivated land and only about two years of forest fallow regeneration.

Closer examination of the data for Mae Yot reveals substantial variation in land use zones among villages, whereas patterns in Mae Tum are somewhat more consistent. Variation in land use zoning allocations across sub-watersheds suggests the presence of four quite distinct land use strategies

(1) Long cycle forest fallow systems. These are clearly present in Mae Yot villages 4, 9 and 17, where forest fallow land appears sufficient for well over 10 years of re-growth before cropping. These are all Karen villages, and this pattern reflects systems that are still quite similar to longstanding traditions. Mae Tum village 8 is a Lawa village with land use zone allocations that allow it to enter this category, which also reflects their longstanding forest fallow traditions.

(2) Medium cycle forest fallow systems. Relative land allocations in Mae Yot villages 3, 13, 14, and Mae Tum villages 3, 4, 5, 6, 7, 9 and 14 are all consistent with forest fallow systems that allow 3-8 years of forest re-growth before cropping. These are all Karen or Lawa villages, and cycle lengths in this range usually reflect either relatively fertile land providing rapid natural re-growth, and/or some internal or external pressures reduce fallow cycle length. A third possibility is that some upland fields are now being planted to fixed field crops (at least 2 Mae Tum villages plant small areas of vegetable cash crops), which could mask a longer fallow for remaining rotational fields. These systems generally appear sustainable for upland rice production without chemical inputs

(3) Short cycle fallow systems. Mae Yot villages 2, 8n, 8s, 12, 15, and Mae Tum village 13 all have aggregate land use zone allocations that include fallow land only sufficient for either a very short (3 years maximum) period of fallow between upland crops, or a somewhat longer fallow for a very small portion of their total upland crop area. In either case, it does not appear very likely that fallow period would be sufficient to provide sufficient regenerative capacity for sustainable management of upland cropping without the use of agricultural chemicals from external sources, especially fertilizers and herbicides. Both research and local knowledge indicate a cycle length threshold at about 5-6 years as a minimum for sustainable production without agricultural chemicals. Four of these villages in Mae Yot may compensate with larger areas of paddy land.

(4) Fixed field systems. These systems reflect either no land allocations to fallow (Mae Yot villages 5, 11), or very small allocations that are less than the area for upland cropping (Mae Yot villages 1, 10, Mae Tum village 10). These villages are all ethnic Northern Thai, ethnic Hmong, or mixed villages that include one or both of these groups. Northern Thai villages are generally at lower elevations and upland fields during this period of time are most frequently planted to maize that is sold to Thai agro-industrial channels for production of animal feed. Hmong villages, on the other hand, are generally in highland areas, where intensive commercial vegetable production is the most common cropping practice in these sub-watersheds. These villages also tend to have high population densities combined with relatively large areas of upland fields per household, and in the case of the Hmong, generally quite large household size. This combination can distort overall data for a sub-watershed, as in the case of upland fields per household for Mae Yot in Figure 82. This overall average figure was distorted by the land allocations in Mae Yot villages 1, 10 and 11, which together contain 32 percent of the people in the sub-watershed, but use only 13 percent of the land area, and more than 90 percent of their relatively large fixed cultivated field holdings are planted to upland crops, primarily vegetables.

Figure 83a. Spatial Distribution of Aggregate Land Use Zones in Mae Yot

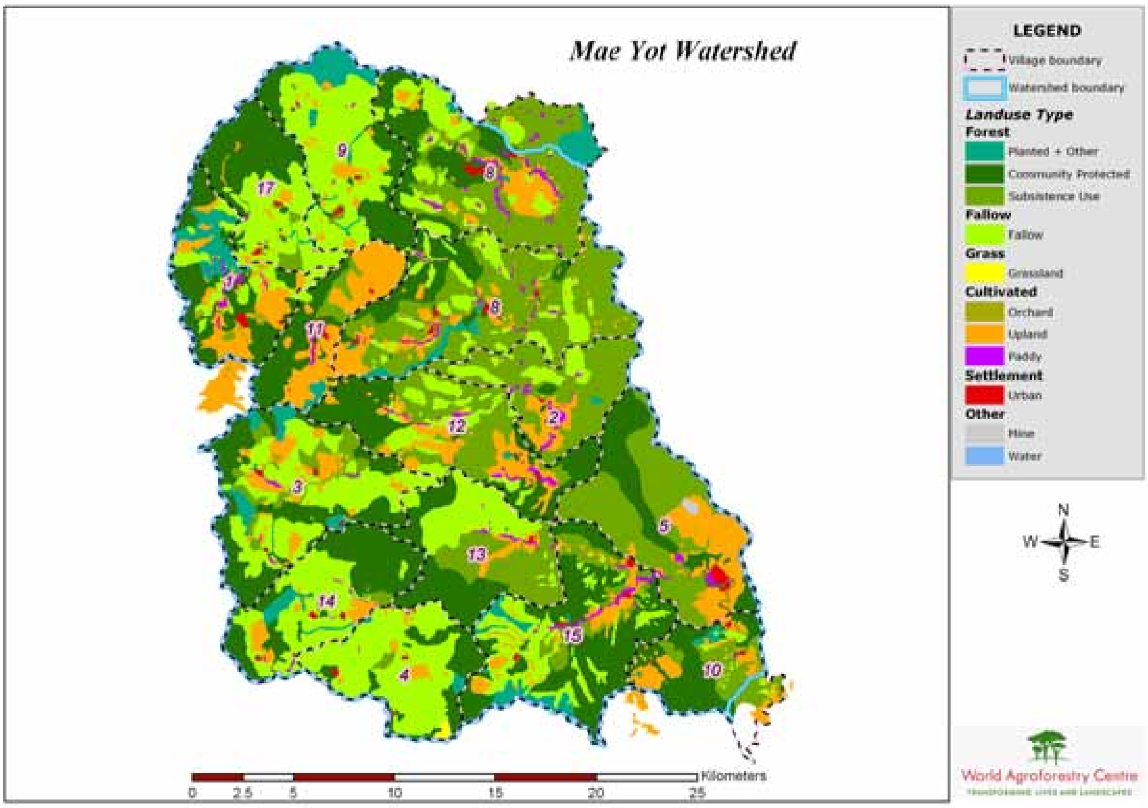
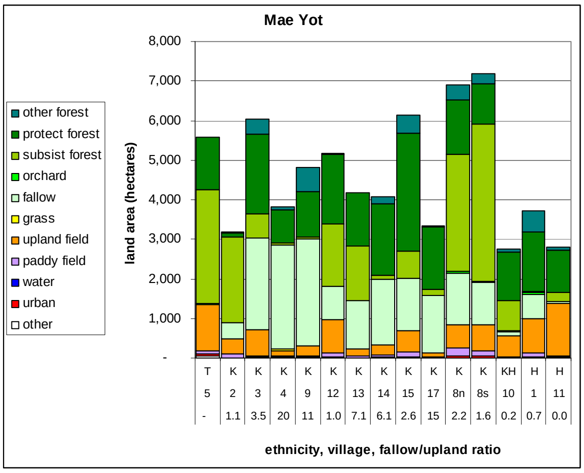


Figure 83b. Mae Yot Distribution by Village and Ethnic Group



	units	Mae Yot	N Thai	Karen	Hmong	Karen + Hmong
Study Area						
Administrative Villages	*no.*	15	1	11	2	1
Settlements	*no.*	41	1	33	5	2
Population	*persons*	10,528	1,313	5,916	2,718	581
	percent	*100*	*12*	*56*	*26*	*6*
Land Area	*hectares*	69,744	5,569	54,892	6,523	2,759
	percent	*100*	*8*	*79*	*9*	*4*
Population Density	*per / sq km*	15.1	23.6	10.8	41.7	21.1
Average Population Data						
settlements/admin village	*no.*	2.7	1.0	3.0	2.5	2.0
settlement size	*households*	32.3	225.0	25.7	39.6	27.0
household size	*persons*	7.9	5.8	7.0	13.7	10.8
Average Land per Household						
house plot	*hectares*	0.3	0.3	0.3	0.3	0.3
cultivated land	*hectares*	7.3	5.6	6.5	11.9	10.0
- paddy land	*percent*	*11*	*5*	*16*	*4*	*1*
- upland crops	*percent*	*87*	*94*	*83*	*93*	*98*
- orchard	*percent*	*2*	*1*	*2*	*3*	*1*
forest fallow	*hectares*	13.4	-	19.9	3.4	2.3
- fallow / upland crops	*ratio*	*2.1*	-	*3.7*	*0.3*	*0.2*
permanent forest	*hectares*	31.5	18.6	37.8	17.4	38.6
- subsistence use	*percent*	*42*	*69*	*43*	*7*	*38*
- community protected	*percent*	*50*	*31*	*50*	*75*	*59*
- plantation & other	*percent*	*8*	-	*8*	*18*	*4*

Areas zoned for community protected forest and community subsistence forest also vary considerably, depending on various contexts, needs and pressures. But the fact that all villages have allocated significant and sometimes quite large areas as zones specifically designated for community protected forest is a good indicator of the impacts being made by generally growing environmental awareness, networks, and the initiatives of projects like the Queen Sirikit Forest Development Project and Care-Thailand's collaborative natural resource management project.

Figure 84a. Spatial Distribution of Aggregate Land Use Zones in Mae Tum

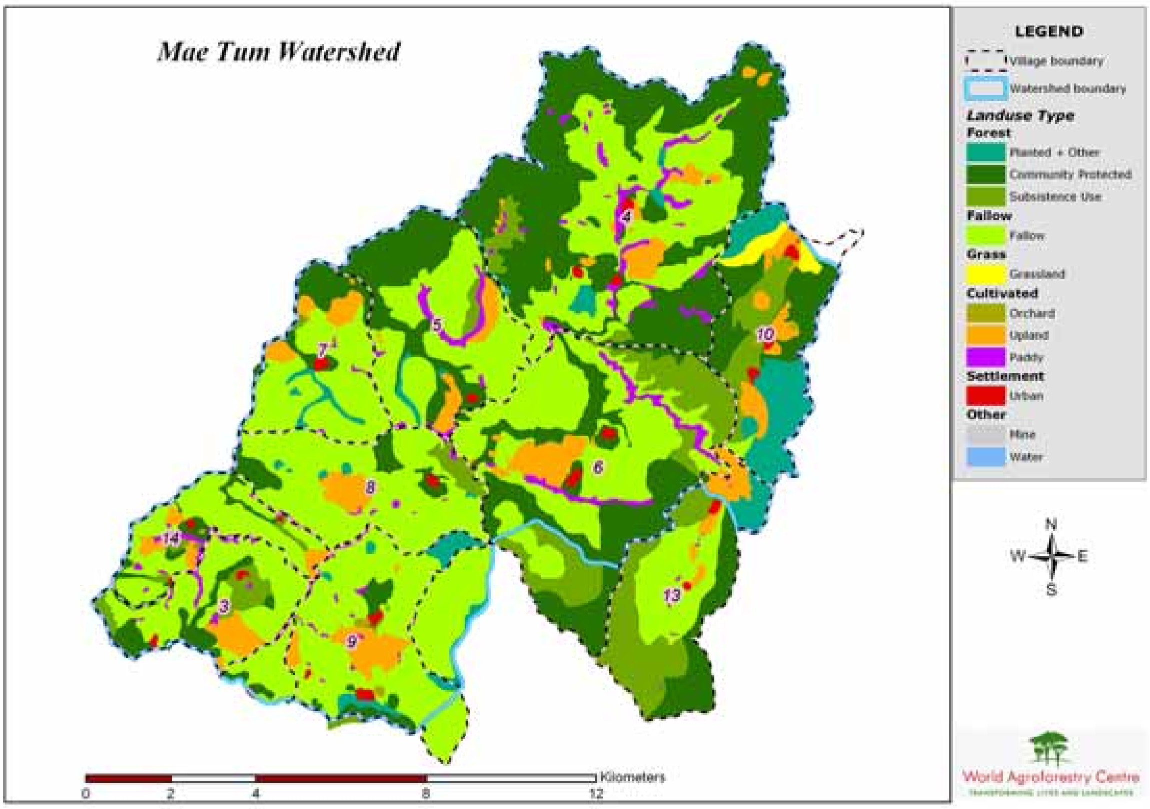
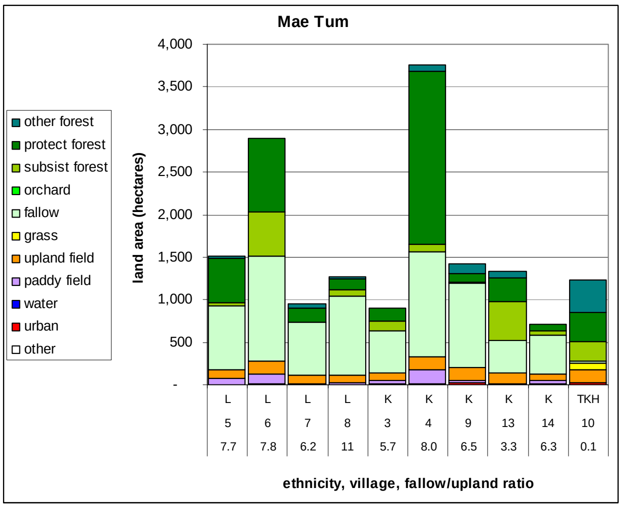


Figure 84b. Mae Tum Distribution by Village and Ethnic Group



	units	Mae Tum	Lawa	Karen	Karen+Thai + Hmong
Study Area					
Administrative Villages	*no.*	10	4	5	1
Settlements	*no.*	20	5	13	2
Population	*persons*	3,613	1,222	2,166	225
	percent	*100*	*34*	*60*	*6*
Land Area	*hectares*	15,981	6,615	8,133	1,234
	percent	*100*	*41*	*51*	*8*
Population Density	*per / sq km*	22.6	18.5	26.6	18.2
Average Population Data					
settlements/admin village	*no.*	2.0	1.3	2.6	2.0
settlement size	*households*	32.6	45.4	28.6	26.0
household size	*persons*	5.5	5.4	5.8	4.3
Average Land per Household					
house plot	*hectares*	0.2	0.2	0.2	0.4
cultivated land	*hectares*	2.6	2.9	2.3	3.0
- paddy land	*percent*	*28*	*32*	*31*	*0*
- upland crops	*percent*	*70*	*68*	*67*	*96*
- orchard	*percent*	*1*	*-*	*2*	*3*
forest fallow	*hectares*	11.0	15.6	9.6	0.4
- fallow / upland crops	*ratio*	*6.1*	*8.0*	*6.1*	*0.1*
permanent forest	*hectares*	10.7	10.5	9.7	18.3
- subsistence use	*percent*	*22*	*26*	*19*	*24*
- community protected	*percent*	*67*	*70*	*73*	*36*
- plantation & other	*percent*	*11*	*4*	*7*	*41*

Yet for environmentalists and foresters who see all forest fallow as degraded forest, conditions in these two sub-watersheds are viewed with great concern and seen as a 'problem' that needs strong efforts to address. For them, the focus of the problem is the need to end all forest fallow practices, either incrementally, or in more dramatic fashion. The incremental approach generally continually urges villages to remove forest fallow units one at a time, thus gradually shortening the overall forest fallow cycle of the system. Many projects, forestry officials and other government agencies have used this approach. Villagers have often yielded to such incremental requests, frequently because they hope it will help increase their legitimacy and mitigate some of the tenurial insecurity that has become an important local concern. There have also been recent efforts by various activist elements to encourage villagers to begin resisting such efforts, and to emphasize justification of rotational forest fallow practices by establishing their legitimacy as a traditional integrated agricultural and natural resource management system that does not require chemical inputs from external sources.

A more dramatic approach is being taken through preliminary declaration of the Mae Tho National Park, the tentative domain of which includes most of the Mae Tum sub-watershed. By turning most all village settlements into enclaves inside of a national park, this approach can bring strong legal measures and social pressure to confine their agricultural activities to very small areas of fixed field cultivation, combined with very restricted access to surrounding permanent forest areas. This much more dramatically aggressive approach has stimulated strong reactions in Mae Tum, and associated tensions and conflict are continuing.

Sub-watersheds where average forest fallow is less than 6 hectares per household.

Two other sub-watersheds, Mae Suk and Mae Oh, were seen in Figure 82 to have much smaller average allocations of forest fallow land per household. Does this mean that these villages have managed to adapt to much shorter rotational forest fallow cycles? Spatial and numerical data in Figures 85 and 86 allow us to explore the patterns of land use zoning that underlie these situations. In order to facilitate comparison with sub-watersheds in the previous section, we will continue to consider how individual villages of various ethnic composition fit with the four land use strategies we have already begun to explore.

(1) <u>Long cycle forest fallow systems</u>. No villages in these watersheds are in this category.

(2) <u>Medium cycle forest fallow systems</u>. One administrative village in each sub-watershed, Mae Suk village 1 and Mae Oh village 13 have land zoning allocations that place them within this category. The Mae Suk village has four small ethnic Karen settlements, and their forest fallows make their land use pattern very distinctive in the context of overall sub-watershed land use zoning patterns. The Mae Oh village has two small ethnic Karen settlements and one larger Hmong settlement near the upper ridge along the eastern edge of the sub-watershed; this pattern indicates the Karen settlements should have enough forest fallow land for a substantial medium cycle rotation.

(3) <u>Short cycle fallow systems</u>. Again, one village in each sub-watershed, Mae Suk village 11 and Mae Oh village 10, fall into this category. Both are ethnic Karen villages, each is composed of four small settlements, and both have significant but still modest amounts of paddy land. In the case of the Mae Suk village, some upland fields are being planted to cabbage in association with neighboring Hmong communities, which means there would be enough forest fallow used for remaining fields to have a somewhat longer rotation cycle. And in Mae Oh, the settlement with the largest area zoned as upland fields has zoned very little land for fallow, indicating they are moving toward fixed field practices and making forest fallow cycle data for the remaining settlements artificially short.

(4) <u>Fixed field systems</u>. These systems are reflected in land allocation data for the remaining seven villages (Mae Suk village 2, 6, 7, 12 and Mae Oh village 3, 17, 19) out of the total of 11 administrative villages located in these two sub-watersheds. Clearly, the fact that fixed field systems are found in such a substantial majority of the villages has had a strong influence on the overall land use zoning data for these two sub-watersheds. The ethnicity of these villages is diverse: 2 are lowland Northern Thai, 2 are Karen, 2 are Hmong, and 1 is mixed Hmong and Karen. The land use strategies reflected in these zoning allocations for fixed field systems reflect three different types of approaches: (a) the 2 Northern Thai villages, located in lower portions of Mae Suk, depend on substantial irrigated paddy fields in combination with upland fields planted largely to maize; the village with smaller paddy fields is also planting small areas of lowland fruit trees. (b) the Hmong and Hmong-Karen villages located in the upper reaches of Mae Suk are heavily focused on intensive commercial vegetable production, largely cabbage, but also now shallots and a growing range of others, and the Hmong village has been experimenting with a few areas of fruit trees. (c) in Mae Oh, however, both Karen and Hmong have shifted from upland field crops entirely into fruit tree orchards; in addition, Karen also have significant areas of paddy

Figure 85a. Spatial Distribution of Aggregate Land Use Zones in Mae Suk

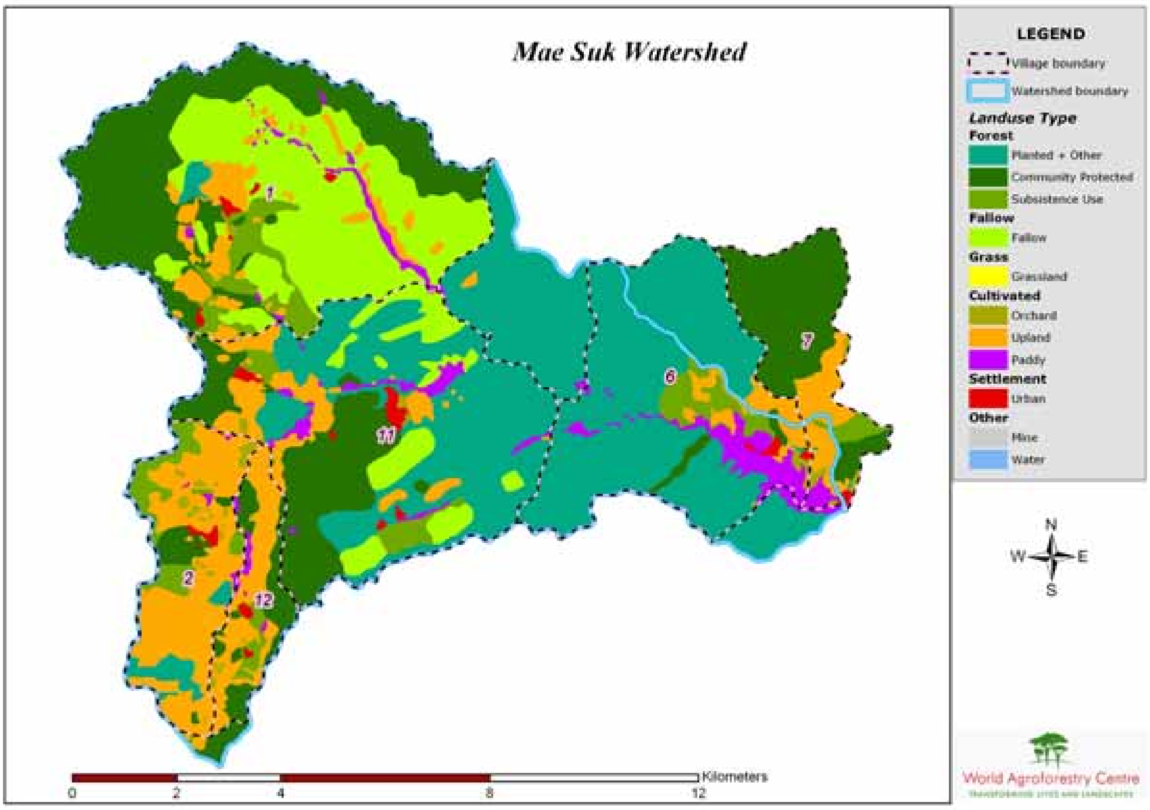
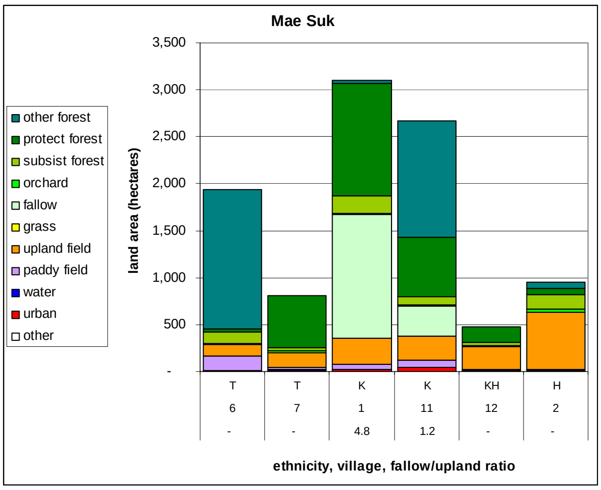


Figure 85b. Mae Suk Distribution by Village and Ethnic Group



	units	Mae Suk	N Thai	Karen	Hmong	Karen + Hmong
Study Area						
Administrative Villages	*no.*	6	2	2	1	1
Settlements	*no.*	14	3	8	1	2
Population	*persons*	3,088	820	1,410	450	408
	percent	*100*	*27*	*46*	*15*	*13*
Land Area	*hectares*	9,943	2,748	5,763	956	477
	percent	*100*	*28*	*58*	*10*	*5*
Population Density	*per / sq km*	31.1	29.8	24.5	47.1	85.6
Average Population Data						
settlements/admin village	*no.*	2.3	1.5	4.0	1.0	2.0
settlement size	*households*	43.1	70.7	32.5	65.0	33.0
household size	*persons*	5.1	3.9	5.4	6.9	6.2
Average Land per Household						
house plot	*hectares*	0.2	0.1	0.2	0.2	0.1
cultivated land	*hectares*	3.5	2.3	2.7	10.1	4.1
- paddy land	*percent*	*16*	*36*	*20*	*1*	*6*
- upland crops	*percent*	*80*	*58*	*78*	*93*	*91*
- orchard	*percent*	*4*	*6*	*2*	*5*	*3*
forest fallow	*hectares*	2.7	-	6.3	-	-
- fallow / upland crops	*ratio*	*1.0*	-	*3.1*	-	-
permanent forest	*hectares*	10.1	10.5	13.0	4.5	3.0
- subsistence use	*percent*	*10*	*7*	*8*	*53*	*18*
- community protected	*percent*	*43*	*26*	*54*	*22*	*82*
- plantation & other	*percent*	*46*	*67*	*38*	*26*	-

field. Fruit tree orchards are composed of a mix of Chinese pear, plum, persimmon and Japanese apricot trees, and Karen plantings also include peach trees. Fruit tree horticulture has developed in this area in association with programs of the Royal Development Foundation (*Khrongkan Luang*).

Thus, the overall land use zoning patterns in these sub-watersheds are not a reflection of uniform shifts into short-cycle rotational forest fallow systems. Rather, they reflect a diversity of decisions about directions for land use change that reflect the diverse cultural backgrounds, perceived needs, and production opportunities of the various communities who live there.

It is also worth noting that most all villages have zoned significant areas for community protected forest, again indicating the significant impacts being made by generally growing

Figure 86a. Spatial Distribution of Aggregate Land Use Zones in Mae Oh

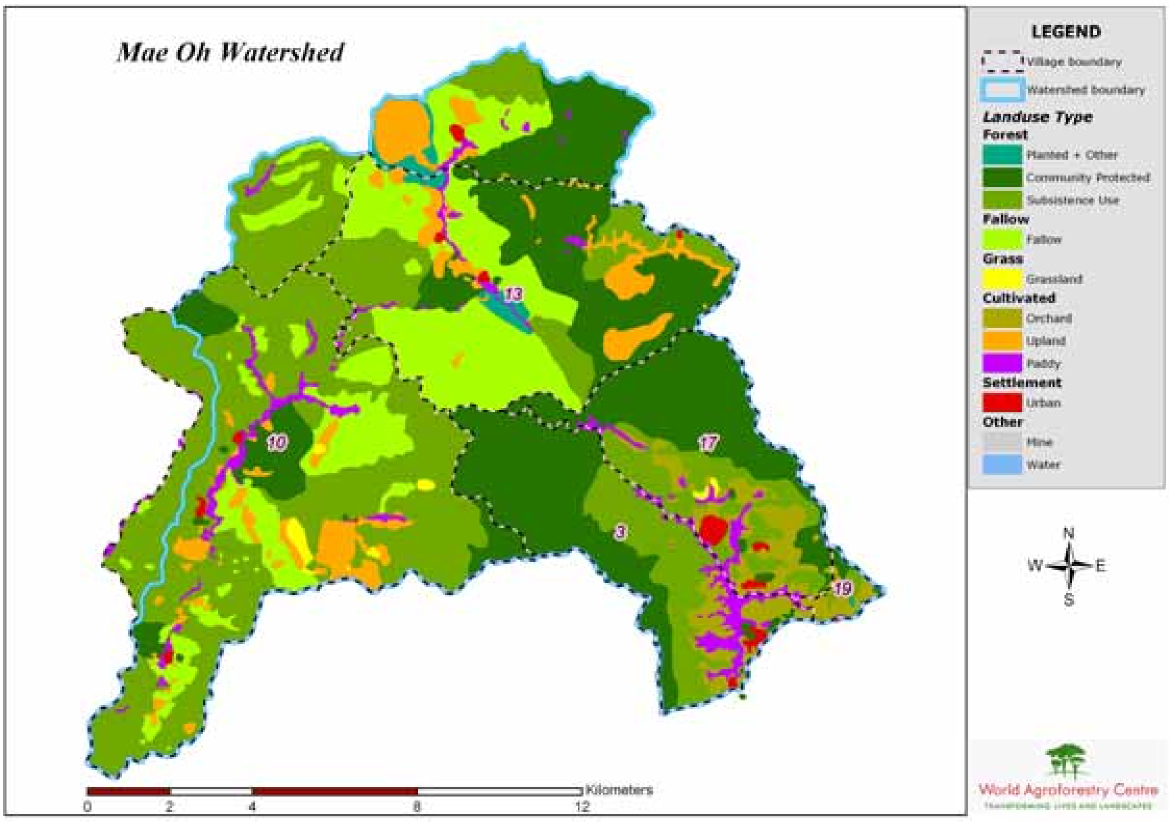
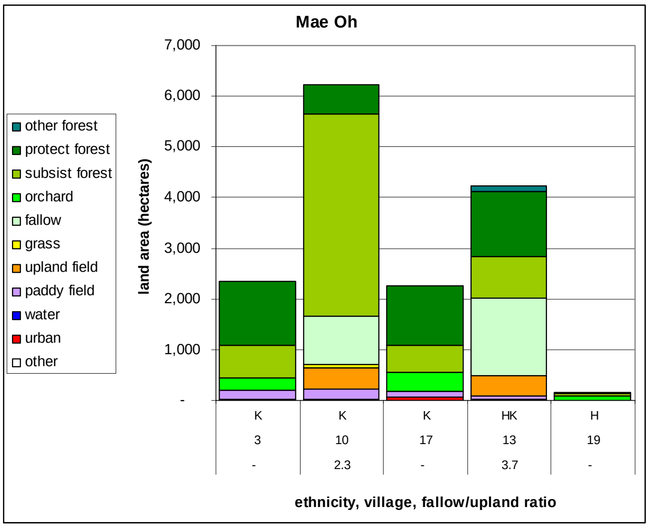


Figure 86b. Mae Oh Distribution by Village and Ethnic Group



	units	Mae Oh	Karen	Hmong	Hmong + Karen
Study Area					
Administrative Villages	*no.*	5	3	1	1
Settlements	*no.*	13	9	1	3
Population	*persons*	3,026	1,881	355	790
	percent	*100*	*62*	*12*	*26*
Land Area	*hectares*	15,218	10,828	165	4,225
	percent	*100*	*71*	*1*	*28*
Population Density	*per / sq km*	19.9	17.4	215.1	18.7
Average Population Data					
settlements/admin village	*no.*	2.6	3.0	1.0	3.0
settlement size	*households*	32.5	34.1	25.0	30.0
household size	*persons*	7.2	6.1	14.2	8.8
Average Land per Household					
house plot	*hectares*	0.3	0.3	0.1	0.2
cultivated land	*hectares*	5.0	5.0	3.6	5.4
- paddy land	*percent*	*26*	*32*	*4*	*14*
- upland crops	*percent*	*40*	*27*	*2*	*86*
- orchard	*percent*	*34*	*41*	*95*	*0*
forest fallow	*hectares*	5.9	3.1	-	17.0
- fallow / upland crops	*ratio*	*3.0*	*2.3*	*-*	*3.7*
permanent forest	*hectares*	24.7	26.6	2.9	24.5
- subsistence use	*percent*	*57*	*63*	*44*	*37*
- community protected	*percent*	*42*	*37*	*49*	*58*
- plantation & other	*percent*	*1*	*0*	*7*	*4*

environmental awareness, networks, and the initiatives of projects like the Queen Sirikit Forest Development Project and Care-Thailand's collaborative natural resource management project. The Karen village in Mae Oh with a short-cycle fallow system has also allocated a much larger than average area for community subsistence use forest, presumably indicating a quite heavy reliance on forest products.

From a permanent forest point of view, one of the most interesting patterns here is the large area that villages in Mae Suk have zoned as simply 'forest' without any further designation, which is reflected in the large blue-green area seen in the central part of the land use zoning map in Figure 85a. In a sense, this seems to represent a 'no man's land' – although significant portions are acknowledged as being within the domain of Mae Suk villages 6 (Northern Thai) and 11 (Karen), neither has thus far been willing to declare their responsibility for managing it as either community subsistence forest or community protected forest. An additional part of this area is zoned as being within the domain of another village with their main land use area outside Mae Suk across the northern ridge. This 'forest' area is an anomaly in comparison with any of the other six sub-watersheds in this study. One hypothesis is that it may be related to the separation of upper and lower Mae Suk into different sub-districts (tambon), and/or to upstream-downstream tensions that have emerged during recent years, especially between lowland Northern Thai and highland Hmong related to water flows and quality. In any event, it is a topic worthy of further study from a community forestry management point of view.

Sub-watersheds where no forest fallow is present.

Overall land use zoning data in Figure 82 indicate that in the remaining three sub-watersheds, Mae Raek, Mae Kong Kha and Mae Wak, there is no land allocated for forest fallows. In order to further investigate the nature of the land use zoning patterns that result in this outcome, spatial and numerical data for these three sub-watersheds are presented in Figures 87, 88 and 89.

Since no fallow fields are present, it is clearly not possible for any of the 17 administrative villages found in these three sub-watersheds to have land use strategies that would place them into any of the first three categories described above. Thus, all of these villages have strategies that employ fixed field systems. How, then, do their fixed field strategies and cultural backgrounds compare with those in the other four sub-watersheds explored above?

As background to addressing this question, there are two contextual points worth noting: (a) all three sub-watersheds are located in the southern half of the eastern slope of Mae Chaem Valley. Their headlands are thus in the ridge that separates Mae Chaem from Chiang Mai Valley, and includes Doi Inthanon, which is Thailand's highest peak. A national park named after Doi Inthanon was one of the first to be established in northern Thailand, and areas along this ridge have seen especially intensive programs directed toward conservation and opium crop substitution. (b) there is only one highland Hmong village located in these three sub-watersheds, resulting in an ethnic distribution that is more strongly dominated by Northern Thai and Karen communities.

For the 8 lowland Northern Thai communities, there is a common pattern across the 3 sub-watersheds for villages to have 20-25 percent of their cultivated land in paddy fields. The rest of their cultivated lands are largely zoned for upland fields, currently planted primarily to maize under contract farming by Thai agro-industrial companies, along with some soybeans and other annual crops. In the case of Mae Raek village 6, substantial areas are also zoned to fruit tree orchards, with current plantings primarily composed of longan, mango and tamarind, which are common in the lowlands.

The single Hmong community, Mae Wak village 18, has taken a commercial horticulture-centered approach in their upland cropping, with areas of fruit tree orchards now approaching half of their total upland field area. Major fruit trees include Chinese pear, peach and Japanese apricot. Development of horticultural production in this area has been in association with the Mae Chon Luang Highland Agricultural Research Station associated with the government's Department of Agricultural Research, and a nearby watershed management unit of the Ministry of Natural Resources and Environment.

Figure 87a. Spatial Distribution of Aggregate Land Use Zones in Mae Kong Kha

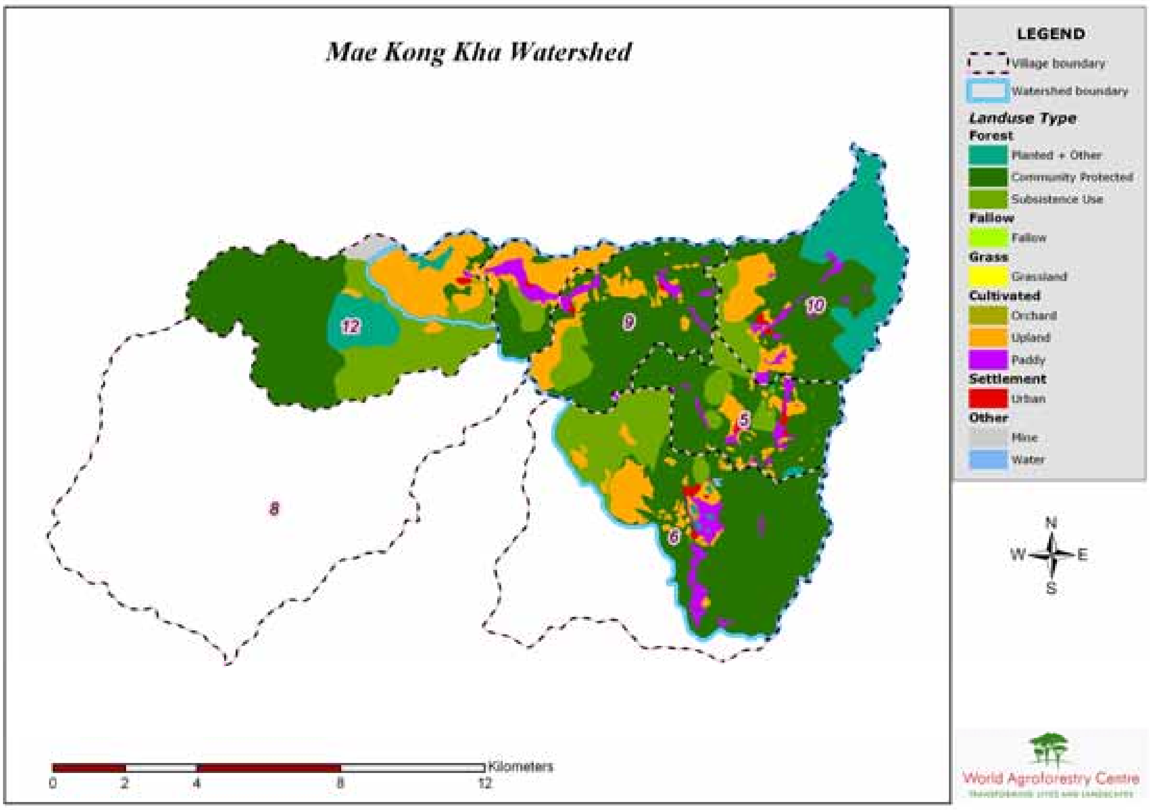
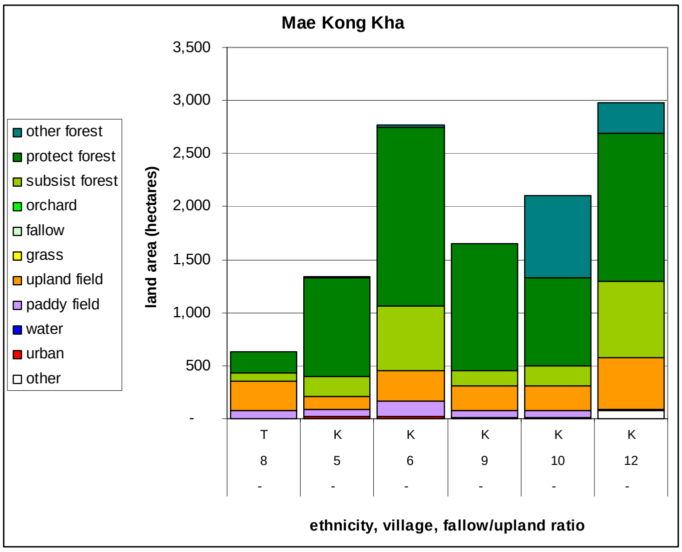


Figure 87b. Mae Kong Kha Distribution by Village and Ethnic Group



	units	Mae Kong Kha	N Thai	Karen
Study Area				
Administrative Villages	*no.*	6	1	5
Settlements	*no.*	11	1	10
Population	*persons*	2,533	650	1,883
	percent	*100*	*26*	*74*
Land Area	*hectares*	11,468	627	10,841
	percent	*100*	*5*	*95*
Population Density	*per / sq km*	22.1	103.7	17.4
Average Population Data				
settlements/admin village	*no.*	1.8	1.0	2.0
settlement size	*households*	50.2	159.0	39.3
household size	*persons*	4.6	4.1	4.8
Average Land per Household				
house plot	*hectares*	0.1	0.02	0.2
cultivated land	*hectares*	3.8	2.2	4.4
- paddy land	*percent*	*20*	*21*	*20*
- upland crops	*percent*	*79*	*78*	*79*
- orchard	*percent*	*0*	*0*	*0*
forest fallow	*hectares*	-	-	-
- fallow / upland crops	*ratio*	-	-	-
permanent forest	*hectares*	16.8	1.7	22.8
- subsistence use	*percent*	*21*	*27*	*20*
- community protected	*percent*	*68*	*73*	*67*
- plantation & other	*percent*	*12*	*-*	*12*

In the remaining 8 Karen and Karen-Thai villages, however, strategies are a bit different. While one Karen village (Mae Wak village 9) has been able to adapt to fixed fields by having more than 60 percent of its cultivated land in irrigated paddy, other villages in this group live in areas where terrain has limited irrigated paddy development to an average of about 20 percent of cultivated area, and for two villages much less. What is different about these Karen villages from what we have seen so far is their fixed field agriculture strategy that still places very substantial emphasis on production of upland rice. In order to make upland rice production possible in continuously cropped fixed fields, villagers developed a crop rotation strategy wherein upland rice fields are planted to upland soybeans every third to fourth year. This appears to be the minimum amount of disruption to continuous cropping that will still prevent yield decline in upland rice. Without the nutrient cycling and weed suppression

Figure 88a. Spatial Distribution of Aggregate Land Use Zones in Mae Raek

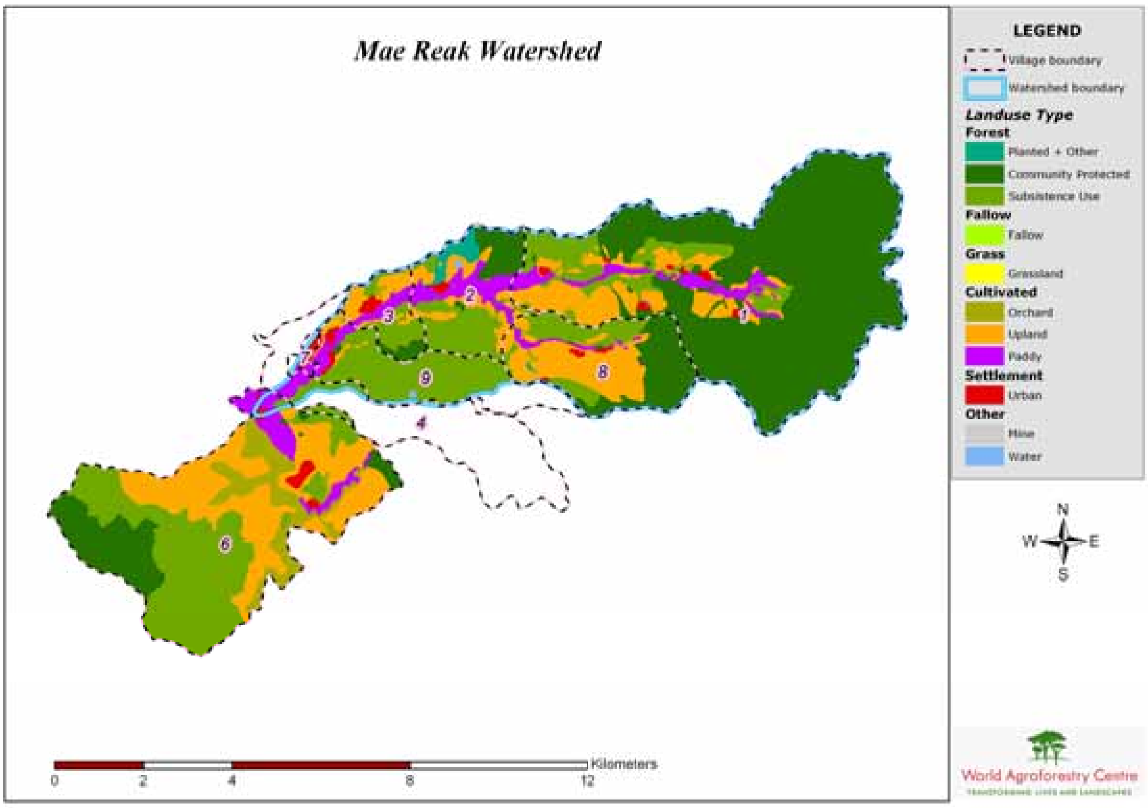
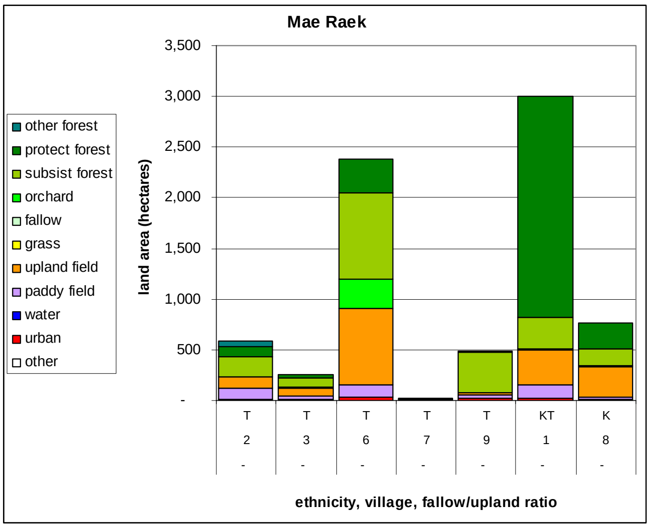


Figure 88b. Mae Raek Distribution by Village and Ethnic Group



	units	Mae Raek	N Thai	Karen	Karen + N Thai
Study Area					
Administrative Villages	*no.*	7	5	1	1
Settlements	*no.*	20	11	3	6
Population	*persons*	3,307	2,351	295	661
	percent	*100*	*71*	*9*	*20*
Land Area	*hectares*	7,497	3,731	761	3,004
	percent	*100*	*50*	*10*	*40*
Population Density	*per / sq km*	44.1	63.0	38.8	22.0
Average Population Data					
settlements/admin village	*no.*	2.9	2.2	3.0	6.0
settlement size	*households*	40.6	53.4	22.7	26.0
household size	*persons*	4.1	4.0	4.3	4.2
Average Land per Household					
house plot	*hectares*	0.1	0.1	0.1	0.1
cultivated land	*hectares*	2.9	2.7	4.9	3.1
- paddy land	*percent*	*19*	*20*	*7*	*26*
- upland crops	*percent*	*68*	*61*	*91*	*72*
- orchard	*percent*	*13*	*19*	*2*	*1*
forest fallow	*hectares*	-	-	-	-
- fallow / upland crops	*ratio*	-	-	-	-
permanent forest	*hectares*	6.2	3.5	6.2	16.0
- subsistence use	*percent*	*41*	*74*	*41*	*12*
- community protected	*percent*	*58*	*23*	*58*	*88*
- plantation & other	*percent*	*1*	*3*	*1*	*-*

functions of the forest fallow system, however, this fixed field system requires external chemical inputs – at least in the form of fertilizers and herbicides – in order for it to remain viable. Since upland rice is a subsistence crop, the need for purchased chemical inputs requires a source of cash income to subsidize the system. Thus, as most of their permanent fields are located on relatively lower slopes and foothill areas, they have sought to obtain cash income by expanding the area of their permanent upland fields to allow for commercial production of first upland soybeans, which have been largely displaced by maize during recent years as opportunities emerged for contract farming arrangements.

In terms of permanent forest, it is quite apparent that all villages in middle to upper slope areas of these sub-watersheds have zoned very substantial areas of community protected

Figure 89a. Spatial Distribution of Aggregate Land Use Zones in Mae Wak

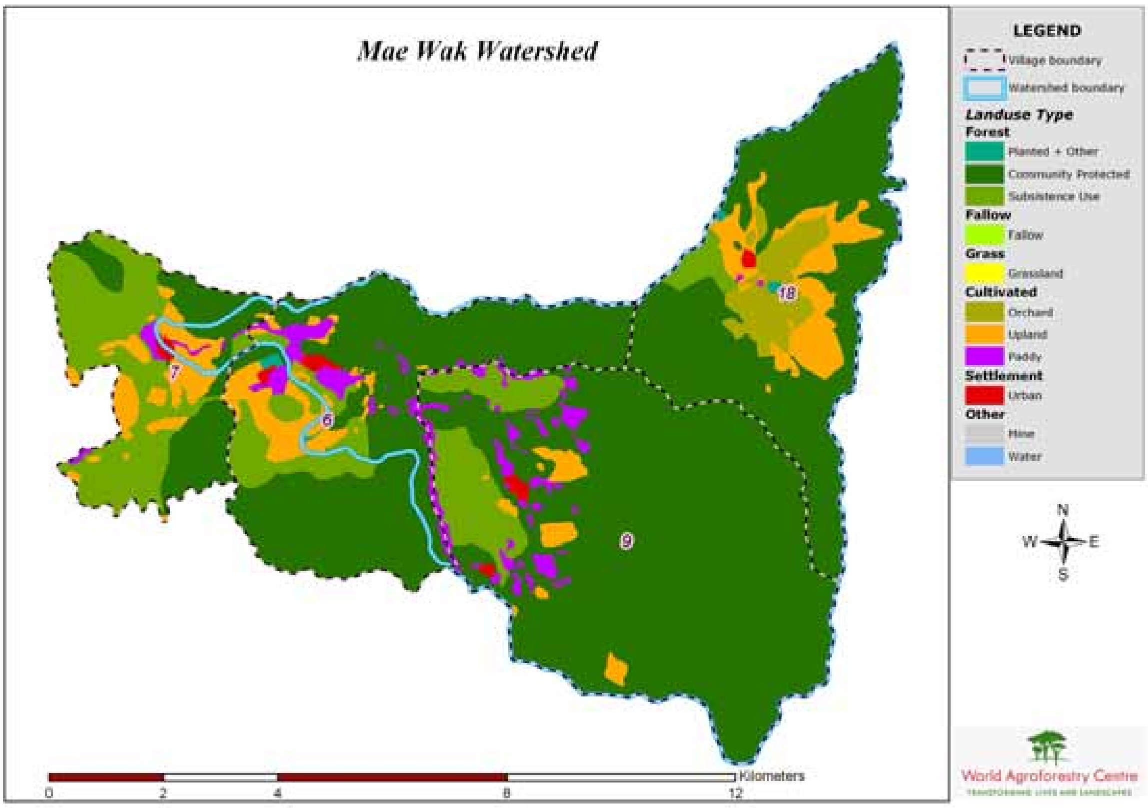
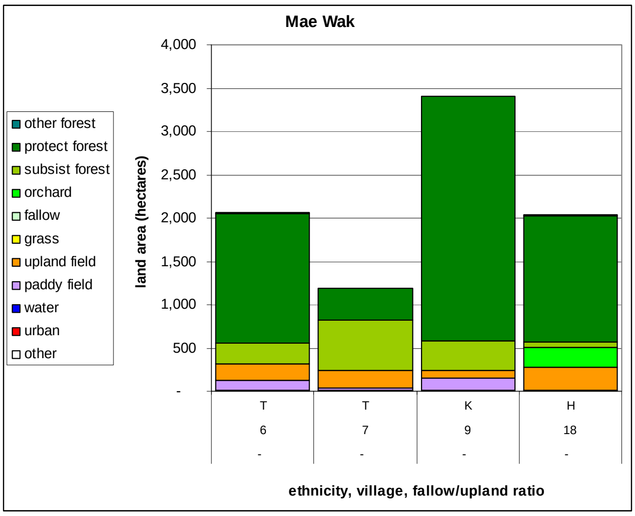


Figure 89b. Mae Wak Distribution by Village and Ethnic Group



	units	Mae Wak	N Thai	Karen	Hmong
Study Area					
Administrative Villages	*no.*	4	2	1	1
Settlements	*no.*	6	3	2	1
Population	*persons*	1,340	682	380	278
	percent	*100*	*51*	*28*	*21*
Land Area	*hectares*	8,695	3,250	3,405	2,039
	percent	*100*	*37*	*39*	*23*
Population Density	*per / sq km*	15.4	21.0	11.2	13.6
Average Population Data					
settlements/admin village	*no.*	1.5	1.5	2.0	1.0
settlement size	*households*	40.8	43.0	36.0	44.0
household size	*persons*	5.5	5.3	5.3	6.3
Average Land per Household					
house plot	*hectares*	0.2	0.2	0.2	0.2
cultivated land	*hectares*	5.1	4.1	3.2	11.3
- paddy land	*percent*	*22*	*26*	*62*	*0*
- upland crops	*percent*	*60*	*73*	*38*	*55*
- orchard	*percent*	*18*	*1*	*-*	*44*
forest fallow	*hectares*	-	-	-	-
- fallow / upland crops	*ratio*	-	-	-	-
permanent forest	*hectares*	30.1	20.9	43.9	34.8
- subsistence use	*percent*	*17*	*31*	*11*	*5*
- community protected	*percent*	*83*	*69*	*89*	*95*
- plantation & other	*percent*	*0*	*0*	*-*	*1*

forest, which are in most all cases quite substantially larger than their total cultivated area. Additional areas for permanent community subsistence use forest are also substantial, but still much smaller than community protected areas. In these sub-watersheds, areas zoned into the (blue-green) ‘other forest’ category are entirely areas that have either been planted to forest tree species by forest agencies, or areas that have been designated by communities for forest rehabilitation; these areas are in this category because it is not yet clear how any community subsistence use or protected forest management practices will apply once more mature permanent forest is established.

C. Livelihood and Land Use Strategies Reflected in Local Land Use Zoning

As initial examples of how this data can be used for cross-watershed analyses, we look first at overall land use patterns and strategies, followed by how these patterns differ among ethnic groups.

1. Village Land Use Zoning Patterns and Strategies

From these examinations of administrative village land use zoning patterns in our seven study sub-watersheds, it is clear that there is substantial variation in local livelihood strategies and the land use zoning patterns in which they are reflected. Indeed, when we aggregate findings for all sub-watersheds and ethnic groups discussed above, we can derive a list of 18 apparently different land use strategies, which are listed in Figure 90 along with data describing a range of their characteristics.

Although at first glance this list looks quite long, closer examination of the data reveals patterns that allow us to group strategies into a much smaller hierarchical set of categories. At the broadest level, there are two major types of strategies, each of which can be broken into 3 generic sub-types:

- **Forest Fallow Systems** are simply those that have more land in naturally regenerating rotational forest fallows than are cropped to upland rice in any given year. All of these systems are set within village landscapes that include irrigated paddy and uncultivated lands, including fallows and permanent forest. In the overall study area, 45 percent of the people and 62 percent of the land are associated with forest fallow systems. As indicated in discussions of each sub-watershed, there are three basic sub-types of forest fallow systems, based on the length of the forest fallow rotation cycle; an increasing number of variants occur as cycle length decreases:
  - <u>Long fallow systems</u> are those allowing for 9 or more years of forest vegetation re-growth during the fallow period, resulting in a total cycle length of at least 10 years. While only 6 percent of the people and 10 percent of the land employ this type of system, it is still quite noteworthy that – contrary to most popular belief – there are indeed still areas where such systems continue to persist and function as promised.
  - <u>Medium fallow systems</u> allow for 4 to 8 years of forest regeneration, for a rotation cycle length of 5 to 10 years. This sub-type is associated with a balanced 23 percent of the people and 24 percent of the land, evenly split between villages with and without expanded areas of irrigated paddy. As systems with more irrigated paddy decrease reliance on rice from the forest fallow component, a somewhat larger proportion of the overall landscape tends to be under permanent forest, with most of it assigned community protection forest status
  - <u>Short fallow systems</u> include less than 4 years of regeneration, for a cycle length of less than 5 years. Unless it is situated on a very unusually high quality site, upland rice produced in such systems tends to suffer from quite low yields per unit of land and/or labor, unless there is some level of external herbicide and/or fertilizer inputs. About 16 percent of our study population operates such systems covering 28 percent of the total land area. The vast majority of these systems are in areas with quite large irrigated paddy holdings, and a bit more than half also plant some upland fields to a maize cash crop. In either case, total upland area cropped in a given year is at least double that of other forest fallow systems. Exceptions are one village relying only on the short fallow system, and another that substitutes vegetables for maize as their commercial crop. Along with the smaller overall portion of land under forest fallow in short cycle systems, is a great increase in average land area per household allocated to subsistence forest. But only in areas where systems include both large paddies and commercial maize does the relative proportion of community protected permanent forest increase substantially.

Figure 90. Overall Land Use Strategies Reflected in Administrative Village Land Use Zoning Maps of the Seven Study Sub-Watersheds

	major village system components				ratio	average land resource use per household: cultivated land					average land resource use per household: uncultivated land (ha)				size of examples in sample: villages practicing system				size of examples in sample	sample share: percent of		system footprint			
	paddy rice	upland rice	field crop	orchard	fallow /upland	paddy (ha)	all (ha)	paddy %	upland %	orchard %	subsist forest	protect forest	all forest	forest + fallow	admin vill	natur vill	house holds	pop	TOTAL Land Area (ha)	sample people	sample land	persons per sq km	% of land cultiv	% forest fallow	% perm forest
Forest Fallow Systems																									
1	*small*	**long forest fallow**	*<minor>*	*<minor>*	13.5	0.3	2.4	11	87	3	1	13	17	45	4	11	279	1,684	13,242	6	10	13	5	58	36
2	*small*	**medium forest fallow**	*<minor>*	*<minor>*	4.8	0.4	3.2	12	87	1	2	10	13	26	6	17	559	3,665	16,503	13	12	22	11	45	44
3	**expanded**	**medium forest fallow**	*<minor>*	*<minor>*	6.0	1.2	4.0	31	69	0.1	7	16	23	40	6	13	395	2,631	17,284	10	12	15	9	37	53
4	*<minor>*	**short forest fallow**	*<minor>*		3.3	0.1	2.9	4	96	-	11	7	19	29	1	2	42	226	1,336	1	1	17	9	29	61
5	**expanded**	**short forest fallow**	*<minor>*	*<minor>*	1.7	1.8	8.3	21	75	4	35	10	47	58	3	9	259	1,605	17,294	6	12	9	12	16	71
6	**expanded**	**short forest fallow**	**maize**	*<minor>*	1.8	1.9	9.5	20	80	1	27	23	51	65	3	10	234	1,918	17,530	7	13	11	13	18	69
7	*small*	**short forest fallow**	**vegetables**	*<minor>*	1.2	0.6	2.9	22	74	4	1	5	16	19	1	4	121	539	2,665	2	2	20	13	12	73
Permanent Field Systems																									
8	*small*	**fixed field**	**maize**	*<minor>*	-	0.4	4.9	7	91	2	3	4	6	6	1	3	68	295	761	1	1	39	44	-	55
9	**expanded**	**fixed field**	**maize**	*<minor>*	-	1.0	3.5	28	72	1	3	14	18	18	5	15	495	2,309	10,865	8	8	21	16	-	83
10	**expanded**	-	**maize**	*<minor>*	-	1.3	3.0	46	52	2	2	6	14	14	3	5	274	1,134	4,590	4	3	25	18	-	81
11	**expanded**	-	**vegetables**		-	1.9	3.2	62	38	-	5	39	44	44	1	2	72	380	3,405	1	2	11	7	-	93
12	**expanded**	-		**fruit trees**		1.3	4.2	31	-	69	5	11	17	17	2	5	216	1,117	4,602	4	3	24	20	-	78
13	*small*	-	**maize**	*<minor>*	-	0.3	3.5	10	89	2	6	5	11	11	7	8	779	3,562	11,906	13	9	30	23	-	75
14	*small*	-	**maize**	**fruit trees**	-	0.6	5.8	11	65	24	4	2	6	6	1	4	199	882	2,386	3	2	37	49	-	50
15	*<minor>*	-		**fruit trees**	-	0.1	3.6	4	2	95	1	1	3	3	1	1	25	355	165	1	0.1	215	55	-	43
16	*<minor>*	-	**vegetables**	**fruit trees**	-	0.05	11.3	0.4	55	44	2	33	35	35	1	1	44	278	2,039	1	1	14	24	-	75
17	*small*	-	**vegetables**	*<minor>*	0.2	0.3	9.1	3	94	3	3	10	16	18	6	12	435	4,382	11,948	16	9	37	33	7	58
Urban Fringe System																									
18	*<minor>*	-	-	**garden**	-	0.1	0.1	83	0	17	-	-	-	-	1	3	114	473	24	2	0.02	1,970	39	-	-
Overall Study Area					1.8	0.8	4.6	17	76	7	7	10	19	25	53	125	4,610	27,435	138,546	100	100	20	15	21	63

- While criteria for distinguishing forest fallow sub-types may seem arbitrary, they are grounded in notions associated with two thresholds. The first is that many villagers make observations that agree with findings of various early, primarily anthropological studies, that traditional systems of the more distant past tended to have cycle lengths of more than 10 years. Such systems appear to usually provide upland rice yields in the range of about 2-3 tons per hectare, with reasonable reliability, relatively little weed pressure, and no chemical inputs. The second observation again results from a correspondence of local knowledge with findings of both biophysical and socio-economic studies, which all indicate a fallow period of at least about 4 years is necessary for forest fallow systems to remain viable without external agricultural chemical inputs. There may, of course, be variation associated with the relative fertility and regenerative capacity of a given site, as well as differences in the growth rates and effects of different plant species and types of fallow vegetation. But as a general 'rule of thumb', it appears that re-growth periods shorter than this threshold are not able to maintain sufficient plant nutrient replenishment and/or noxious weed suppression to allow crop yields providing reasonable returns to labor and effort invested. Other ecological factors may also be involved that have yet to be systematically investigated.

- **Permanent Field Systems** are those with no fallow land, or very minor areas of fallow smaller than the area currently cropped. In our overall sample, 54 percent of the people employ such systems on 38 percent of the land area, under relatively higher overall population densities. There are three basic sub-types of this system, each with 2 or more variations:
  - Fixed field upland rice and maize systems are used by 9 percent of the people on 9 percent of the land in study sub-watersheds. In all but one administrative village this type of system also includes quite substantial areas of irrigated paddy fields. As already mentioned, fixed field upland rice requires another crop (usually upland soybean) planted in rotation at least one out of every 3 to 4 years, as well as use of purchased herbicides and fertilizer. Thus, fixed field upland rice is always associated with a crop that can generate cash income.
  - Irrigated paddy and upland cash crop systems have either eliminated or not engaged in upland rice production, depending on the ethnic group and the area. These systems are also used by about 9 percent of the people on 8 percent of the study area land. Three variations in these systems result from use of different types of cash crops: maize, vegetables or fruit tree orchards, depending on availability of location-related opportunities.
  - Upland cash crop systems have a strong primary focus in their agricultural component on upland cash crops. In study sub-watersheds, 34 percent of the people are using just over 20 percent of the land area to operate five variants of this type of system. The variants focus on either maize or vegetables with or without fruit tree orchards, or else exclusively on fruit tree orchards. The vast majority focuses on either maize or vegetables without the other combinations; irrigated paddy is a quite minor part of all of these systems.
    In terms of uncultivated land resources in permanent field systems, mixed systems where paddy makes up a relatively large portion of cultivated land appear to be accompanied by larger areas of permanent forest than in other types of permanent field systems, and much of it is in community protected status.

Given its very different characteristics, an **Urban Fringe System** is identified as a third category, although our sample of one village can only flag this type of system as a subject for further study

2. Variation in Land Use Zoning Strategies Among Ethnic Groups

While this hierarchy of alternative land use system strategies includes a quite diverse and distributed range of alternatives that are being embraced by various administrative villages across a broad sample of the Mae Chaem sub-basin, systems are far from evenly distributed across ethnic groups. Summary data on the various strategies employed by different ethnic groups in study sub-watersheds are displayed in Figure 91. As this table indicates, all Northern Thai villages are engaged in commercial crop production of maize, which in one case is combined with fruit tree orchards. Similarly, all Hmong villages also focus heavily on commercial crop production, but their crops are commercial vegetables and/or fruit tree orchards. Lawa villages are at the other extreme, with a very strong focus on long to medium cycle rotational forest fallow systems that emphasize subsistence upland rice production without external inputs. While some of these differences relate to correlations between ethnicity and locational choices associated with ecological condition, as indicated in the diagram displayed previously in Figure 7, there are also strong differences seen among ethnic groups living in close proximity to each other under similar environmental and access-related conditions.

Since the Karen are the dominant ethnic group in Mae Chaem, it is perhaps not surprising that they would show the most variation in land use strategies. Yet, distribution of their systems across 12 variants that include all six major sub-types is still quite striking. Although the Karen are often subjected to popular depictions as reclusive people resistant to change, evidence in our study areas indicate that they are adapting to a wide range of conditions by employing a variety of livelihood strategies. Yet, do we perhaps still see some of their traditional heritage in efforts by many to continue producing subsistence upland rice, even in short forest fallow or fixed field systems where productivity and relative profitability can be quite problematic?

Moreover, distributions of land use strategies across ethnic groups raises further questions regarding processes underlying broader land use change in Mae Chaem during recent decades, and implications for the land use zoning plans that local communities have helped us map. Some examples include:

- If the various ethnic groups had distinctive characteristic traditional approaches to agroecosystem management, then how did this range of diversity (especially among the Karen) come about?
- Did change happen quickly or gradually? Were there particular stages associated with events?
- Have shortening rotational forest fallow system cycles made these systems unsustainable?
- Has land use change resulted in a radical loss of forest cover during the last 50 years?
- What are the overall and lasting impacts of the various projects that have been implemented?

The next section reports on efforts under this project to provide improved information we hope can help strengthen our ability to address such questions, based on exploration of land use change in our study sub-watersheds.

Figure 91. Overall Land Use Strategies Reflected in Administrative Village Land Use Zoning Maps of the Seven Study Sub-Watersheds by Ethnic Group

	major village system components				ratio	average land resource use per household									size of examples in sample					sample share		system footprint			
						cultivated land					uncultivated land (ha)				villages practicing system				TOTAL Land Area (ha)	percent of					
	paddy rice	upland rice	field crop	orchard	fallow /upland	paddy (ha)	all (ha)	paddy %	upland %	orchard %	subsist forest	protect forest	all forest	forest + fallow	admin vill	natur vill	house holds	pop		sample people	sample land	persons per sq km	% of land cultiv	% forest fallow	% perm forest
Northern Thai Villages																									
10	**expanded**	-	**maize**	<minor>	-	1.3	3.0	46	52	2	2	6	14	14	3	5	274	1,134	4,590	4	3	25	18	-	81
13	small	-	**maize**	<minor>	-	0.4	3.1	12	87	2	6	3	9	9	6	7	725	3,327	8,926	12	6	37	25	-	73
14	small	-	**maize**	**fruit trees**	-	0.6	5.8	11	65	24	4	2	6	6	1	4	199	882	2,386	3	2	37	49	-	50
18	<minor>	-	-	**garden**	-	0.1	0.1	83	0	17	-	-	-	-	1	3	114	473	24	2	0.02	1,970	39	-	-
Lawa Villages																									
1	small	**long forest fallow**	<minor>	<minor>	10.7	0.4	2.3	19	81	-	2	3	5	25	1	1	46	237	1,268	1	1	19	9	74	17
2	<minor>	**medium forest fallow**	<minor>	<minor>	6.2	0.1	1.6	8	92	-	0.1	2	3	13	1	1	65	375	947	1	1	40	11	65	22
3	**expanded**	**medium forest fallow**	<minor>	<minor>	7.8	1.5	3.7	41	59	-	5	12	17	34	2	3	116	610	4,400	2	3	14	10	45	44
Karen Villages																									
1	<minor>	**long forest fallow**	<minor>	<minor>	14.0	0.2	2.4	9	88	3	1	15	19	48	3	10	233	1,447	11,973	5	9	12	5	57	38
2	small	**medium forest fallow**	<minor>	<minor>	4.7	0.4	3.4	12	87	1	2	11	14	28	5	16	494	3,290	15,556	12	11	21	11	44	45
3	**expanded**	**medium forest fallow**	<minor>	<minor>	7.3	1.3	3.4	38	62	0.2	8	18	27	42	3	7	189	1,231	8,659	4	6	14	7	34	58
4	<minor>	**short forest fallow**	<minor>		3.3	0.1	2.9	4	96	-	11	7	19	29	1	2	42	226	1,336	1	1	17	9	29	61
5	**expanded**	**short forest fallow**	<minor>	<minor>	1.7	1.8	8.3	21	75	4	35	10	47	58	3	9	259	1,605	17,294	6	12	9	12	16	71
6	**expanded**	**short forest fallow**	**maize**	<minor>	1.8	1.9	9.5	20	80	1	27	23	51	65	3	10	234	1,918	17,530	7	13	11	13	18	69
7	small	**short forest fallow**	**vegetables**	<minor>	1.2	0.6	2.9	22	74	4	1	5	16	19	1	4	121	539	2,665	2	2	20	13	12	73
8	small	**fixed field**	**maize**	<minor>	-	0.4	4.9	7	91	2	3	4	6	6	1	3	68	295	761	1	1	39	44	-	55
9	**expanded**	**fixed field**	**maize**	<minor>	-	1.0	3.6	28	72	0.2	3	14	19	19	4	9	339	1,648	7,861	6	6	21	16	-	84
11	**expanded**	-	**vegetables**		-	1.9	3.2	62	38	-	5	39	44	44	1	2	72	380	3,405	1	2	11	7	-	93
12	**expanded**	-		**fruit trees**		1.3	4.2	31	-	69	5	11	17	17	2	5	216	1,117	4,602	4	3	24	20	-	78
13	<minor>	-	**maize**	<minor>	-	0.1	9.2	1	98	1	13	26	44	44	1	1	54	235	2,980	1	2	8	17	-	81
Hmong Villages																									
15	<minor>	-	<minor>	**fruit trees**	-	0.1	3.6	4	2	95	1	1	3	3	1	1	25	355	165	1	0.1	215	55	-	43
16	<minor>	-	**vegetables**	**fruit trees**	-	0.05	11.3	0.4	55	44	2	33	35	35	1	1	44	278	2,039	1	1	14	24	-	75
17	small	-	**vegetables**	<minor>	0.2	0.4	11.4	4	93	3	2	10	14	17	3	6	263	3,168	7,479	12	5	42	40	9	50
Mixed Villages																									
3	**expanded**	**medium forest fallow**	<minor>	<minor>	3.7	0.8	5.4	14	86	0.1	9	14	24	41	1	3	90	790	4,225	3	3	19	11	36	52
9	**expanded**	**fixed field**	**maize**	<minor>	-	0.8	3.1	26	72	1	2	14	16	16	1	6	156	661	3,004	2	2	22	16	-	83
17	<minor>	-	**vegetables**	<minor>	0.2	0.1	5.6	2	96	2	6	10	19	20	3	6	172	1,214	4,469	4	3	27	22	3	72
Overall Study Area					1.8	0.8	4.6	17	76	7	7	10	19	25	53	125	4,610	27,435	138,546	100	100	20	15	21	63

D. Land use change and accountability

We have seen that current land use and zoning at administrative village level reflects a diverse range of land use strategies. For the Northern Thai, Hmong and Lawa, each ethnic group is associated with a very different, but narrow range of alternatives. The majority ethnic Karen population, however, displays a broad range of alternative land use strategies that spans all six major sub-types of systems found in study sub-watersheds.

The previous section ended by raising several important broader questions related to processes of land use change in Mae Chaem during recent decades and how they have affected the nature of community land use strategies and management approaches reflected in their current land use zoning plans. Answers to these broader questions could help us in addressing more specific questions related to each ethnic group, as well as help us begin addressing general questions very important for the potential future of participatory land use planning and community-based land use zoning processes, which are addressed in the final section of this report.

The set of project activities described in this section have sought to help begin addressing such issues and questions by examining land use change in a substantial portion of the study area in Mae Chaem.

1. Assessment Approach and Methods

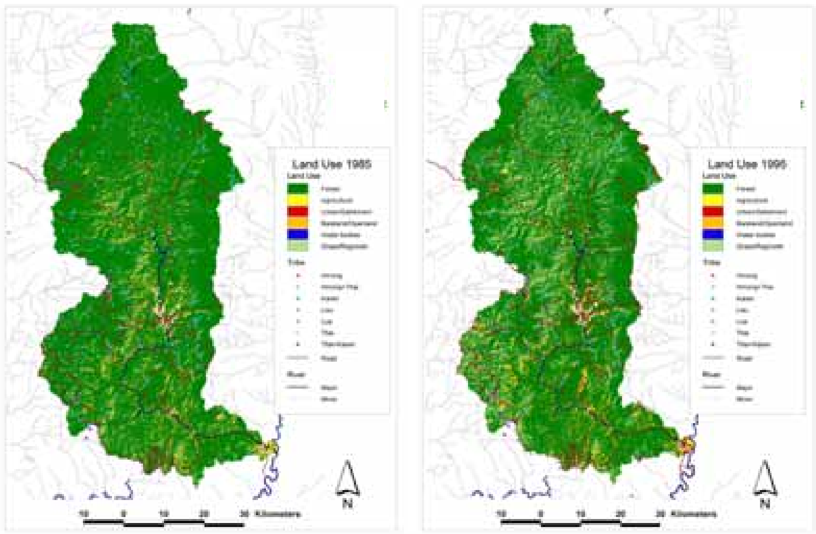
Before examining the project's findings on land use change, we first need to summarize key aspects of the approach and methods used in project analyses.

Sources of Empirical Information on Land Use Change

While most would agree there has been extensive change in Mae Chaem during recent decades, there are various opinions about the directions of this change. The District Officer assigned to Mae Chaem during most of the work on this study, at one point told us of a recent experience he had when two groups of senior officials made a field trip around the district within a two week period. After the first group's field trip, they told him how they sympathized with efforts to address the very bad deterioration of natural resources that was occurring in the Mae Chaem watershed, and lamented about how bad conditions had become. But after the second group's travel, they congratulated him on the excellent job that was being done on natural resource management in Mae Chaem, and told him how pleased they were with conditions in the district. He told us he was not sure how to respond to these types of contradictory comments, and was himself feeling confused about the direction and degree of progress, if any, that was being made on natural resource management.

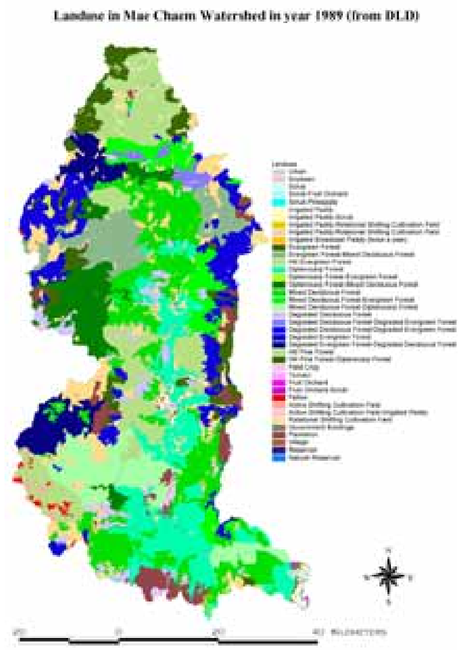
This type of apparent contradiction is also common in debates regarding natural resource management seen and heard in the mass media and other components of the public policy arena. One side in the debate tells us that natural resources are vanishing rapidly, and only radical efforts to stop massive deforestation occurring in the mountains by relocating or severely limiting mountain agricultural communities will be able to save the natural resource base for our children and grandchildren. Then the opposing side tells us that all is going well, and that if only agencies and society would leave natural resource management to rural mountain communities there would be no problems. Given the general nature of rhetorical dynamics involved with such debate, one suspects that reality is located somewhere between these two poles of opinion. Yet without some empirical information that is not suspected of being simply a reflection of vested interests, it is difficult to find common ground and to identify a constructive means of moving forward. Although remotely sensed data from satellite and aerial photos would appear to be an obvious tool for use in such situations, most efforts thus far have been have been suspected of being partisan in their interpretation. Thus, this component of the project has sought to make the most careful and balanced exploration of how such tools can be used that time and available resources would allow.

Figure 92. Mae Chaem Land Use under LUCC, 1985 & 1995



Various studies of forest cover and land use change have been conducted in Thailand during the last 25 years. Most have relied on satellite remote sensing imagery and used quite simple and coarse categories of analysis. For example, results of Landsat-based land use assessments in Mae Chaem under the Land Use and Land Cover Change (LUCC) project are shown in Figure 92. While the quality of satellite imagery has now increased to very high resolution, such imagery is still too expensive for a project like this one, and high resolution images are not available for earlier years. Moreover, even when quite detailed assessments have been made, such as some of those conducted by the Department of Land Development (Figure 93, for example), land use categories used in the interpretation do not allow us to make useful comparisons with the categories that have emerged from the community-based land use zoning maps described in the previous section. Fortunately, however, availability of a time series of aerial photos for a substantial portion of the pilot study area has allowed us to make a quite detailed investigation of land use change during the last 50 years.

Figure 93. DLD Land Use 1989



As the aerial photos available for this analysis were obtained prior to this project, their coverage in Mae Chaem was based on an earlier sampling approach that did not focus specifically on sub-watersheds. Thus, available coverage for our study sub-watersheds is considerably less than the full strategic sample of sub-watersheds for which we obtained the current land use zoning data explored in the previous section. Nevertheless, we have been able to complete the full time series analysis for about one-third of our total sample of administrative villages. And, since available coverage was most extensive for the earliest set of air photos, we can compare current land use zoning with actual land use in the same area in 1954 for well over one-half of our quite substantial sample of administrative villages.

Methods for aerial photo analysis

A very central factor for our analysis, which distinguishes it from most previous analyses of air photos in Thailand, was the nature of our concerted effort to seek to distinguish different categories of forest cover. Of particular concern was whether we could differentiate distinct phases of forest re-growth that could help us identify areas of regenerating forest associated with rotational forest fallow shifting cultivation systems. Indeed, it turned out that this was not only possible, it was even less difficult than we had initially anticipated. Under leadership of Dr. Thaworn Onpraphai, a well-known professional in this subject at Chiang Mai University's Multiple Cropping Centre, a broad preliminary examination of the aerial photos revealed quite clear differences associated with canopy texture and tree height that allowed for fairly straightforward differentiation of: (a) relatively mature and intact natural forest; (b) relatively mature forest that was subject to significant disturbance; (c) young forest fallow at an early stage of re-growth; (d) older forest fallow that was significantly more mature than young fallow, but still had clearly not reached the stage of more mature forest; and (e) regularly spaced even-aged plantings of forest species clearly conducted as part of the programs of forestry agencies.

Once criteria for distinguishing these categories were identified, Dr. Thaworn trained and supervised several of his university students to interpret the substantial number of aerial photos required for this analysis; assistance was also provided by Dr. Horst Weyerhaeuser. The resolution of air photos varied from 1:50,000 in 1954 to 1:10,000 in 1996. Each pair of aerial photos was analyzed under a stereoscope, and land cover (see Figure 26 for categories) was delineated with felt pens on acetate transparencies. Some variations in the degree of interpretation detail are associated with differences in aerial photo resolution; delineation of very small areas was sometimes more difficult at scales of 1:50,000. This initial analysis was then verified in the field using a GPS, and up to 10 points were selected and referenced on each aerial photo for later georeferencing. After returning to the laboratory, the first analysis was verified, and Pornwilai and her GIS team digitized each transparency into ARC-View GIS. Each data set (transparency) was then joined with its pair, and each line and entity connected to develop a consecutive row of base maps. Each single row was then joined with its upper and lower row to develop an overall base map. Physical copies of aerial photos and transparency overlays with interpretation boundaries have been retained in archives in order to maintain the transparency and accountability of the entire interpretation process. Historical images and data shown in this section are the final product of land-use maps of 1954, 1976, 1984 and 1996 created through this process. Further verification and understanding of processes underlying patterns and why they changed over time was obtained through discussions with villagers and local leaders in Mae Chaem who had observed and experienced these changes during their lives.

As part of this process, we have found that the lack of previous studies in which forest fallow areas are distinguished as a distinct type of forest land use does not result primarily from inadequacies of available air photo data. Rather, we believe it has been associated with at least 3 major factors: (a) Most previous interpretations have been conducted by foresters or others with a similar preconceived view of these areas as degraded forest; (b) those conducting studies were unfamiliar with the nature of forest fallow agroecosystems, and were thus unable to see relevant patterns in the data; and/or (c) air photo and land use analysts were unwilling to consider categories of forest or land use classification that did not correspond with conventional categories already established at national or international levels. In any event, data presented below will demonstrate the viability of this approach if there is a will to seek such information.

Land Use Categories and Aggregations for this Analysis

While we made great effort to maximize compatibility between categories used in air photo analyses and those that were emerging during the village land use zone mapping work, complete compatibility was not possible, particularly in relation to categories of forest land. There are two main differences:

(a) Although air photos allowed us to identify areas of relatively mature forest and whether it was generally intact or disturbed, they could not provide us with information about the intentions with which a given area was being managed. The village land use zoning maps, however, have provided us with valuable information on objectives for managing permanent forest areas, which were already simplified into aggregate categories for assessment in a previous section.

(b) While air photos allowed us to distinguish two stages of forest fallow regeneration, which reflected differences in vegetation that were clearly visible in aerial photos, this does not allow us to delineate each of the annual forest fallow units within a given village rotational forest fallow system. Given the purposes for which village land use zoning maps were constructed, and complexity of delineating annual forest fallow units, villager land use zoning maps only identify the overall boundaries within which forest fallow rotations occur. While for research purposes we have mapped individual annual forest fallow units for villages in the Mae Tum sub-watershed, this type of information is not available for other areas, and still does not allow us to aggregate into two categories that would be consistent with those visible in air photos.

Figure 94. Land Use Aggregations and Colors

aggregate	air photo categories	aggregate	local categories
Forest Areas			
Planted + Other		***Planted + other***	
	140 forest plantation		900 forest without further designation
			940 government forest plantings
			930 village forest rehabilitation areas
		Community Protected	
			910 community protected forest
Forest			911 birth spirit forest groves
	100 forest		912 cemetery forest groves
	150 disturbed forest		913 other spiritual groves
		Subsistence Use	
			920 community subsistence use forest
			950 community forest
			914 'food bank' forest
Other Uncultivated Areas			
Fallow		***Fallow***	
	321 young fallow		320 regenerating forest fallow areas
	322 old fallow		
Grass		***Grass***	
	330 grassland areas		330 grassland areas
Cultivated Fields			
Orchards		***Orchards***	
	242 fruit trees		242 fruit tree gardens and orchards
Upland fields		***Upland fields***	
	220 upland crop fields		220 current cultivated field crop areas
	230 upland vegetables		230 specific upland vegetable areas
	310 bare soil		
Paddy fields		***Paddy fields***	
	210 bunded paddy fields		210 bunded paddy fields
Settlement Areas			
	500 village house areas		500 village 'urban' housing areas
Other			
	700 clouds / unknown		400 areas of mining operations
	600 water		600 water

Thus, to help facilitate clear comparison of land use at each point in the historical time series with our project village land use zoning maps, we have adopted the aggregate categories seen in Figure 94. With these aggregate categories, the only difference between historical air photo data presentation and presentation of aggregate current village land use zoning data is that the zoning map splits forest into areas for either protection or subsistence use; zoning maps also combine government agency plantations with areas locally designated for forest rehabilitation with unclear management objectives, as well as with areas identified only as 'forest' without any further local designation. For purposes of constructing bar charts used for time series comparisons in this chapter, community protected and subsistence use forest have been combined and color coded to match the forest category in air photo interpretations.

2. Significance of periods in the aerial photo time series

Land use data from points in the time series allowed us to establish a baseline in 1954, followed by 4 subsequent periods of change. Some major elements of historical information that help us interpret how and why observed patterns of change have occurred during each of these periods include:

- **Baseline: 1954.** At this time, little of what is considered modern development had occurred in the Mae Chaem watershed. The national development planning process had not yet begun, national forest reserves had not yet been declared, the national park and wildlife acts had not yet been formulated, and even the very process of modern land titling in the lowlands was only just beginning to be set in motion in lowlands of the Central Plain region. Mountainous upper tributary watersheds like Mae Chaem were considered very remote, there were very few and very poor roads leading only to a few major settlements. The only real alternative to walking was transport by horse or oxcart. Traditional subsistence-oriented agroecosystems were dominant, and impact of production linked to international markets was primarily limited to logging of teak and a few other valuable species in (and sometimes beyond) concession areas superimposed on forest reserve areas containing valuable timber species, or participation in opium production and trade.

- **Change Period 1: 1954 – 1976.** During this period, Thailand implemented its first three 5-year national development plans and launched its fourth, large areas of forest reserves were declared and Inthanon National Park was established along with a set of other national parks and wildlife sanctuaries around the country, and a new watershed conservation division was established in the Royal Forest Department and began setting up units in highland areas. Forestry programs began planting primarily pine plantations in a few high priority highland areas where shifting cultivation was being practiced. Opium crop substitution projects began operating on a modest scale at a few points around Mae Chaem. The district was still considered a very remote area with poor road access and infrastructure. Most lands were incorporated into forest reserves and protected forest areas with very little regard for, and virtually no recognition of, existing land use by mountain ethnic minority communities, who were seen as non-citizens practicing primitive agriculture.

- **Change Period 2: 1976 – 1984.** Early during this period, Mae Chaem was declared a 'pink' zone to signify concerns about national security, partially in association with fears about the allegiances of some mountain minorities, and with groups of student activists who fled to forests in the area after the 1976 military coup. Thus, both major roads into the Mae Chaem valley and government administration systems began to be upgraded. Near the beginning of the 1980's, a large opium crop substitution and rural development project was launched primarily in southern portions of the watershed with financial support from the U.S. Agency for International Development. Forestry programs expanded pine tree plantings within national park boundaries and highland areas around expanding watershed conservation units.

- **Change Period 3: 1984 – 1996.** During this period, the road network continued to be elaborated, including cross-links between valley and ridge-based roads, and commercial agricultural production was strongly supported by the Mae Chaem watershed development project as an approach for addressing both opium crop substitution in highland areas, and rural poverty problems in middle and lowland areas. With encouragement by government agencies and the project, elements of the expanding Thai agro-industry sector began operations in lower elevation areas of Mae Chaem, resulting in rapid expansion of upland soybean production, followed by contract farming of maize for animal feed and seed. Various types of lowland vegetable production also expanded under project encouragement, and completion of paved roads into highland ethnic Hmong settlements brought a major boom in production of highland vegetables promoted by opium crop substitution programs, and especially cabbage. Thus, upland crop production surged as the Mae Chaem watershed development project ended, raising considerable concern in forestry agencies. As a major response, the Queen Sirikit Forest Development Project (Suan Pah Sirikit) was established and began developing pilot activities that would seek approaches for helping to address livelihood needs of the rural poor, while maintaining sound approaches to natural resource management.

- **Change Period 4: 1996 – 2001/2**. During this most recent period, the Suan Pah Sirikit project continued to develop and expanded its programs to the vast majority of sub-districts in the Mae Chaem sub-basin. Care-Thailand, which began working with villages in Mae Chaem during the USAID-supported project, was transformed into a fully Thai NGO (Raks Thai Foundation), and began shifting its programs from a focus on nutrition and health toward increasing emphasis on community-based sustainable natural resource management.

  Environmental awareness and activisim continued to grow rapidly, resulting in public concern and upstream-downstream tensions about land use change in upland areas and its impacts on environmental services, and thus the sustainability of natural resource management. As part of its increasingly aggressive programs aimed at addressing such issues, the Royal Forest Department announced the preliminary declaration of two new national parks covering parts of Mae Chaem (with efforts now under the new Ministry of Natural Resources and Environment), including the Mae Tho National Park that would occupy a very large portion of the entire southwestern quadrant of the Mae Chaem watershed. Farmer networks supported by NGOs and activist academics began organizing to help mountain minority communities respond to such aggressive measures.

  Meanwhile, the Asian Economic Crisis brought a major devaluation of Thai currency in 1997, which resulted in dramatic increases in local prices for imported agricultural inputs. At the same time, a depression in world prices for agricultural commodities such as soybean and maize prevented rises in prices received by farmers. A major Thai agro-industrial company introduced contract farming of maize using improved varieties, however, that provided increased yields that could help offset declining profitability brought by the input-output price squeeze. Off-farm employment opportunities also declined rapidly, and rural wage rates dropped, but by the end of this period, the economy had stabilized and was beginning to pick up.

3. Multiple Faces of Periods of Land Use Change in Mae Chaem

Keeping events associated with these periods of time in mind, we can now examine evidence of land use change from aerial photos in two of our study sub-watersheds where communities currently have quite different strategies for land use management as reflected in the current land use zones already examined in the previous section. The Mae Raek sub-watershed is currently characterized by a total absence of systems with forest fallows, whereas Mae Tum is still clearly dominated by such systems.

Mae Raek Sub-Watershed: Transformation to Permanent Agriculture

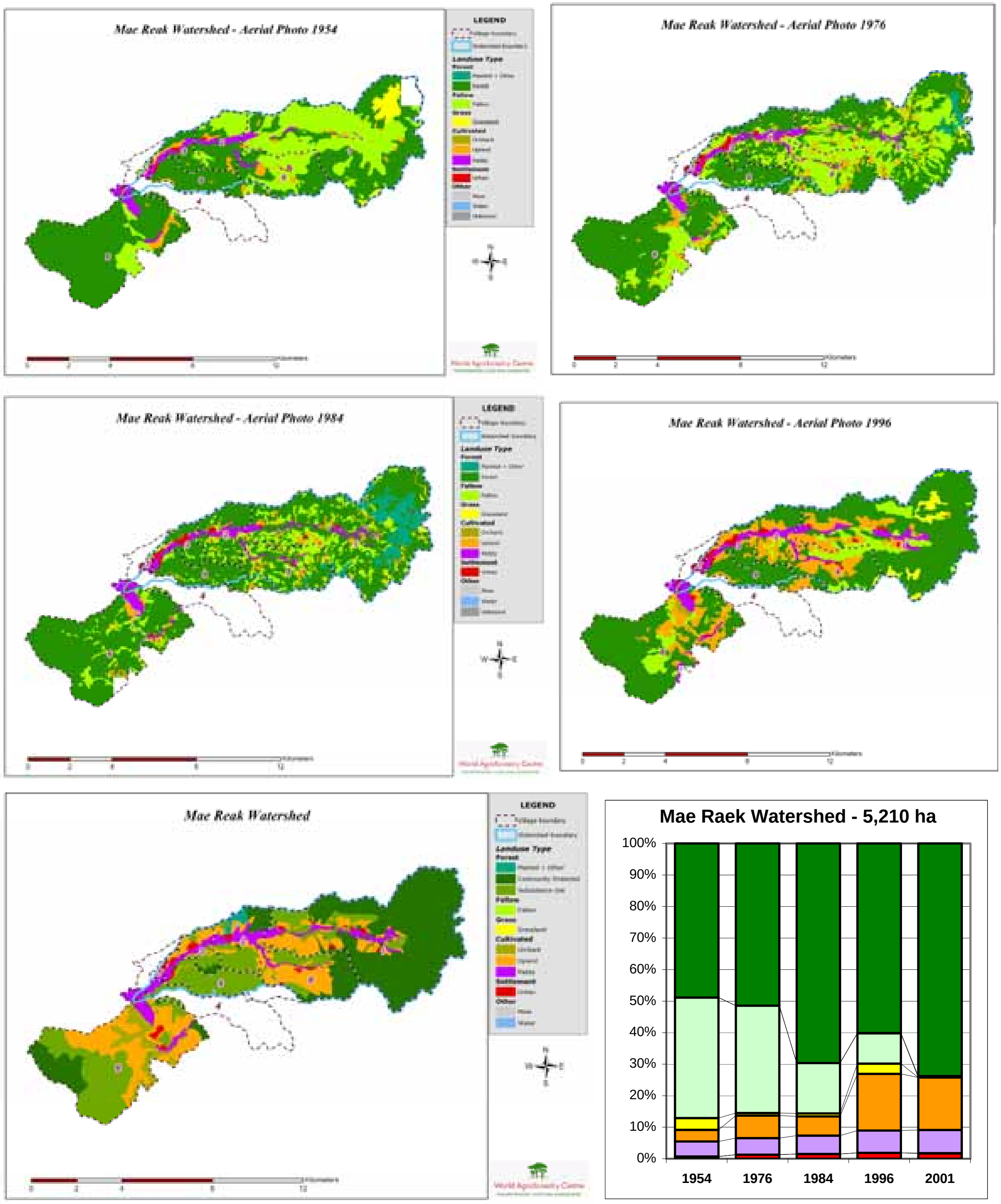
As presented in considerable detail in the previous section of this report, the Mae Raek sub-watershed is a clear example of an area where all village land use zoning strategies center on agricultural production in permanent fixed fields. While the majority population of the area is lowland Northern Thai, it also includes areas settled by midland ethnic Karen communities, who have long traditions associated with rotational forest fallow shifting cultivation. Data presented in Figure 95 allow us to see that especially in the middle to upper reaches of this sub-watershed there has been a transition during the last 50 years from forest fallow to permanent field land management systems.

Discussions with people from local communities in Mae Raek and others working in the area have helped us clarify the processes underlying this land use transformation.

- In 1954, the different land use patterns of the paddy-oriented lowland Thai and the forest fallow-oriented midland Karen communities are quite clear. Indeed, Karen groups were practicing fairly long cycle forest fallow systems (ratios indicate a 10 year cycle) using traditions that employ annually changing community-scale land units. We are also told that opium production was an important highland element that involved people of various ethnic groups, including ethnic Thai.
- But by 1976, Inthanon National Park had been established, programs to end opium production had begun, and the road across the ridge into Mae Chaem valley located along the northern boundary of the sub-watershed was being upgraded. Government efforts had already begun to convert forest fallow areas to permanent forest, fallow ratios show a drop to 6-year cycles, and mature forest was being re-established along the road, as well as in upper reaches of the sub-watershed.
- By 1984, more areas had returned to mature forest, and forestry authorities had planted substantial areas within the national park to pine trees. Moreover, forest fallow areas had become smaller and more fragmented, as programs placed increasingly heavy pressure on local communities to 'settle' their agriculture on permanent fields. Fallow ratios indicate systems were moving to short cycles.
- By 1996, villagers had basically complied with government policies and development project actvities. Relatively small areas still classed as forest fallow were in the old fallow category, and on their way to returning to permanent forest. On the agricultural side, while paddy land increased somewhat as villagers were encouraged to maximize the amount of irrigated paddy they could establish, the most striking feature is the very dramatic increase in the area of currently cultivated upland fields, and their concentration on lower slopes throughout areas occupied by lowland Northern Thai, as well as midland Karen communities.

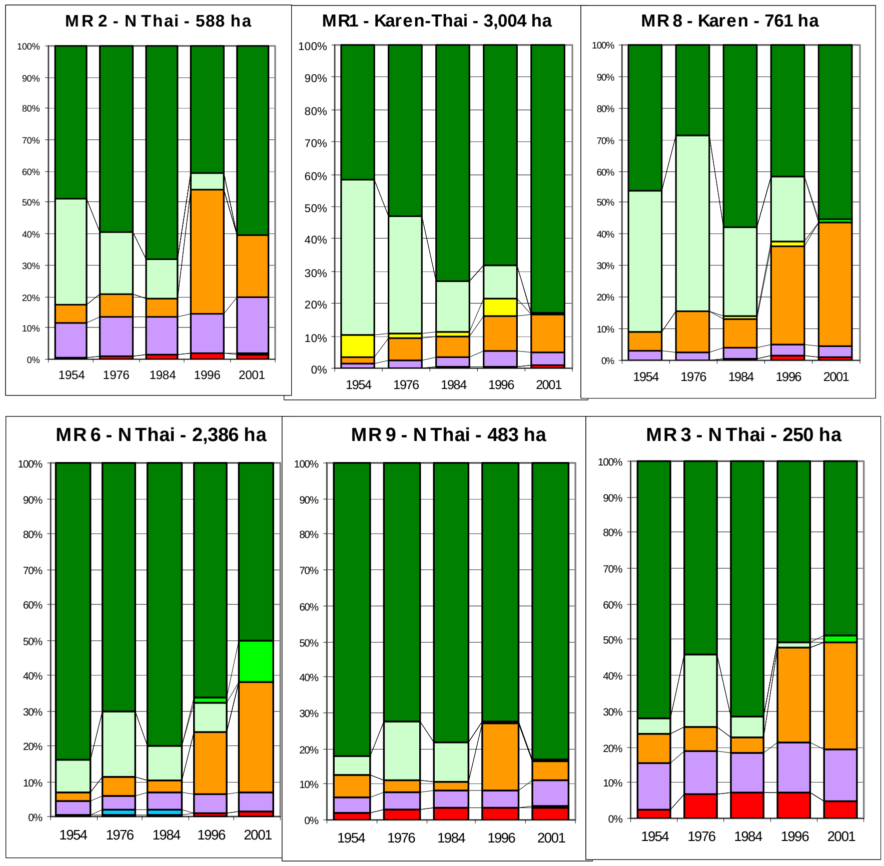
  This pattern reflects two major changes from 1984: (a) development of the permanent field upland rice system using a periodic crop rotation of upland soybean, along with purchased chemical fertilizer and herbicide inputs; and (b) emergence of transport and market infrastructure that provided opportunities for commercial production of upland soybeans, and initial emergence of contract farming opportunities for maize production. Moreover, this was the peak of the economic boom that preceded the Asian economic crisis.
- By 2001, the land use transition became virtually complete. Community-based land use zoning now clearly indicates the return of all non-cultivated areas to permanent forest, which especially in all upper areas of the sub-watershed are under community protected forest status, consistent with their overlap into border areas of Inthanon National Park. Irrigated paddy is close to maximized, permanent upland fields are mostly located in a small number of relatively large blocks of land, and substantial areas of subsistence use forest border agricultural fields below the park boundary.

Figure 95. Land use change in the Mae Raek Sub-Watershed, 1954 – 2001.



In order to help clarify how these changes have played out within individual village domains that have contributed to this overall pattern at the sub-watershed level, Figure 96 charts overall patterns of change in proportions of land use in each major administrative village. The first row of charts includes the three villages that occupy most of the mid-to-upper portions of the sub-watershed, while the lower row depicts village areas nearer the outlet of the sub-watershed (as the map indicates, MR6 has a major part of its land outside the sub-watershed). Both villages with high Karen populations show patterns very consistent with the overall sub-watershed patterns described. The Northern Thai village MR2 begins with a similar pattern, but shows a greater relative response to the boom in upland crop production for commercial markets, followed by a decline in upland fields. This pattern appears related to reported movements of more Thai people into this area during the early years, and their easier access to market and contract farming opportunities as they appeared. Decline in the area of upland fields since 1996 is not consistent among villages. Responses in villages 2 and 9 appear related to both an increase in paddy area and response to declining market profitability. For villages 1 and 8, further paddy expansion has not been an option, and their commitment to permanent field upland rice requires continuation of cash crop production.

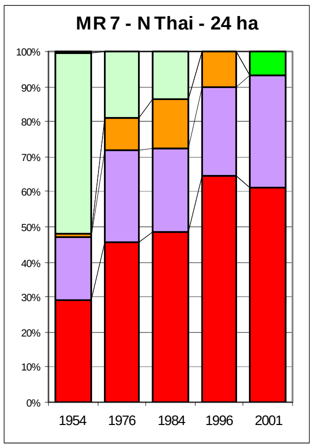
Figure 96. Land Use Change in Major Mae Raek Villages, 1954-2001



What, then, have been the overall impacts of this transformation? From a forestry policy point of view, the overall pattern of the Mae Raek sub-watersheds appears to fall into the category of a ‘success story’, since: (a) most areas within the national park have been returned to permanent forest, and the few remaining areas are small, irrigated paddy-centered areas surrounded by community protected forest; (b) all ‘shifting cultivation’ forest fallow areas have been eliminated; and (c) intensive agriculture is practiced on permanent fields and integrated into the market economy. From a broader environmental point of view, however, questions are raised about the use of agricultural chemicals in upland fields, and large contiguous blocks of upland fields on sloping lands located near streams may result in long cultivated slopes that could increase the risk of soil erosion. And from a livelihood and rural poverty point of view, there are questions about the overall profitability and sustainability of the new systems, as well as their vulnerability to market fluctuations that are likely to follow from the changing international trade and macro-economic environment.

As somewhat of a footnote to land use change in Mae Raek, Figure 97 shows the pattern of land use change in a small village that has entered the urban fringe of the modestly growing district town of Mae Chaem. This data charts its change into the type of densely populated area interspersed with irrigated paddy and home gardens that characterizes much of the area in the immediate vicinity of the district town.

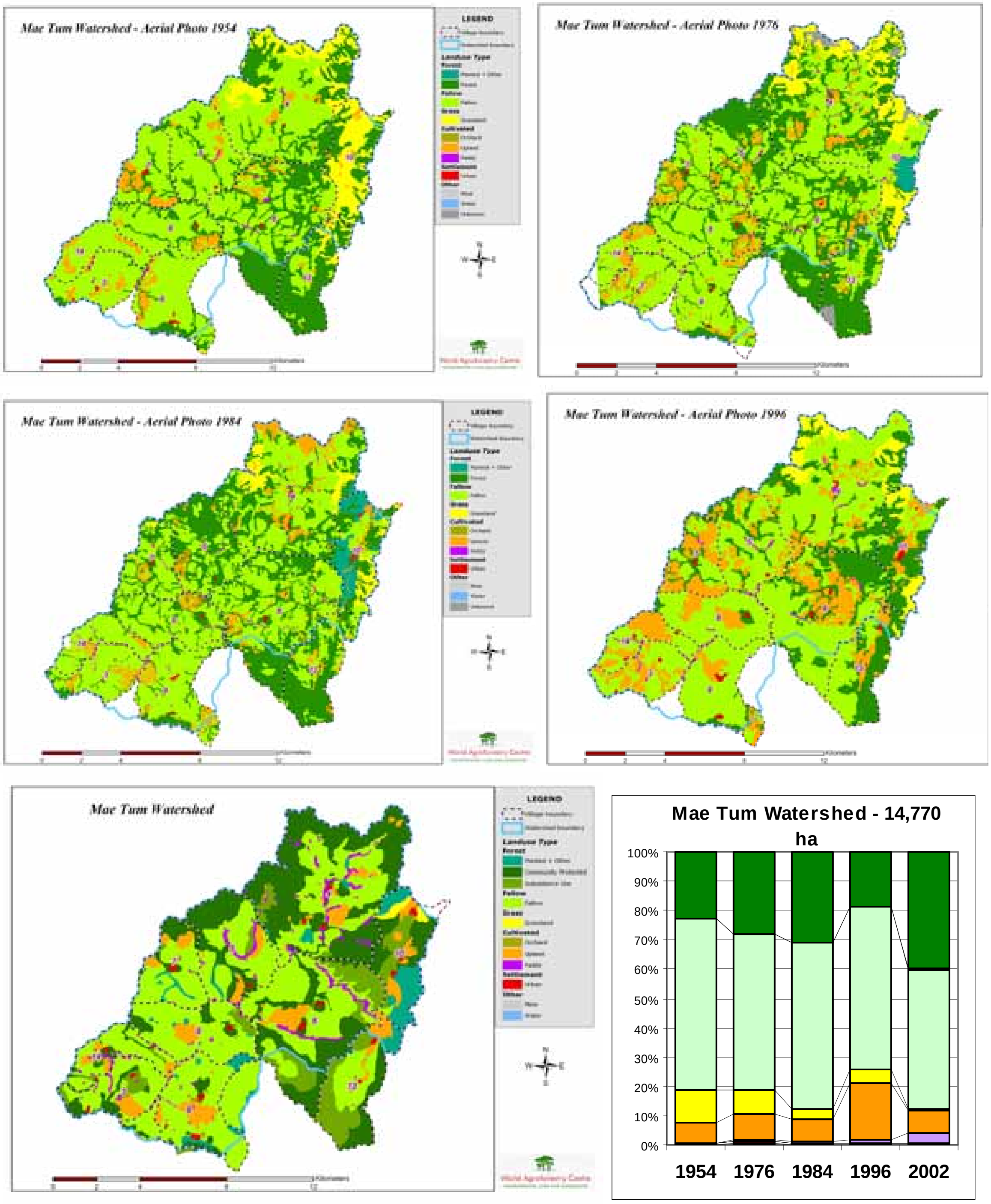
Figure 97. Urban Fringe



Mae Tum Sub-Watershed: Persistence of Forest Fallow Systems

In contrast to Mae Raek, the Mae Tum sub-watershed is an area where current land use zoning allocations reflect a dominance of land use strategies that center on maintenance of medium to long cycle rotational forest fallow agroecosystems. Given the story that has emerged from land use change in Mae Raek, it is clear that there must have been a very different set of conditions here. In order to give us an overall view of patterns of change, Figure 98 shows the results of our time series of land use change from aerial photos of the Mae Tum sub-watershed. In interpreting these spatial data, one should not be distracted by the change in position of upland fields – as these are rotational forest fallow

Figure 98. Land use change in the Mae Tum Sub-Watershed, 1954 – 2002.



systems, the position of fields changes annually, so the main focus should be on the relative proportions of land in upland fields, forest fallow and mature forest, as summarized in the bar chart.

Using a process similar to that for Mae Raek, we can now look at stages that have occurred along what appears at first glance to be a very different pathway of land use change:

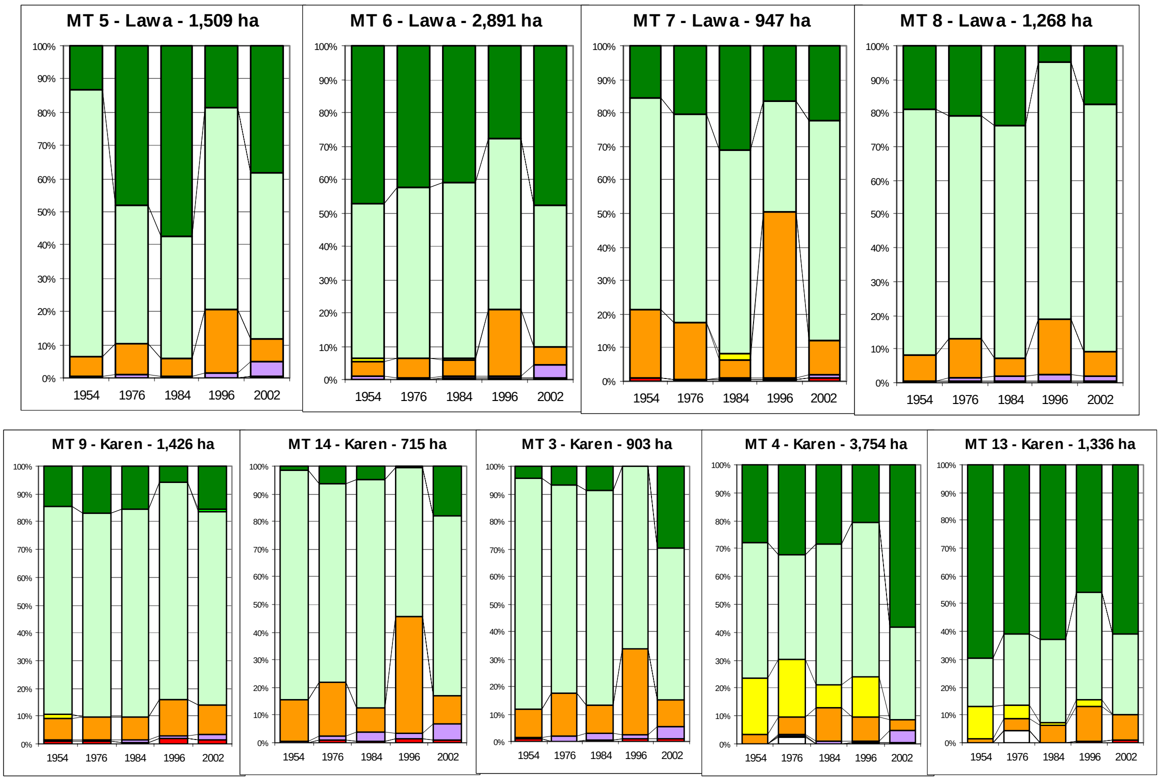
- In 1954, land use in the Mae Tum sub-watershed was already strongly dominated by land use systems that clearly must have had quite long periods of rotational forest fallow. The ratio of our estimates for forest fallow and upland fields indicate an overall system cycle length of at least 10 years (older fallows may appear as mature forest). Grasslands near ridges along the northern and eastern boundaries of the sub-watershed are similar to those seen in 1954 aerial photos of many areas along the mountain ridge that separates Mae Chaem from the Mae Hong Son valley to the west; although some believe these areas may have been associated with an earlier boom in opium production, the areas are quite extensive and explanations have not yet been very convincing.
- By 1976, general patterns appear to have been little changed in Mae Tum. There does, however appear to have been somewhat of an increase in both upland crop fields and mature forest, resulting in a modest drop in estimates of minimum forest fallow rotation cycle length to at least a still quite sustainable 7 to 8 years. An area of forestry plantation along the eastern ridge indicate some early government reforestation activity.
- By 1984, there had still been little change in overall sub-watershed land use, other than a decrease in the relative size of grasslands and a modest increase in mature forest, including expansion of forestry agency plantings. Overall forest fallow cycle length remained at least 7 to 8 years.
- Between 1984 to 1996, however, some significant changes appear to have occurred in Mae Tum. The main net effect was a more than doubling of the size of upland crop fields, combined with a similarly sized decrease in mature forest, although the proportion of forest fallow was very little changed. Although current sensitivities made villagers in the area reluctant to talk too much about this phenomenon, given the general events occurring in Mae Chaem during this period it would appear that upland cash crops were also being planted in Mae Tum. This may also help to explain the concern that natural resource management agencies began directing toward this area, in contrast to the relatively low priority that it appears to have warranted during earlier periods.
- Considering the land use pattern in 1996, it appears quite striking that current land use zoning plans have basically returned to the proportions of upland crop fields and forest fallow observed in 1976 and 1984. In addition, increases appear in the area of irrigated paddy, and in permanent forest, more than 70 percent of which is now assigned community protected forest status.

In order to again cross-check this pattern with data for individual villages within the Mae Tum sub-watershed, Figure 99 displays a time series of summary data for each administrative village.

These data makes it quite clear that the "pulse" of increased upland cultivation observed in 1996 was a general phenomenon that occurred across villages, but with varying degrees of relative magnitude. And similarly, the "response" reflected in their current land use zoning plans is also evident in all villages. That the component of the "response" related to expansion of irrigated paddy land appears to have been quite modest in some of the villages is likely a reflection of limitations imposed by terrain.

We interpret land use changes between 1996 and 2002 as a "response" to both economic and policy changes during that period. On the economic side, changes associated with the Asian economic crisis helped "burst the bubble" of artificially high profitability during the "economic bubble" period. And on the policy side, announcement of the preliminary declaration of the new Mae Tho national park meant that the government was responding with very aggressive new measures that would place severe new constraints on land use. Indeed, it was not unreasonable for villagers to perceive these policies as intending to force them into transforming their forest fallow systems into something similar to what had happened on the eastern side of the Mae Chaem valley in sub-watersheds such as Mae Raek. With support from NGO and academic activists through farmer networks, villagers have clearly been very

Figure 99: Land Use Change in Major Mae Tum Villages, 1954-2002.



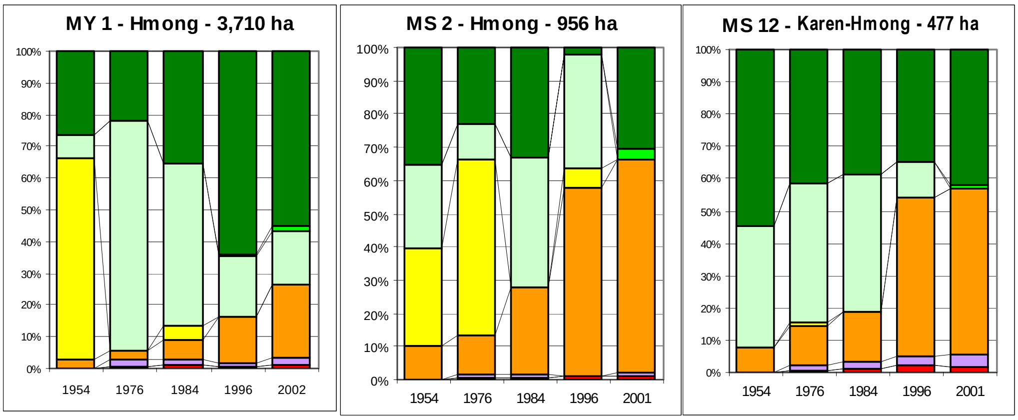
actively involved with re-thinking how to retain their traditional land use systems and way of life by formulating land use zoning plans that counter many of the criticisms used to justify forestry agency plans for radical transformation to permanent field land use systems.

Selected Highland Villages: Impacts of Opium Crop Substitution

Although this examination of land use changes in two significantly different sub-watersheds has provided substantial insight into variation of processes of land use change in Mae Chaem, it has unfortunately not included any highland Hmong villages that were the primary focus of opium crop substitution programs, and are currently a major concern of critics of highland communities in mountain area watersheds. In order to help fill this gap, we have been able to make a full time series assessment of patterns of land use change in three relevant and strategically important Hmong villages. Summary data for these villages is charted in Figure 100. The first village is what is now a large and important administrative village located near the upper ridge of the Mae Yot sub-watershed (see Figure 15). The second is an administrative village located near the upper ridge of the Mae Suk sub-watershed, and the third is a neighboring administrative village that also includes Karen settlements (see Figure 17 for both). Major elements of interpretation for these charts include:

- In 1954, Hmong settlements at these locations did not yet exist. While there was some upland cropping in the area, it was likely associated with opium cultivation where various interest groups of multiple ethnicities were involved, and/or perhaps minor parts of agricultural activities of existing neighboring villages; the third village was a completely Karen area. Ridge areas at both locations had large grassland areas with unclear origins but may have been associated with opium.
- By 1976, Hmong settlements were established in these areas, and were engaged in various land use activities, including opium production. While grasslands at MS2 had expanded from 1954, those at MY1 were already beginning to return to woody vegetation, with 80 percent of the area now corresponding to young fallow vegetation.
- By 1984, grasslands at MS2 also began returning to woody vegetation as half of the greatly expanded area appearing as forest fallow fell into our young regrowth category. Significant

Figure 100. Land Use Change in 3 Highland Hmong Villages, 1954 - 2001



expansion of upland crop fields was appearing at both villages, but mature forest was roughly equivalent or slightly greater than in 1954.

- During 1984 – 1996 there was also a very significant "surge" in expansion of upland crop fields in all 3 of these villages, corresponding with completion of paved road corridors and a subsequent boom in commercial vegetable crops, and especially cabbage. Upland field expansion appears to have been at the net expense of forest fallow vegetation at MS12 and MY1, but large areas at MY1 also continued to grow into mature forest stands. Upland field expansion at MS2 coincided with substantial reduction in mature forest.
- By 2001/2, there had also been a "response" reflected in land use zoning of Hmong villages in Mae Suk, but the nature of the response resembles events in Karen villages of Mae Raek more that what was observed for villages of the more nearby Mae Tum sub-watershed. All forest fallow areas are now eliminated, even in MS12 which has a substantial ethnic Karen component to its population, 30 to 40 percent of land area is now zoned for permanent forest, and MS2 has at least trial plantings of fruit trees and other crops. In Mae Yot, upland field zones are larger and mature forest zones are smaller than the areas observed in 1996, but overall mature forest still more than double of what was observed in 1954 aerial photos.

From an opium crop substitution policy perspective, these villages are also a "success story", where opium production is now insignificant, production of commercial replacement crops appears booming, and villages show clear signs of significant accumulation of material wealth. They are also effectively becoming increasingly significant "nodes" in the highland commercial agriculture network. Highland areas of Mae Wak and Mae Oh sub-watersheds include another variant of this story, where commercial fruit tree production has become a very significant alternative to vegetables in intensive highland commercial crop systems. Unfortunately, however, we did not have a similar time series of aerial photos available for these areas. In Mae Chaem, highland commercial fruit tree production is still limited to fairly small areas associated with particular projects and supporting infrastructure. But, like cabbages in Mae Chaem, highland fruit trees have developed their own growth momentum in other areas of North Thailand, and the potential appears to remain if appropriate conditions develop.

From a broader environmental point of view, a number of issues again appear. Data from ridgetop locations indicate mature forest is greater than it was in 1954, and that highland upland crop expansion has been due much more to the net displacement of grassland and fallow (or 'fallow-like' regenerating forest) than to displacement of mature forest. Yet, foresters and environmentalists still believe highland areas should be returned to permanent hill evergreen forest, which was presumably their condition before whatever events led to the extensive grasslands observed in 1954 data. In addition, highland vegetable production is conducted year-round using portable gravity-fed sprinkler irrigation systems that have led to increasing seasonal competition for water, and its use of heavy applications of agricultural chemicals has led to fears of water pollution in downstream communities.

4. Overall Impacts of Land Use Change since 1954

In the sample of villages observed thus far, we have not been able to detect dramatic loss of mature forest cover relative to what existed in 1954, and in quite a number of cases, current community land use zoning offers a net increase in areas under permanent forest. As one further cross-check on this question, we can examine data comparing 1954 land cover with current land use zoning plans for 30 of the administrative villages in our study area.

Overall summaries of aggregate data comparing current land use zoning with 1954 land cover in twelve Northern Thai and Karen administrative villages where permanent field systems are now used (including our one 'urban fringe' village) are displayed in Figure 101. Patterns consistently indicate that in villages where forest fallow existed in 1954, there has been a significant net increase in both permanent forest cover and cultivated upland field area. Only in villages with very little fallow area in 1954 has the increase in upland field cultivation resulted in a net loss of relatively mature forest. Expansion of irrigated paddy land also appears to have been a trend that may have had a substitution effect greater than what appears as its relative share of land area.

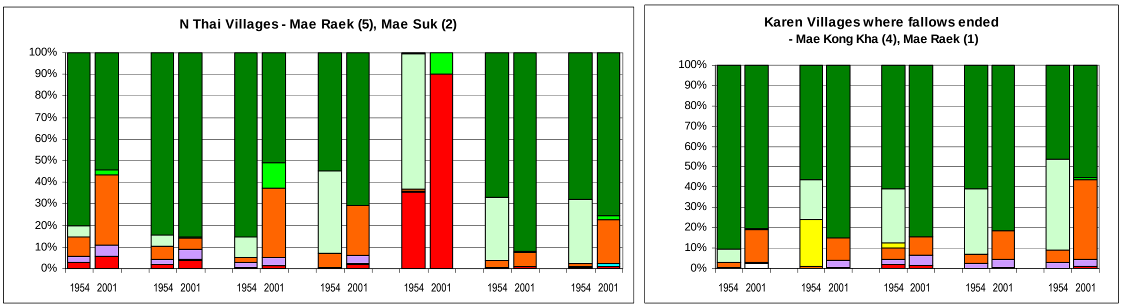


Figure 101. Current Land Use Zone & 1954 Land Cover 1: Thai & Karen Fixed Fields

Similar data for twelve ethnic Karen and Lawa villages that continue to employ rotational forest fallow systems is displayed in Figure 102. There is again a net gain in mature forest cover over 1954 in nine of the villages, no change in one, and a modest decrease in the remaining two. It is also clear that there has been much smaller relative increases in upland field area (and even a decrease in one), although our more detailed examination of land use change in Mae Tum indicates this data may be masking a surge in upland crops during the mid-1990s that may been withdrawn as part of their response to implementation of reactive government policies. Elimination of the 1954 grasslands and expansion of irrigated paddy are also common features in these patterns of change.

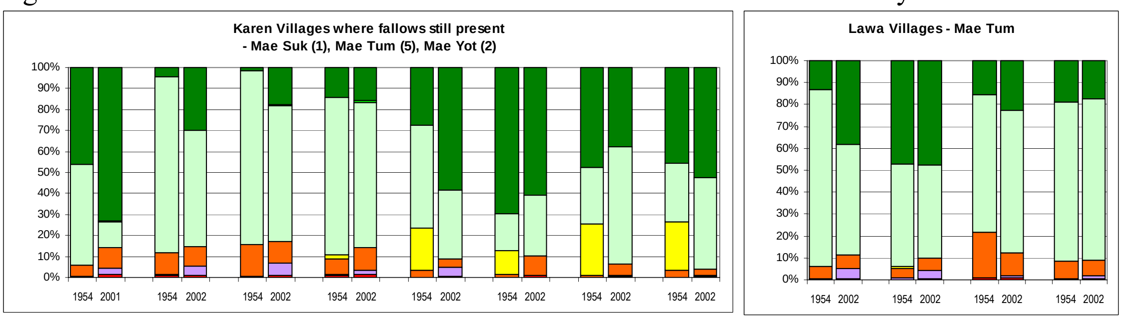
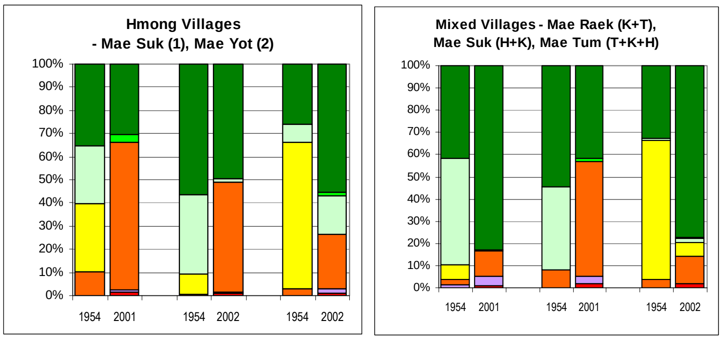


Figure 102: Current Land Use Zones & 1954 Land Cover 2: Forest Fallow Systems

To complete this comparison, similar comparative data from three Hmong and three ethnically mixed administrative villages are presented in Figure 103. Data from an additional Hmong village in Mae Yot is consistent with our previous findings that dramatic increase in upland field cultivation in these areas has been primarily a net result of displacing grasslands and forest fallow areas, rather that due to dramatic net decreases in mature forest area. The mixed Karen-Northern Thai village pattern of change

Figure 103: Current & 1954 Land Cover 3: Hmong & Mixed Villages



appears to be dominated by impacts of its majority Karen population as they made the transition to permanent field systems, whereas patterns in the Hmong-Karen village appear to be dominated by impact of agricultural transitions of the Hmong. Perhaps not surprisingly, patterns in the very mixed Thai-Karen-Hmong village appear to be something akin to an eclectic compromise . In any event, although increases in upland fields are very dramatic in most cases, none of these villages show similarly dramatic decreases in mature forest cover.

Clearly, even with our now expanded sample of 30 administrative villages, we have not been able to identify significant deviations from the overall patterns that have emerged from this assessment of land use change in Mae Chaem during the last 50 years.

5. Information to Help Address Land Use Change Issues in Mae Chaem

Under this line of activities, the project sought to apply science-based tools to explore time dimensions of local land use change in pilot study areas. This section seeks to apply the experience gained and lessons learned from these activities to improve our understanding of the past and to identify approaches for improving management in the future.

Processes of Land Use Change

We can now try to determine the degree to which information from our assessment of land use change have been able to provide insight and advance our understanding, by seeking to address the five broader land use questions raised at the end of the previous section:

(1) If various ethnic groups had distinctive characteristic traditional approaches to agroecosystem management, then how did this range of diversity (especially among the Karen) come about?

Our data indicates that: (a) among the lowland Northern Thai, diversification has primarily occurred through expansion into commercial field crop production associated with Thai agro-industry, which was at least initially promoted by government officials and development projects; (b) change in Hmong communities has been more of a transformation into a fairly narrow set of highland commercial cash crop options initially promoted as replacements for opium; (c) Lawa communities are seeking to retain their quite productive subsistence-oriented traditional systems, with perhaps only minor additional commercial components to provide cash to meet other needs.

The main focus of questions about diversification, then, are primarily on the range of alternatives now seen among the majority Karen population. The wide range of systems appears to have resulted from both ‘push’ and ‘pull’ factors. Push factors have largely been the result of efforts by government agencies, programs and projects, and are most strongly associated with systems that now have short fallows or permanent fields for upland rice production. Pull factors have centered primarily on economic opportunities, emerging largely as a result of developments in nearby communities of other ethnic groups, and are most strongly associated with commercial crop components of systems and their variants.

(2) Did change happen quickly or gradually? Were there particular stages associated with events?

Changes in land use observed in study areas suggest there are two answers to this question:

(a) Changes induced through government programs aimed at stopping shifting cultivation, and at initiating replacement crops for opium production both appear to have taken a period of decades to accomplish. Implementation of consistent policies through long-term programs and projects were important. Especially in the case of opium crop substitution, supporting research, demonstration and experimental trials in collaboration with farmers were a key part of the relatively painstaking early phase of identifying a range of agronomically viable alternatives; it also took many years of consistent effort to develop the road infrastructure necessary for such commercial ventures to function. In the case of stopping shifting cultivation in eastern sub-watersheds like Mae Raek, it took years of consistent pressure from forestry agencies, as well as long-term projects that encouraged farmer experimentation with alternatives and subsidized their establishment.

(b) Changes induced through economic markets, and through more aggressive and confrontational policies appear to have elicited quite significant responses in relatively short periods of time. Although there was likely a substantial gestation period before appropriate conditions were all in place, expansion of commercial upland field crop production up into sub-watersheds from its lowland entry points was able to make a very substantial impact on land use within the span of a few years. In some cases expansion of such cash crops appears to have been able to reverse itself just as quickly, while in others it appears to have been more permanent. Indeed, the “pulse” of field crop expansion that swept through much of Mae Chaem during the “economic bubble” period was even greater than currently remaining evidence would indicate. Expansion of cabbage production in the highlands has been even more dramatic and sustained. Similarly, announcement of preliminary boundaries for the Mae Tho National Park and associated aggressive policies to push for a rapid end of forest fallow systems appear to have generated a rapid response that is already reflected in land use plans and practices.

(3) Have shortening rotational forest fallow system cycles made these systems unsustainable?

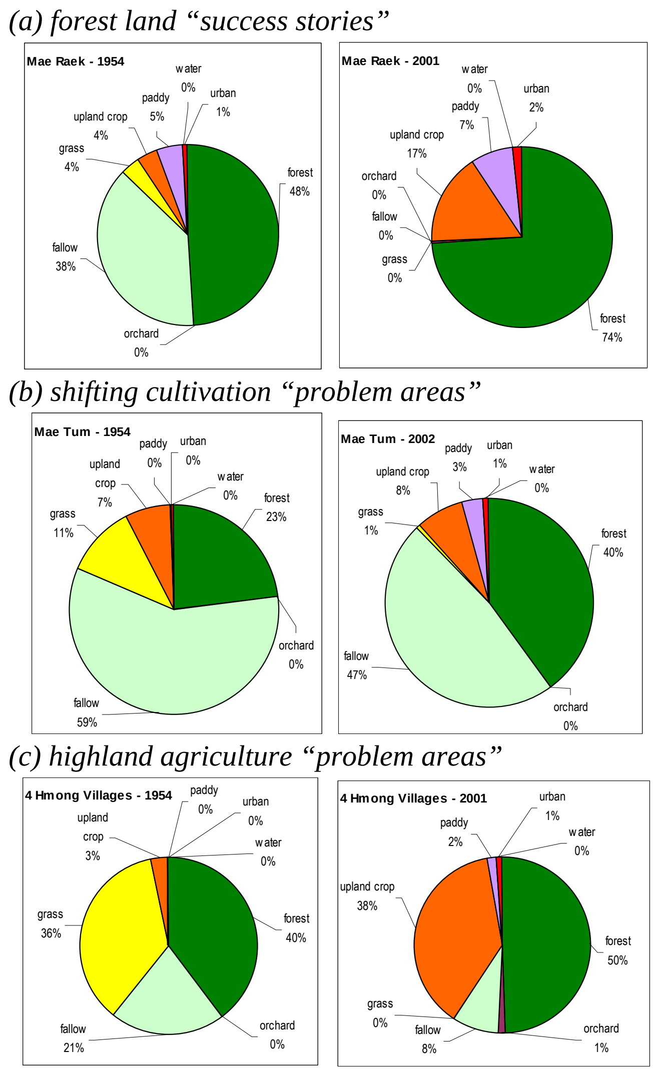
Evidence from our study suggests that the central issues associated with sustainability of these systems relate to key thresholds of system cycle length. Most everyone agrees that systems with long cycles are most productive and agro-ecologically sustainable without chemical inputs. And, there is much local knowledge and biophysical evidence to indicate that systems in the category we have termed ‘medium cycle’ are also agro-ecologically sustainable without chemicals, but returns to labor and effort employed in managing the systems may in many cases be somewhat lower; economic viability will depend on preferences and opportunity costs. But there is also strong agreement that there is a threshold, usually somewhere around a 4-year cycle length, when systems cease being viable without chemical inputs from external sources. This is the point beyond which it becomes important to define the type of ‘sustainability’ one is seeking to determine – assessment of agronomic, environmental and economic sustainability, for example, can have very different outcomes and implications.

In any event, however, while there appear to be clear negative impacts associated with shortened rotational cycles – especially below the 4-5 year cycle threshold – some very important questions have been raised about why the cycles in those systems have shortened. The most common cause seems to be associated with government persuasion, inducement and/or coercion, rather than from some internal process of system degradation. Government agencies and environmentalist groups almost always justify their position by claiming that mountain minority communities have explosive population growth and are expanding their destructive and primitive agricultural practices so rapidly that if they are not forced to transform their agroecosystems there will soon be no forest left on the mountains of North Thailand. Our data analysis indicates, however, that regardless of the population growth rate, we see no evidence that would suggest there has been explosive growth in Karen or Lawa areas, and although general demographic data has been very poor in these areas until very recent years, data we have found so far does not support such conclusions. A case may be made for evidence of more rapid growth in both population and cultivated land area in many highland areas settled by Hmong and other groups that tend to settle near the tops of mountain ridges, who tend not to have traditions associated with forest fallow systems similar to the Karen and Lawa, but recent evidence suggest their population growth rates may now also be declining rapidly.

(4) Has land use change resulted in a radical loss of forest cover during the last 50 years?

This is another question where initial definitions are likely to determine the answer to the question. The definition at issue here is what is meant by 'forest cover' – three key options include (a) all non-cultivated land; (b) all land with natural woody vegetation at various stages of growth; (c) only areas with relatively mature stands of forest tree species (avoiding the issue of planted versus natural stands). Why these issues are important are indicated in the pie charts in Figure 104 that compare overall 1954 land cover with current land use zoning data. If forest cover is seen as all non-cultivated land, then there has, indeed, been a loss of forest cover in some areas, but they have been precisely those areas of "successful" land use transition induced by programs to stop shifting cultivation (as in Mae Raek) or to eliminate opium production (as in the Hmong villages). If either of the other two definitions are used, then there has been a net gain in forest cover during the last 50 years, rather than a loss. Given the nature of rotational forest fallow systems, each shift among fields in a rotation has been seen as evidence of forest destruction and 'encroachment', and the fire employed in clearing and preparing a new field for planting is seen by them as clear evidence of destruction; such 'destructive' practices are also assumed to be the underlying cause of all grasslands. Thus, the degree to which the resulting current forest cover is "acceptable", will depend on which of the other definitions is used, as well as whether even land use patterns in 1954 are considered 'acceptable'. Ideally, one would hope this would be a function of the types of legitimately justifiable management objectives society has for the area, rather than simply a reflection or projection of ideology, ethnocentricity, or vested interests. For example, changes in the quality of permanent forest due to logging or other practices may be at least as important as forest cover if society's natural resource management goal for these areas is preservation of mature natural ecosystems. If the goal is watershed services, however, a different set of issues and questions should prevail.

Figure 104. Fifty-Year Change in Strategic Areas



(5) What overall and lasting land use impacts have the various projects had in Mae Chaem?

From one point of view, the first pair of pie charts in Figure 104 depicts the overall impact of projects that have been 'successful' at halting forest fallow shifting cultivation, while the third pair of charts shows 'successful' impacts of opium crop replacement projects. From this point of view, the second chart pair shows impacts in areas where projects have been 'unsuccessful' by not stopping shifting cultivation, but where currently more aggressive measures have raised enough tension that villagers are at least responding with more systematic and articulated management plans.

From another point of view, projects that have pushed replacement of opium production and forest fallow systems with intensive commercial crops have helped stimulate development of large blocks of permanently cultivated upland fields with long slopes, use of agricultural chemicals, and sometimes sprinkler irrigation, in watershed headlands and near streams. These are now an important and growing concern of downstream communities and environmental groups who question at least this dimension of their ‘success’. Remaining forest fallow systems, however, have retained lower percentages of land cultivated in any given year, and do not use agricultural chemicals. Yet, forestry and environmental interests still have forest fallow elimination high on their agenda of ‘unfinished business’.

In terms of livelihoods, highland opium crop substitution projects have resulted in what appears to be among the most profitable commercial agriculture in Mae Chaem, and these villages show clear signs of accumulating material wealth that also provides them with a buffer against price fluctuations; much of society is quite concerned, however, that they are externalizing significant costs to other parts of society. Medium to long cycle forest fallow systems appear to provide quite reliable and adequate supplies of subsistence products, but face the challenge of finding suitable sources of cash income to meet their evolving needs. Short cycle forest fallow systems appear to have quite low returns to agricultural labor and effort, in either subsistence or commercial terms, and appear to be moving toward more products from paddy and/or uncultivated lands, or to making the transition to permanent field commercial crops. Permanent field systems with upland rice can often meet their subsistence rice needs, but only with a subsidy from other commercial activity to meet their needs for chemical inputs, resulting in quite low overall returns to their effort; at least in times when prices are attractive, some are now moving to replace upland rice by expanding cash crop production to most or all of their permanent upland fields. Permanent field systems focused only on upland commercial field crops have seen their profitability wax and wane during recent years in line with events in very distant places. But contract production of maize and very recently a (perhaps temporary) rise in soybean prices, are currently keeping this option quite attractive for lowland Northern Thai and Karen villages with permanent upland fields. Some villagers are concerned about the sustainability of these practices, however, and both local and downstream communities have begun to look more closely at impacts of agricultural chemicals on their water supplies.

How long impacts such as these will endure into the future is subject to a variety of factors that include very significant levels of uncertainty. Major examples include: (a) absence of any framework for land tenure, or even any type of formal recognition of land use legitimacy in upland areas; (b) fluctuations of prices in markets for agricultural inputs and products, which are expected to take even more radical turns with increasing liberalization of international trade; (c) unclear prospects for the agronomic and ecological sustainability of commercial cropping practices in permanent fields; (d) growing tensions among upstream and downstream communities related to seasonal stream flows, water use, and water quality; (e) weakness of local institutions expected by government and society to take an increasingly leading role in governance, including poverty reduction, natural resource management, conflict management, and administration of public rules and regulations.

Although the first three sources of uncertainty remain major issues, the most recent wave of projects – especially the Queen Sirikit Forest Development Project and the Raks Thai Foundation (Care-Thailand) collaborative natural resources management project – have brought with them a new wave of emphasis on strengthening local institutions (including their role in managing natural resource-associated conflict), and helping them integrate into the decentralizing national system of governance. While they have made very considerable strides in fostering and supporting local initiatives within villages, among multi-village local networks, and by elected local sub-district governments (TAO) – including collaboration in the development and testing of science-based tools under this project – many challenges and uncertainties remain as support from international donors ends. The challenge is now to make a transition to longer-term domestic support systems such as the Queen Sirikit Project, the upper Ping Basin project, and emerging networks of sub-district governments and civil society institutions. Prospects appear brightened by growing recognition of the innovation and progress made in Mae Chaem, but remaining challenges are still substantial.

With data from our study that have improved our insights into such issues, we will return in the final section of this report to examine how far we have come in being able to address the important general questions posed in our original proposal regarding the potential future for participatory land use planning and community-based land use zoning approaches such as applied under this project.

Future Accountability in Land Use Zoning

Experience under this project has demonstrated the feasibility of using aerial photo analysis to help clarify patterns of past land use change and provide empirical evidence of the impacts of processes driving that change. It has also provided significant amounts of evidence to help substantiate local rationales underlying their current community land use zoning strategies and plans, while at the same time helping identify challenges for efforts to continue implementing and enforcing these strategies under the changing conditions likely to occur in the wider economic, social and policy environments.

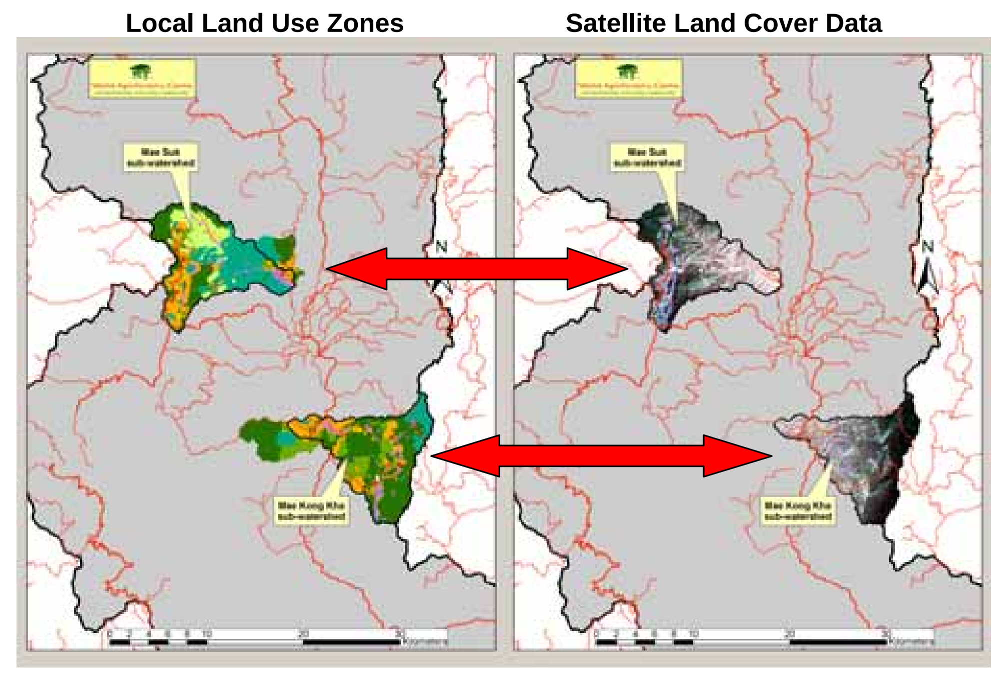
Clearly, one of the key challenges for local land use zoning approaches is how can transparency be assured in ascertaining the extent to which the key actors are indeed complying with zoning plans. Given the often dramatic differences in views and opinions of key stakeholders at the various levels involved, including their views of each other's motives and tactics, without measures and tools to assure the accountability of those responsible for implementing and enforcing local plans, it is highly unlikely that any types of formal agreements about local land use zoning can be concluded. And, unless transparency can be maintained in these processes, it is unlikely that various key stakeholders will have sufficient confidence and trust to proceed.

Thus, one of the important questions for activities under this project is whether the types of tools being tested here could be used to provide the types of transparency and accountability required to monitor compliance with local land use zoning maps such as those we have helped produce.

Our experience under this project leads us to conclude that yes, we do belive tools are readily available that are capable of monitoring compliance in an open and transparent manner. There are, however, six requirements that must be met in order for this goal to be achieved:

1. Boundaries of land use zoning units. The two levels of mapped boundaries required include: (a) areas of management responsibility, as demonstrated by the domains of administrative village responsibility shown on village land use zoning maps under this project; and (b) individual land use zones within areas of management responsibility. Ideally, specific local types of land use zones would be aggregated into a minimum set of types that would reflect the key issues of concern to natural resource management policy. Figure 26 provides examples of how such aggregations were made under this project. Boundaries must be digitized and available in a suitable GIS data format.
2. Types of land cover that indicate compliance with rules for the zoning unit. One of the major reasons for identifying a minimum number of types of land use zoning units is to facilitate the type(s) of land cover that would indicate compliance with the land use rules or conditions for that unit. For example, the type of land cover that would indicate compliance with local protected forest zones might be mature forest stands of good quality according to the type of forest native to that location (hill evergreen, dry dipterocarp, etc.); whereas a much wider range of annual plant or tree cover types could indicate compliance with zones for permanent upland fields.
3. Indicators of these types of land cover that can be identified from remote sensing data. Once the types of suitable land cover have been identified, there may need to be some more technical agreement on how those types of cover can be suitably identified using remote sensing data. The main source of data used for land cover assessments under this project was aerial photos. While air photos can provide quite detailed information that is relatively easy for various people to see and agree upon, acquisition of aerial photos is an expensive endeavor that is unlikely to be undertaken at an interval that would provide a sufficient frequency of feedback for monitoring land use zoning compliance. Thus, data from satellite-based remote sensing sources would likely be necessary to provide a suitable flow of time series data.

Figure 105. Using satellite land cover data to monitor land use zones.



Various sources of satellite data are now available at a range of resolutions and at intervals that are more than adequate for land use zone monitoring purposes. As an example, Figure 105 displays data from Landsat for two of the sub-watersheds where local land use zoning maps were constructed under this project. Many of the major features seen in the zoning map are quite clearly identifiable in the Landsate image. Higher resolution satellite imagery is also available, but at higher costs for acquiring and interpreting the data. There would probably need to be some transparency, however, in demonstrating that the methods used to interpret satellite data are identifying suitable land cover types with reasonable accuracy. As the Thai government has just completed a large project to obtain very high resolution aerial photos for the entire country, perhaps satellite imagery from the same period of time when these photos were obtained could be used in calibrating and demonstrating the accuracy of satellite data.

4. <u>Remote sensing data that can be routinely obtained at suitable intervals</u>. Whatever source of satellite data is agreed upon, it needs to be regularly acquired and interpreted at intervals that are sufficiently frequent to satisfy major stakeholders in the natural resource management and public policy arenas.

5. <u>An institutional unit capable of conducting analysis of remote sensing data at these intervals</u>. Once suitable remote sensing data is obtained at appropriate intervals, there needs to be an institutional unit that has the mandate, capacity and resources to conduct regular analyses in a timely manner. Analyses would include interpreting current land cover types, and then comparing land cover with land use zoning units. Areas of disagreement could be identified as something like 'non-compliance hot spots' that would require further investigation, explanation, and possible action. It would also be quite straightforward to compare current land cover with that from the previous period, at least for types of mapping units where it would be useful to trace change over time. If it is useful, for example, it may be possible to develop indicators of 'improvement' in areas of non-compliance, or 'deterioration' in areas that may be moving toward non-compliance but have not yet breached the standard.

6. A means for making analyses available to all relevant members of the public policy arena. The final requirement includes mechanisms for disseminating and explaining findings from regular remote sensing analyses of land cover to determine compliance with land use zoning agreements. In order for these tools to be effective and acceptable to the range of stakeholders involved with these issues, information must be fully available to all parties. Some recent innovative developments in institutions and spatial information tools that may be useful in helping build these mechanisms are mentioned in subsequent sections.

How this overall approach could help improve the effective use of monitoring of forest data, for example, can be illustrated by a current example from Mae Chaem. Forestry agency units in Mae Chaem have recently been advised by their headquarters units in Bangkok that a new analysis of satellite data indicates that during a recent three year interval 3,520 hectares (22,000 rai) of forest land in Mae Chaem was destroyed by 'encroachment'. This information is now being used to help justify increasingly aggressive measures to stop remaining rotational forest fallow practices and implement increasingly strict measures to limit land use in forest lands. No map or further details on where this forest 'encroachment' has taken place is available. We have suggested to our colleagues in the forest department that if the interpreted coverage that revealed this 'encroachment' could be made available, we could overlay the boundary files from our local land use zoning work to help identify in more detail where, and possibly why and how, such land use has taken place, and who claims responsibility for land use in that area. Some of this 'encroachment', for example, may be occurring in forest fallow areas as part of their annual rotation process, which would mean a roughly equivalent area was also returned for natural forest regeneration. Other areas, however, may indicate what would be violations of the local land use zones we have mapped, and further investigation in that area may be able to reveal who conducted that action and what was their purpose for doing so. In short, it would allow everyone to move beyond the 'broad-brush blame game' that is often being played by all sides, to much more specific information that could be used to increase our understanding and take suitable specific actions that could help assure improved management of natural resources.

E. Information for local governance

Previous sections have described work under this project that has demonstrated that localized land use zoning is already being conducted in most all villages in Mae Chaem, and that it is feasible to collaborate with local communities in using science-based tools to bring local zoning information into a GIS format. We have then begun to show how such data can be used to assess overall impacts on wider landscapes, improve understanding of how and where land use strategies and practices vary, and thus possibly improve programs to support more productive and sustainable land use and natural resource management. We have also assessed patterns of change during the last 50 years that have resulted in the land cover and land use patterns we see today, and how the underlying processes of change link with current local land use zoning strategies and plans. Moreover, we have explored how science-based tools can be further employed to provide transparency and accountability in monitoring compliance with local land use zoning plans, which may help improve the feasibility of concluding and enforcing agreements that could provide local communities with some degree of land usufruct security, while helping assure that the nation's valuable natural resources are being used in a sustainable and equitable manner.

This section continues our story, by describing results of activities under this project that were directed toward exploring who could utilize these types of information and the science-based tools with which its generation and utilization is associated. Key components include examination of the institutional context of local natural resource governance, exploration of where tools might best be located and used, and demonstration of how the tools can be used to help address locally important issues.

1. Toward spatial information systems to meet local needs

Given the type of findings summarized above, the general strategy we have employed under this project has been to explore how the science-based tools used under the project may be able to match with the needs of these key institutional actors, as well as the institutional needs and capacities of our partner institutions with whom we have implemented this project.

Tambon Administration Organization (TAO)

Given their key institutional role, as well as widespread expectations of the increasing role they will play in the future, one of our first priorities was to explore local views about how our spatial information tools would be perceived by TAO leaders and staff from sub-districts within which our pilot activities were being implemented. Thus, considerable efforts were made to explain the entire system and process to interested TAO leaders and staff, including familiarization seminars and workshops held in Mae Chaem and in our GIS laboratory in Chiang Mai, such as in the images shown in Figure 106.

The interest and response from TAOs was even stronger and more positive than what we had expected, despite the fact that these TAO are all considered to be in 'class 5' status, indicating that they are in the lowest capacity category. Their strong interest was largely because they were quick to see how these types of spatial information tools could be very useful for a range of TAO needs extending well beyond the primary areas of focus for this project. While most were very eager to get the system up and running on computers they already had in their offices, it soon became apparent in follow-up work that the process would require more skill and time than was currently available for such purposes. Thus, the project continued to keep them informed of our activities, and provide them with specific spatial information from our database upon request, while we continued to explore other possibilities for providing them with support services on a longer-term basis.

Indeed, it was quite discouraging to discover how little information is available in any type of spatial format for use by TAO prior to this project. And, while it is heartening to see the project now cited by TAO as one of its primary sources of local information, that this is so only helps to point out the importance and urgency of developing more sustainable long term solutions to meeting the data needs of TAOs.

District Officer and staff

Figure 106. System Demos for TAOs

One of our initial notions was that it may be possible to establish a spatial information 'node' within the district office that would be able to service needs at both district and TAO levels, at least until more capacity can be developed within the TAOs. And indeed, we found very strong interest from the District Officer and his staff, who have eagerly assisted project staff in obtaining various types of data available from district sources to enter into the database. They have also requested a considerable number of specialized maps from the project for particular purposes, several of which can be seen on various walls in district office facilities.

One interesting example of their interest related to the administrative village domains of responsibility mapped under the project. The District Office provides the Ministry of Interior with rough, usually hand drawn sketches, of administrative village boundaries that are part of their official records. Thus, some of our NGO colleagues were concerned that problems might be created if district officials saw the village boundaries drawn by villagers under this project. In fact, when the District Officer first saw these boundaries that were being generated by villagers themselves, he was very pleased. He even asked for copies of the boundaries so that they could be used in the official files in place of the ones currently used. He and his staff admitted that they knew many of the village boundaries that they had in their files were not very accurate, but they were at a loss about what else to do because they have neither the staff nor the resources to use for improving them. While this and various other exchanges with the District Officer and his staff were very promising, various follow-up activities were limited by the frequent changes of district officials as they transferred from one district to another as part of their career development path and the personnel policies of the Ministry of Interior.

Despite such difficulties, the project made concerted efforts to build communications with district officials who have been assigned to Mae Chaem during project implementation, to familiarize them with the activities and information systems of the project, and to seek their views on how such services could be integrated into permanent institutions. Virtually without exception, officials have appreciated the spatial information tools, and expressed their desire to see them provided at district and tambon levels. But given the continual down-sizing of district-level positions and budgets, which are part of the overall restructuring of governance as more authority shifts to TAOs, they do not have either the personnel or budget resources to try to build such an operation under the auspices of the district office. It appears that most effort under the Ministry of Interior aimed at improving information systems for rural areas is being directed toward the provincial level, with the notion that districts would be able to use and contribute to the provincial system.

Watershed Management Networks

Given the informal, multi-village nature of sub-watershed management networks, it is clearly not feasible for them to consider developing their own spatial information system 'node'. Rather, they should be considered as primary users and contributors of information in the system. Indeed, core members of these networks played key roles in facilitating participatory mapping by project staff in pilot sub-watersheds, and especially in helping reach agreement between neighboring villages on mutually agreeable boundaries of village domains of land use responsibility, as well as in identifying local place names and locally important locations for inclusion in the maps. Another dimension of major project interaction with these networks in generating local information has been community-based monitoring of watershed services, which will be discussed in another section below.

As consumers of spatial data, sub-watershed management networks have been a primary target for work under this project, and they have been very keen to obtain maps generated by the project for use at both village and sub-watershed levels. They have also played a very active role in helping the project refine the format in which they were produced to maximize their usefulness at local levels. It is a primary challenge for any further efforts to build and refine interactive information support services for these important types of new local institutional innovation in upper tributary watersheds.

Ping River Basin Initiative

As mentioned in the above section on the institutional context in Mae Chaem, leaders of efforts to develop the Ping River Basin Organization are very aware of the need for spatial information to support their work and the future functioning of the organization. The project held several briefings for and discussions with members, staff and consultants from national committees developing the conceptual approach for river basin management programs, and participated in panel discussions held in Mae Chaem to discuss ideas at the sub-basin level. One of our research staff based in Mae Chaem, Thanut Promduang, was invited to participate on behalf of ICRAF as an advisor to a preliminary group established to develop ideas and plans for the Mae Chaem sub-basin. At their request, we have provided a range of data and information from our studies, and organized discussions with villagers participating in our participatory mapping and watershed monitoring activities. Leaders of the Ping river basin initiative and their representatives have participated in a range project seminars and discussions, and have visited with participating villagers at several of our field sites. They have expressed their appreciation of the types of information and activities that the project has developed, as well as their interest in further exploring how such services might be built into the new basin system.

As part of the process to develop the Ping river basin organization, the Department of Environmental Quality Promotion under the Ministry of Natural Resources and Environment has commissioned some supporting studies in the Ping river basin. One of these studies managed by the Chiang Mai University Faculty of Engineering in collaboration with other faculties and organizations included development of basic spatial data that is available for leaders of the Ping initiative. It is not yet clear, however, where the database will be located or who will manage it.

Our most recent joint discussions with leaders of the Ping river basin initiative and the Chiang Mai provincial association of tambon administration organizations (TAOs) indicate that they believe it is feasible to develop means to expand digital mapping of local land use zones, as well as other types of information support systems piloted under this project.

Project Partner Institutions

Another of our initial notions was that we would assist the Raks Thai Foundation (Care-Thailand) office in Mae Chaem to develop a spatial information node that they could use for their project, and then transfer to an appropriate district-level unit as the project ended. Unfortunately, their available personnel and budgetary resources did not allow this to happen. Thus, we agreed to shift our strategy to collaborate with Care staff in obtaining information to build the system, and their project became a 'consumer' of information from our system. Care also invited ICRAF to join their project advisory committee, and they provided close collaboration in helping us explore possible avenues for establishing more long-term information services in Mae Chaem.

One of the most encouraging developments is resulting from work by colleagues at the CMU Multiple Cropping Center who have been constructing pilot spatial information systems under support from the Thailand Research Fund. They have now completed systems for Chiang Mai, Lamphun and Chiang Rai provinces that include most all 'standard' spatial datasets from a wide range of agencies and sources; as well as new datasets that they have generated through their own analyses. The system is managed via a user-friendly Thai language menu-driven decision support shell, which provides means for easily producing custom on-demand maps, as well as conducting various types of analyses to assist in agriculture and natural resource management and administration activities. Users can easily access information and decision support at provincial, district or tambon (sub-district) levels, or at river basin, sub-basin, or user-specified sub-watershed levels. The system is also open for inclusion of additional spatial data from other sources. It will soon be introduced for use within the three pilot provinces.

This is clearly a promising important new tool with great potential for providing a foundation for many of the information services tested under this project, and we are developing joint plans to further explore means for achieving this.

2. Applying spatial information to address an important local issue: Mae Tho National Park

Announcement of the preliminary boundaries of the new Mae Tho National Park and establishment of a headquarters unit for the park as hit the southwestern quadrant of the Mae Chaem watershed in a manner somewhat analogous to a tsunami wave. In essence, this is one on-the-ground manifestation of a management strategy for national forest lands that was formulated very quietly by elements of the forestry and environmental movement elite, and launched behind the scenes during the early 1990's, soon after the 1989 'logging ban', largely under the reign of the Democrat Party at the Ministry of Agriculture and Cooperatives. The essence of the argument underlying this strategy is that basically all remaining productive natural forest areas in the country are to be brought into the 'protected area system', preferably in the form of national parks or wildlife sanctuaries, which are backed by the strongest and most restrictive legislation; class 1 watersheds are still based only on the authority of Cabinet resolutions. After a number of years of moving quietly through the legal appropriate legal processes, it finally burst into the open at a number of sites, including Mae Chaem. In this case, no public hearings, debates, or any of the other processes for public input that writers of the 1997 national constitution valued so strongly, appear to have been necessary.

The most immediate and obvious impact of this action is to threaten the agroecosystems of the numerous villages who inhabit areas within the park boundary. Foresters will quietly admit on an informal basis that it is no accident that most of these villages are ethnic Karen and Lawa who still practice medium cycle rotational forest fallow shifting cultivation systems, the continued existence of which is still seen by some powerful forestry factions as 'unfinished business'. While villagers in the area generally felt shocked and intimidated, some began looking for a compromise way out of the problem, while others felt pushed to the point of resistance. The tactics employed by the forestry agency are not centered on forced relocation of villagers out of the area, which could erupt in scandal. Rather, the 'deal' that foresters began to offer them basically consisted of their being provided with enough land for some small fields for paddy (if possible) and some fixed cultivation of upland crops, which might be 'mapped out' of the boundary, as an enclave if necessary. The rest of the area is to be given full national park status, which means villagers would have virtually no rights to use it for any purpose. Villagers are aware that this is generally what happened to Karen communities on the eastern side of Mae Chaem, a process this report has detailed for the case of Mae Raek. For most foresters assigned to 'negotiate' the final boundaries of the park, this is not an ideological struggle, but only part of the job that they have to perform if they are to continue their career at the agency. Moreover, several of the forestry staff assigned to this task had enough background in community forestry principles to realize that even from the forest department's own point of view it is not wise to turn local communities into your enemies, or to be so aggressive as to induce mass protests or violent conflict.

In any event, given the rapid rise in tensions during the early phase of implementation of this project, the Raks Thai Foundation (Care-Thailand) was approached to serve as a neutral party in trying to help facilitate constructive discussions and negotiations between park staff and local villagers. Since Care is a partner in this project, their staff then requested assistance from the project to see if some of the spatial information tools we were developing might be able to assist with this process. In response, our field mapping and GIS teams collaborated with Care staff and local communities in conducting participatory mapping in some of the villages, and building a basic spatial database that could help clarify and visualize some of the issues under discussion among local communities and staff from the national park, Care, the district office, and the TAOs . Results were summarized in a Thai-language report submitted to the Care-Thailand project.[85] A few examples of maps generated during this process are shown in Figure 107. The project also provided advice and assistance for an American doctoral student who conducted her dissertation research in a portion of this area.[86]

As mentioned earlier, most of the Mae Tum sub-watershed is included within the boundaries of Mae Tho national park. Mae Tum was one of this project's pilot sub-watersheds, and additional information on it is shown in Figures 16 and 31 and associated discussions.

While these inputs have not 'solved' the problems in this area, they did provide some very constructive input into the debate and negotiation process, and it is worth noting that maps and spatial information tools are now regularly used by both sides in this continuing debate and negotiation process. This experience has also pointed out the hazards of aggressive environmental policies formulated through processes that involve no transparency or consultation with those who will be most severely affected. Moreover, justification for national park status in this area is obscure at best, and the benefits to be received by society by converting these systems into fixed field commercial cultivation are equally obscure. Issues here are not so much trying to prove one side as 'right' or 'wrong', as they are about whether these sorts of questions should be addressed by more rational processes in a more transparent and inclusive manner. If so, this experience helps demonstrate that science-based tools can help.

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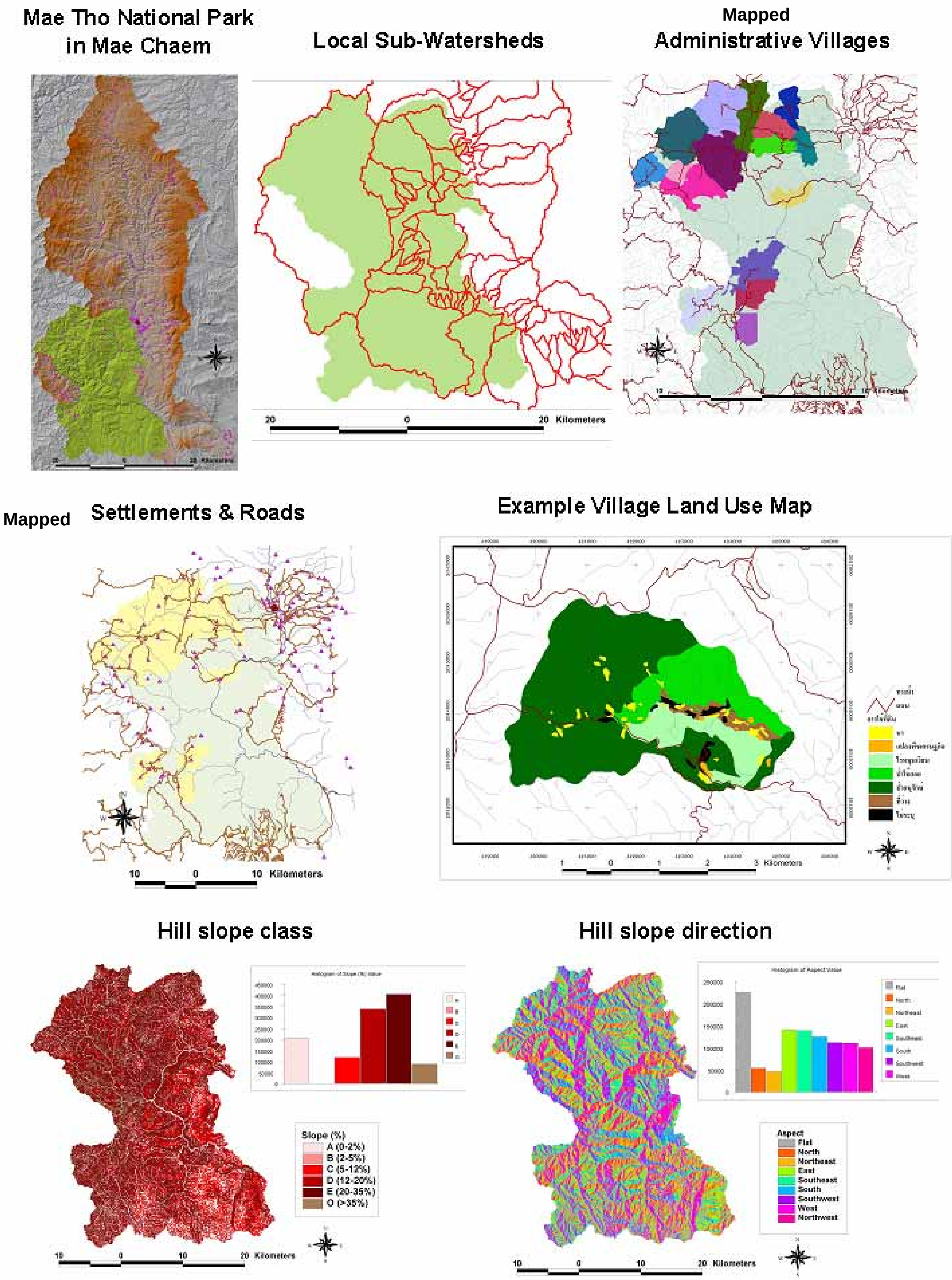
[85] พรวิไล ไทรโพธิ์ทอง, วุฒิกร โคจรรุ่งโรจน์, อนันทิกา รัตน์น้ำหิน, ประภัสสร พันธ์สมพงษ์ . 2002. รายงาน โครงการการจัดทำและประยุกต์ใช้ข้อมูลจากสารสนเทศทางภูมิศาสตร์ (Geographic Information System, GIS) เพื่อสำรวจการใช้ที่ดินในพื้นที่เตรียมจัดตั้งอุทยานแห่งชาติแม่โถ (บางส่วน). มูลนิธิแคร์-รักษ์ไทย, ศูนย์วิจัยวนเกษตรนานาชาติ

[86] Robin J. Roth. 2004. 'Fixing' the Forest: The spatial reorganization of inhabited landscapes in Mae Tho National Park, Thailand. Ph.D. dissertation. Department of Geography, Clark University, Worcester, Massachusetts, USA.

Figure 107. Examples of data for Mae Tho negotiation processes



F. Tools for Community-based watershed monitoring and management

In order to further explore approaches for addressing some of the key issues related to communication, trust, transparency and accountability, this set of activities sought to improve science-based methods for measuring, monitoring and managing impacts of land use change on watershed services and local livelihoods. Basic principles underlying these efforts included:

- Primary focus was on developing simple participatory tools that can be used by local communities, NGO field workers, and local officials, as well as researchers. Local villagers and field staff were directly involved in development, field testing and refinement activities.
- Types of information selected related directly to key components of growing debate, tension and conflict. Information generated by these activities was expected to be directly useful for efforts to reach common understandings and reduce tension and conflict at local inter-community, sub-catchment and sub-district levels.
- Information gathered by these methods needs to be scientifically accurate within reasonable levels of confidence and precision, in order to provide a foundation for efforts to build broader monitoring, information and analytical components that can improve the basis for local interaction with other stakeholders in the larger basin context, relevant state agencies and wider society.

Based on these principles, emphasis was placed on testing tools for monitoring watershed services.

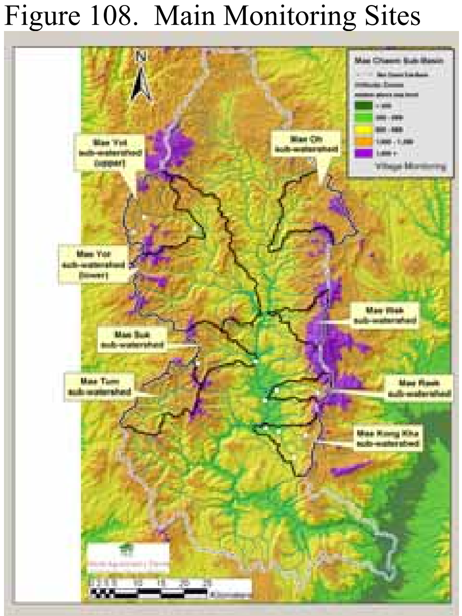
1. Watershed monitoring tools

The greatest emphasis in developing science-based tools for direct monitoring by local communities was placed on tools for assessing watershed services provided by local agroforestry landscapes. As we have seen, upper tributary landscapes are composed of fairly complex mosaic patterns of various types of cultivated and non-cultivated land use practices. The net impacts of these various configurations on watershed services are subject to considerable speculation and much debate, the vast majority of which is based far more on theory, emotional impressions and/or vested interests than on empirical evidence. Thus, the project has sought to test a set of simple science-based tools employed by members of local villages in the context of their sub-watershed management network, in order to produce information useful for: (1) feedback on impacts of local land use management on watershed services; (2) helping manage watershed service-related tensions and conflicts among local communities; and (3) facilitating communication and negotiations by local upland communities with downstream communities and with broader society regarding impacts of land use in upper tributary watersheds.

Monitoring Site Locations

The 12 sites for major emphasis by activities under this component were in the four phase 1 sub-watersheds (Mae Raek, Mae Kong Kha, Mae Suk, and upper Mae Yot) where more time was available to work with local networks in testing and assessing these approaches and tools. The white circles in Figure 108 indicate strategic locations selected in collaboration with local networks for regular monitoring in those sub-watersheds. The limited time available for expansion to phase 2 sub-watersheds then provided additional experience and insights that reflected some additional sets of conditions, which helped refine our overall assessments and recommendations.

Figure 108. Main Monitoring Sites



Testing the Monitoring Toolkit

Four basic sets of tools were selected for this initial exploration in community-based monitoring.

Figure 109

Rainfall, Temperature & Relative Humidity

Climate and Stream Flow

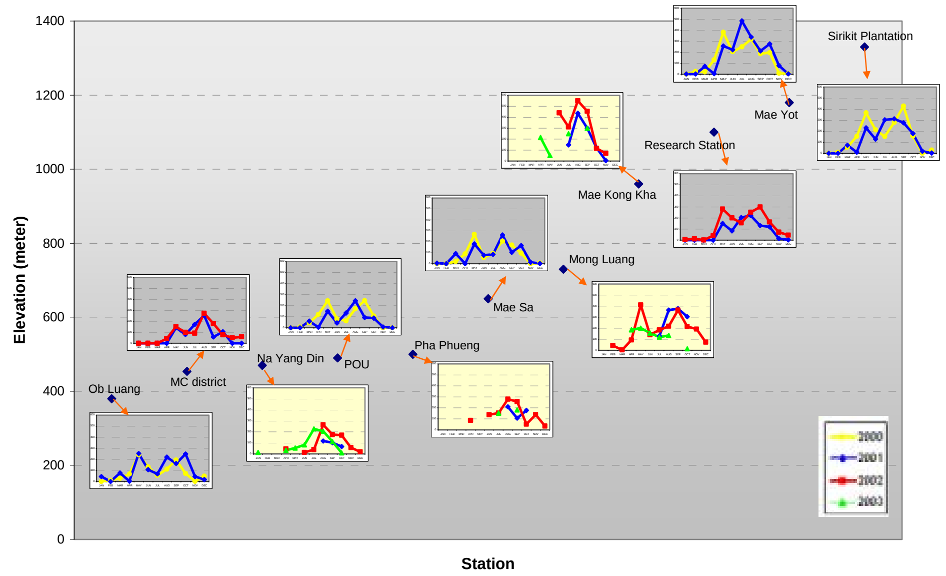
The first set of tools focused on daily measurements of basic climatic variables, including rainfall, maximum and minimum temperatures, and relative humidity, along with weekly indicators of stream flow. As indicated in Figure 109, rainfall was measured with a very simple device constructed from a used plastic bottled water container that was modified and calibrated to mimic larger and more sophisticated devices. A simple inexpensive maximum-minimum thermometer available in local markets was used for temperature, and a pair of matched thermometers, one wrapped in cloth immersed in water, provided wet-dry temperatures for calculating relative humidity. Simple structures or shelters were made for these instruments at a location within or near the village settlement area where daily readings could be made and recorded with minimal inconvenience.

Steam flow was monitored by 2 simple measurements: stream depth and surface flow velocity. A simple sketch of the cross-section of the stream where regular monitoring was conducted provided the context and a basis for simple flow volume calculations. Water depth was a simple weekly measurement at the same point using an improvised staff gauge. Surface velocity was estimated using a leaf or foam float and a stop watch to time its travel time along a 5 to 10 meter measured distance, averaged over a series of at least 5 runs. Water temperature was also measured.

Data collected by villagers appear comparable to data collected by more sophisticated techniques. As an example, Figure 111 displays rainfall data collected by four of our communities (light yellow background) located at increasing altitudes, along with data from official weather stations (grey background) located in Mae Chaem along a similar altitude gradient. Data patterns are comparable to official sources at similar elevation, and differences among elevations are similar for both sources. Differences along altitudinal gradients also reflect the general relationships resulting from analyses of earlier weather data in Mae Chaem under the GAME-T Project. In a similar vein, temperature data collected by the same 4 communities are compared in Figure 112 with official data from a data logger at the watershed research station in Mae Chaem. We have not yet been able to obtain official data on relative humidity, water temperature or stream flow from sources suitable for comparison during this period. While

Figure 110.
Water depth & surface flow velocity

Figure 111. Rainfall Data Compared with Other Sources of Data

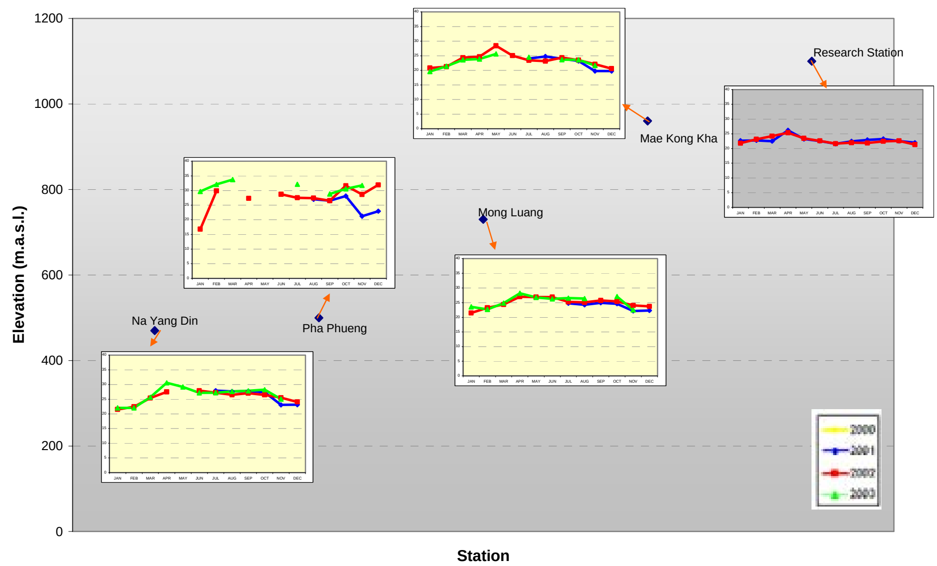


daily values appear to be very reasonable and consistent in comparison with official data, official or research sources employing sensors attached to data loggers are able to provide much more fine resolution data associated with variation within the daily time step, including important data associated with individual storm events.

Stream water quality

The second set of tools focuses on overall water quality by using a bio-indicator approach. The general approach was based on work conducted by researchers seeking to adapt similar approaches used in the United Kingdom[87]. Background materials and methods are detailed in 5 handbooks and guides that are packaged along with an identification key and associated materials in the *Stream Detectives Package for the Investigating and Caring of Stream's Health*, originally published in 1999 in Thai language, and now available in an English language edition, by the Green World Foundation based in Bangkok. These

Figure 112. Temperature Data Compared with Data Logger

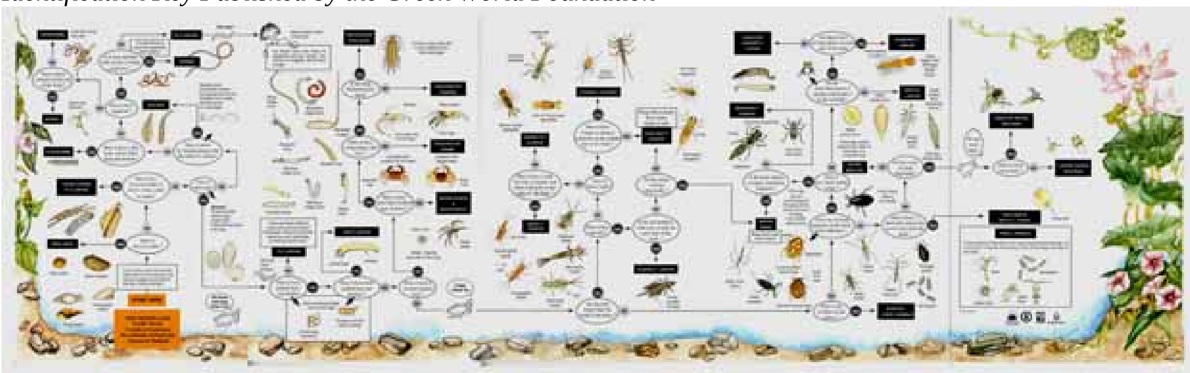


[87] Stephen E. Mustow. 1997. Aquatic Macroinvertebrates and Environmental Quality of Rivers in Northern Thailand. Ph.D. Thesis. Faculty of Science, University of London.

Oy Kanjanavanit. 2002. Identification Guide to Stream Invertebrates. Green World Foundation. Bangkok.

Figure 113. Water Quality using Aquatic Invertebrates as Biological Indicators

Identification Key Published by the Green World Foundation

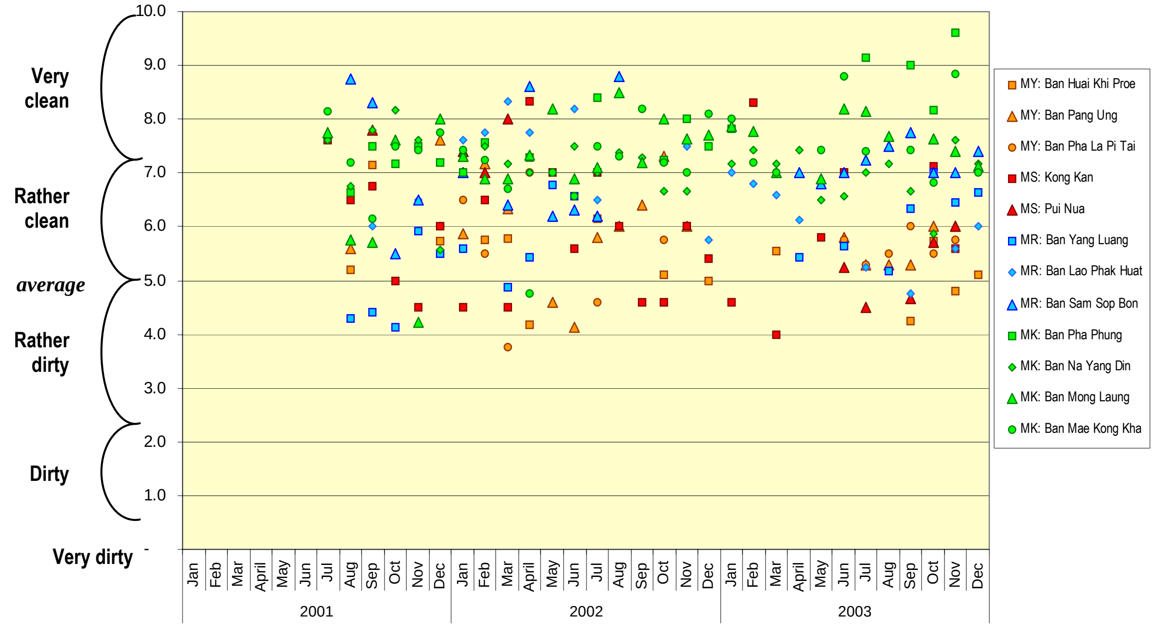


materials were developed under GWF's River and Stream Investigation Project for Youth (RSPY), initiated in 1998 with financial support from DANCED to promote active learning to empower teachers and students of secondary schools in the Ping River catchment to evaluate the state of streams' health, and to link with local communities to promote a responsible attitude toward river conservation. A preliminary cross-check and comparison of this bio-indicator approach was conducted in Mae Chaem by ICRAF and forest department staff in collaboration with researchers at the Chiang Mai University Faculty of Science. Use of aquatic invertebrates compared favorably with other types of bio-indicators, including algae, diatoms and aquatic plants, but is relatively easier for villagers to learn and implement.

As depicted in Figure 113, this method requires only simple equipment, and identification of specific organisms is facilitated by local knowledge and familiarity with many of them. The identification key helps match the system with local names and provides a score for different groups of organisms, based on their relative sensitivity or tolerance to factors contributing to poor water quality. Scores of organisms collected at a particular site and time are aggregated to provide an overall index of water quality based on weighted scores of the resulting 'suite' of species. The index has a 10-point scale that can place water quality into one of the five categories indicated along the Y-axis in Figure 114.

Mean monthly values of the water quality index as measured by villagers at each of the 12 main monitoring sites (Figure 108) during a thirty month period are also displayed in Figure 114. Data points are color coded according to the sub-watershed in which they are located. It is worth noting that most values are in the clean to very clean categories, and especially in the Mae Kong Kha sub-watershed. Most of the lower values are in Mae Suk and Mae Yot sub-watersheds, where there are more settlements as well as intensive vegetable production in highland areas. This may be a point worthy of more study if these differences continue to be verified over time and at additional locations. Although many villagers were initially quite apprehensive about the difficulty of this method, it has become one of the most popular and highly regarded of our monitoring tools.

Figure 114. Mean Monthly Water Quality Indicator Index Values, 2001 - 2003



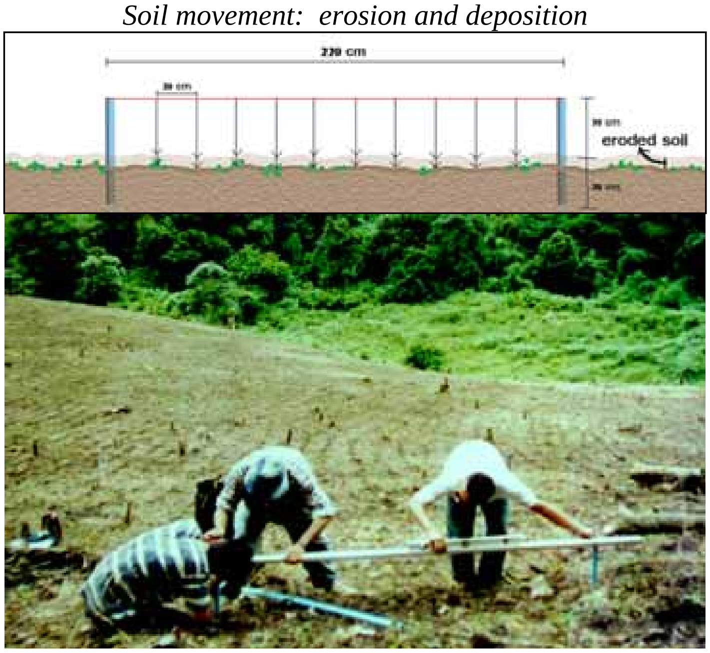
Soil Erosion and Stream Sediment

The third category of data focused on simple measurements of stream sediment, and on soil movement in cultivated fields. This approach began with villagers taking a one liter sample of stream water from below the surface at mid-stream, filling a calibrated plastic water bottle with its neck cut off, as indicated in Figure 115. A small red colored disc was then placed at the bottom of the container, and water was siphoned off into a plastic bag using a rubber hose until the red disc became visible from the surface. The amount of water remaining in the bottle at this point was recorded, after which the remaining water was transferred to the plastic bag. The bag containing the water was then placed in the sun or a sheltered spot at a secure location, where the water was allowed to evaporate. The source and time of the sample was marked on the bag with a marker pen, and the sample was later sent to the

Figure 115. Simple measurement of stream sediment and soil movement.

Stream Turbidity & Sediment

Soil movement: erosion and deposition



ICRAF field office in Mae Chaem where the oven-dried sediment was weighed with a balance and recorded. This data was collected weekly and reflected the project's effort to contribute to compilation of data to verify linkages between stream water turbidity and its actual sediment content.

Soil movement in cultivated fields was measured monthly using a simple soil 'bridge', as also indicated in Figure 115. The vertical standards were made using PVC pipe that was driven into the ground enough that they would remain fixed; width between the two standards was 2.2 meters. A strong electrical cord marked with tape at 20 centimeter intervals was then stretched along a board placed on top of the pair of poles, and the distance to the soil surface was measured at each interval. This method allows the detection of both soil loss and soil accumulation, and replicate pairs of such sites were established at upper, middle and lower slope locations of selected cultivated fields.

Local Environmental Knowledge

The fourth category of monitoring data focused on identifying local environmental knowledge associated with data in the previous three categories, and on efforts to relate local knowledge to those measurements. The greatest amount of initial information in this category turned out to be local indicators of weather conditions, and particularly indicators of rainfall or drought events. Less data were collected on knowledge about factors affecting soil characteristics related to soil erosion. For indicators of rainfall and climatic trends, village data collection volunteers made efforts to record the time, place and prediction associated with the indicator and the person making the observation. Data records from rainfall and temperature monitoring activities could then be use to systematically verify whether or not the prediction was accurate. Villagers at several locations are finding this a very interesting activity for helping sort out the range of local indicators associated with various sources.

2. Assessing Performance Quality in the Use of Monitoring Indicators

The project believed the thirty month period of pilot implementation of the monitoring tools at the 12 main project sites located in four sub-watersheds of Mae Chaem should provide sufficient experience to assess the performance of these tools in the context of community-based monitoring. In order to facilitate this assessment, project scientific and field staff collaborated in developing some basic criteria for assessing the completeness and consistency of data records generated by village monitor volunteers at each of the 12 main monitoring sites. These criteria were used to assign a score of zero to four for each of the data records associated with measurements for each type of indicator, reflecting the overall quality of the data as follows:

- 4 points = all complete and consistent
- 3 points = mostly complete and consistent
- 2 points = reasonably complete and consistent
- 1 point = only partially complete and consistent
- 0 points = incomplete and unacceptable

Results of mean scores of data records generated by village sites in each of the four phase 1 sub-watersheds are presented in Figure 116. While none of the sites were able to achieve a complete high quality data record, results of these initial pilot efforts conducted by village volunteers were quite impressive at many sites. In order to understand and learn from the variability among sites and types of measurements, a more detailed assessment of experience by community volunteers was conducted by key project field staff and summarized in a Thai language report.[88] Village volunteers were able to explain reasons for a number of the gaps and inconsistencies in their data records by describing some of the problems they encountered during the data collection process. Examples of some of these problems are listed in Figure 117.

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[88] ธนัตถ์ พรมด้วง, นงลักษณ์ แก้วโภคา, โสนัฐ นที, Pornchai Preechapanya, David Thomas.. 2004. การพัฒนาเครื่องมือวิทยาศาสตร์อย่างง่ายเพื่อการจัดการลุ่มน้ำโดยชุมชนมีส่วนร่วม. รายงานการวิจัย ศูนย์วิจัยวนเกษตรนานาชาติ (World Agroforestry Centre,. Chiang Mai).

Figure 116.

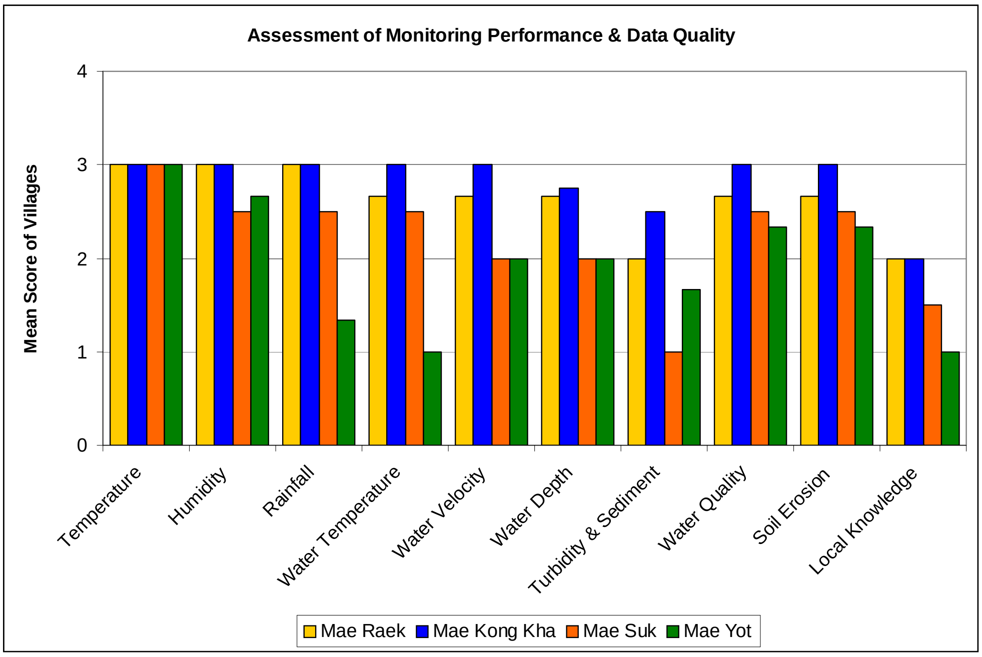


Figure 117. Problems Encountered in Collecting Monitoring Data

Type of Data	*Problem*
Local Environmental Knowledge	• Some data differs by location • Some data needs to be collected only once or once per year
Soil Erosion	• Field cultivation activities disturb poles for soil erosion bridge - solution may be to use cement to make stronger base for poles
Water Quality	• Cannot collect data at points in season of very heavy stream flow
Temperature & Humidity	• Maximum/Minimum temperature markers sometimes have problem • Sometimes wet temperature higher than dry temperature
Rainfall	• Rain gauge capacity too small for some periods of constant heavy rainfall
Stream Depth	• Cannot collect data during heavy stream flow
Stream Temperature	• No data possible during dry season when no water
Stream Velocity	• Difficult to collect when stream expands during heavy rain periods
Turbidity & Sediment	• Not yet been able to use data • Do not yet see how data can be used

Participating villagers were also asked to give their opinions about teach of the different types of measurements, based on their perceptions of how useful the data would be for them in the context of their local issues and watershed management network. Overall results of this line of questioning are presented in Figure 118. All villagers agreed on the relevance and utility of collecting temperature, humidity, rainfall and water quality data, as well as relevant information on local knowledge. Opinions were split on the usefulness of data on stream depth and water temperature. Although no villagers could see the immediate usefulness of data on stream velocity, soil erosion or

Figure 118. Local Perceptions of Data Usefulness

		Opinion on Usefulness of Data *(Percent)*	
	Type of Data	*Known*	*Not Known*
1	Temperature & Relative Humidity	100	-
2	Rainfall	100	-
3	Water Quality	100	-
4	Stream Depth	42	58
5	Water Temperature	42	58
6	Stream Velocity	-	100
7	Turbidity & Sediment	-	100
8	Soil Erosion	-	100
9	Local Environmental Knowledge	100	-

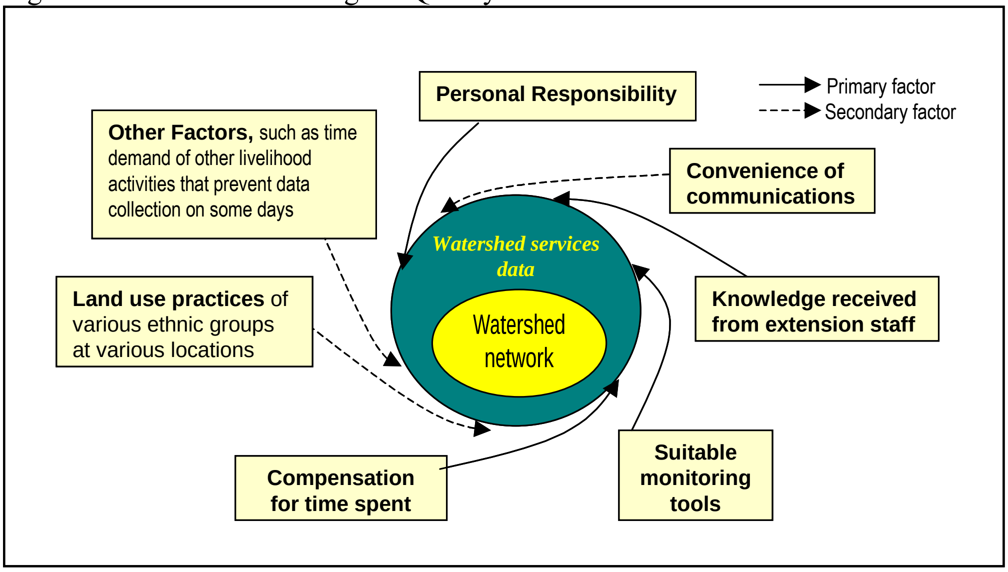
stream water turbidity and sediment, many also expressed the opinion that data on soil erosion and stream sediment are likely to become more important in the future. As indicated in Figure 51, their problem with turbidity and sediment measures were that they did not yet see how the data they have been collecting can be used. In the case of stream velocity, they felt that stream depth was a better and sufficient measure of stream flow and that velocity measurements did not add useful information.

In addition to opinions about the various types of simple science-based tools, volunteers gave these additional suggestions about collecting data on watershed services:

- Monthly meetings schedules were uncertain. Although individuals all have other various commitments, specified times for these meetings would provide volunteers with time to discuss and exchange observations more easily.
- It is also important to have periodic meetings among data collectors in various sub-watersheds, in order to exchange data and information
- Data collectors should have sufficient basic knowledge or ability to learn quickly
- Since many types of data are very detailed, requiring understanding and time for their collection, there should be an appropriate modest level of compensation for the people doing this work.
- Volunteers who collect data should be chosen from people willing to sacrifice time for collecting data, and who are capable of coordinating with village leaders or various units to provide continuity in data analysis and use.
- Activities should be coordinated with village headmen to keep them informed and understanding of the usefulness and importance of the data
- A "prachakhom" should be formed by data collection networks together with village headmen, village committees, TAO, and assisting organizations.
- Officials need to allocate time to help supervise, build understanding and answer questions in issues about which volunteers are uncertain, in order to improve data quality.

In summarizing their findings, project field staff constructed the diagram presented in Figure 119 to describe key primary and secondary factors affecting the quality of performance in collecting watershed monitoring data. Monitoring tools, along with the people involved and their opportunity costs, and effective interaction are all of central importance; communication convenience, ethnic differences, and other factors are also involved, but their importance is secondary.

Figure 119. Factors Affecting the Quality of Watershed Data Collection



Lessons for further use of watershed monitoring tools

During later stages of the project, efforts were also made to expand watershed monitoring data collection to the four phase 2 sub-watersheds: Mae Tum, Mae Wak, Mae Oh and lower Mae Yot. These efforts encountered various additional conditions and factors that were somewhat different than what was encountered in initial pilot sub-watersheds. Two factors were of particular importance: (1) areas where tensions related to watershed services were still low enough that villagers felt that the lack of any clear issues or problems that these measures could help address meant the usefulness of any data collection efforts would not be worth their effort; and (2) areas where tensions and concerns were so high that villagers hesitated to become involved because of fears that there was some sort of hidden agenda driving our efforts to test community-based watershed monitoring tools, which may be aimed at further undermining the security of local communities. Although these two factors reflect almost opposite directions, both resulted in substantial delays during which substantial additional effort was required from field staff before initial tests of data collection tools could begin.

In most of these cases, extended discussions, explanations and additional efforts by field staff were able to overcome the obstacles encountered, but remaining time was insufficient for community-based watershed monitoring data collection activities to become as well explored and tested as in the four phase 1 sub-watersheds. This experience has added important additional lessons for this pilot project, however, that are reflected in the overall assessment of this line of activity. Overall views of villagers about the types of measurements tested are listed in Figure 120. Only stream velocity and stream turbidity and sediment are recommended to stop, and views about turbidity and sediment are open for review and reassessment if and when it can be made clear to villagers how this data can be interpreted and used to provide information that can be directly useful for them. It is worth noting in these recommendations that even though all villagers initially responded that they did not see the immediate usefulness of data on factors such as soil erosion, they are aware of the general issues with which such data are associated, and they believe that it will be able to make significant contributions to meeting their needs in the not too distant future.

Figure 120. Overall Villager Recommendations on Measurements

Data collection that should continue	*Data collection that should stop*
• Temperature & Relative Humidity • Rainfall • Water Quality • Stream Depth • Stream Temperature • Soil Erosion • Local Environmental Knowledge	• Stream Velocity • Turbidity & Sediment

Summary observations from key field staff involved in this set of activities in all 8 sub-watersheds list the following lessons as important for consideration by any further efforts to support expansion of simple science-based tools for participatory monitoring of watershed services:

- Before collecting data, the local context should be analyzed to develop understanding of general characteristics and identify a suitable approach to support development of data collection
- All relevant ethnic groups in the local area should be included
- Network-type relationships are needed in this type of activity
- Authority for data collectors needs to be derived from relationships with a network or a local unit such as the TAO.
- An appropriate modest amount of compensation is necessary.
- Persons providing extension support services must give sufficient time for training in collecting, interpreting, and using data, and helping point out its importance.
- Technical specialists should help provide knowledge about analyses, including their use and meaning, that can be conducted using these types of data

- Use of local knowledge together with science-based tools can help improve coordination between them and is likely to give rise to new types of knowledge, but there is not yet a clear mechanism for how it will be spread throughout local communities
- Needs for data by researchers, watershed managers, or technicians, must be matched together with needs of local people from the beginning in order to prevent conflicts, because data needs of watershed managers probably differ from needs of villagers.

Use of science-based tools, together with local environmental knowledge, in participatory watershed monitoring and management is possible, because communities have seen that knowledge from these two sources can be combined to increase their usefulness. But two issues need careful consideration: (1) confusion about use and interpretation of data from science-based tools; and (2) study of factors that can help support emergence of these activities, considering that volunteers must manage their time carefully in relation to data collection processes. There will likely be a need for adaptation to local contexts that may affect what data is collected (or not), as well as the completeness of data records. Local monitors also want to exchange knowledge and experience. Thus, future efforts need to emphasize easy tool use and data interpretation, and ways to support information exchange, in order to facilitate the widespread use and acceptability of data among villagers, technicians, other stakeholders, and policy decision-makers at various levels.

3. Additional tools for land use management information

This project component also included three additional activities that sought to link data and information generated by application of science-based tools with local knowledge and experience in efforts to help improve the availability and use of information in land use management.

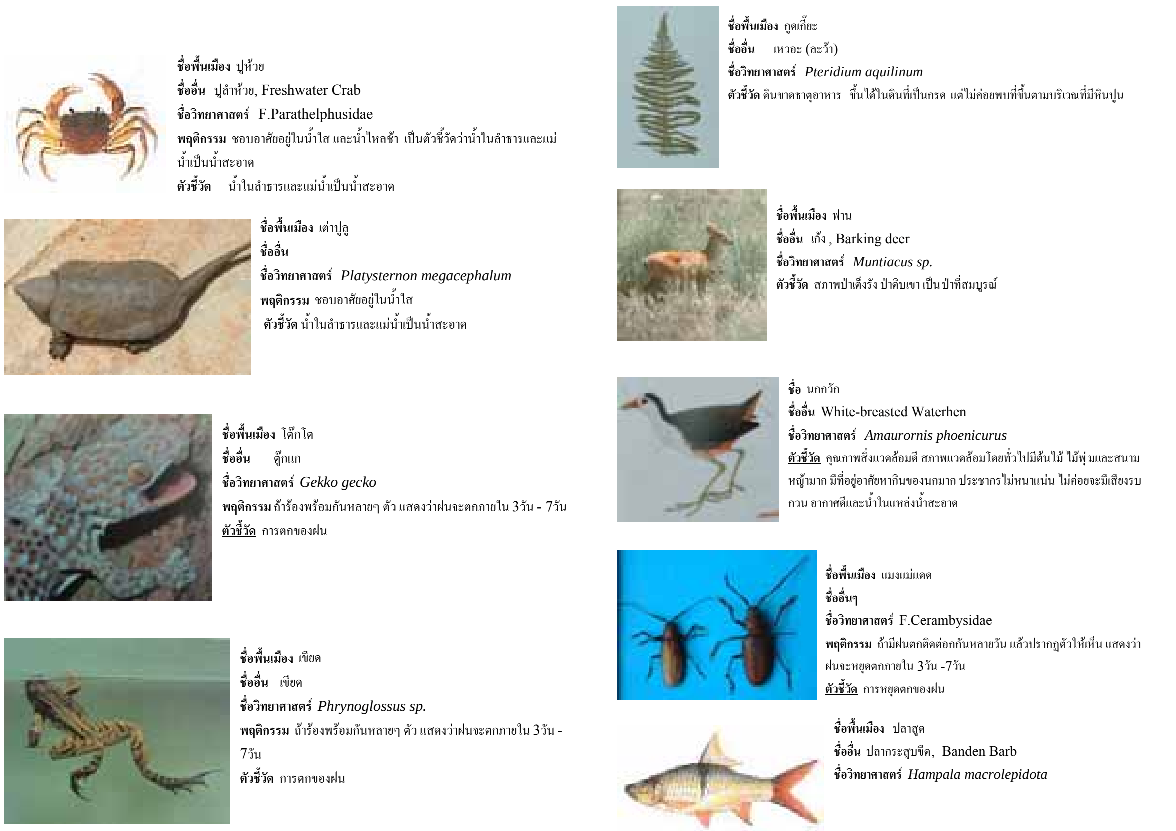
Additional biological indicators of environmental quality

Given the importance of and interest in use of biological indicators, among both villagers and our colleagues at governmental and non-governmental institutions, additional work in this area was conducted under the leadership of Dr. Pornchai Preechapanya, who heads the watershed research center for northern Thailand, under the Department of National Parks, Wildlife and Plant Conservation. Given his research interests, experience and training, he is particularly interested in building on local knowledge as well as scientific knowledge systems. Thus, he and his staff pursued dual lines of investigation that reviewed existing Thai research records and both Thai and international research literature, while at the same time collaborating with local communities in gathering information from local environmental knowledge. This is another dimension of local knowledge that is being entered into the database he and his colleagues are building using the Agroforestry Knowledge Toolkit (AKT) software system developed by Dr. Fergus Sinclair and colleagues at the University of Wales, Bangor, where Dr. Pornchai obtained his doctoral degree, in collaboration with a growing network of researchers at various locations around Thailand and elsewhere in the world.

Based on their progress, Dr. Pornchai and his staff printed and distributed a 'Handbook for inspecting environmental quality' during this project that catalogs 133 entries of biological indicators of water, soil, forest, air, and general environmental quality. Entries cover a range of indicator organisms, including aquatic invertebrates, fish, algae, plants, mammals, amphibians, reptiles, birds, and insects. Information includes local names, scientific names, other names, pictures and detail on what it is able to indicate in terms of characteristics related to environmental quality. A few selected examples are displayed in Figure 121.

This is meant to be a first version of this handbook, which is being circulated in an effort to stimulate awareness, discussion, and further study and exchange on use of biological indicators of various types of environmental quality. The collection intentionally seeks to combine local environmental knowledge and knowledge of scientists, to provide a more robust set of tools for interested persons of many backgrounds to be able to more easily inspect and assess environmental quality. These indicators may not provide a great deal of detail, but they are easily used by local communities and can at least help identify where problems are present or not.

Figure 121. Examples of additional biological indicators of environmental quality



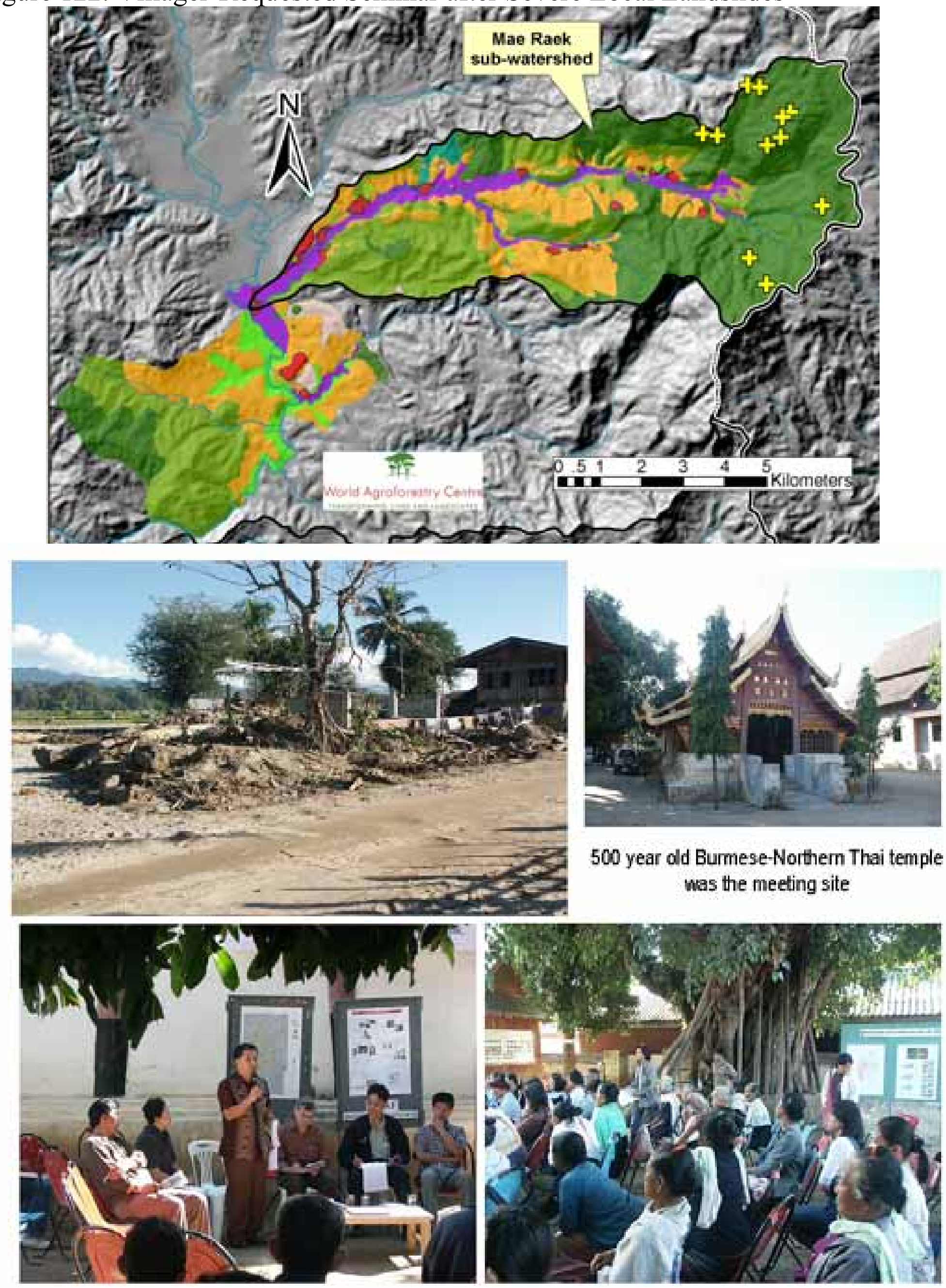
Local response to landslide disaster

The occurrence of serious landslides in upper tributary watersheds of northern Thailand has become an increasingly important issue in the public policy arena. While news of loss of life and damage to property has made numerous headlines at the national level during the last few years, major impacts are actually manifest most clearly at the sub-watershed level. Mae Chaem has been part of this story.

The point was made very clear during the implementation of this project, when a set of serious landslides occurred in the upper reaches of the Mae Raek sub-watershed. As we have seen in previous sections of this report, Mae Raek is an area where ethnic northern Thai inhabit lower portions of the sub-watershed, whereas ethnic Karen form the majority of the population in upper areas. It is also an area where virtually no traditional rotational forest fallow systems remain, as projects associated with Inthanon National Park and opium crop substitution programs have succeeded in inducing the transformation of agricultural components of those systems into permanent paddy and upland fields. Local land use zoning classifies most upper reaches of the sub-watershed as protected forest, and portions of it are located within the boundary of the national park.

The landslides occurred in several upper areas of the sub-watershed, as indicated by the yellow "+" marks on the local land use zoning map in Figure 56. Slides were massive enough that debris moved down streambeds draining the sub-watershed, inflicting heavy damage on paddy fields and altering stream channels all the way down to near the outlet where Mae Raek joins the Mae Chaem river. The photo below the map in Figure 122 shows some of the debris in lower parts of the sub-watershed. At the village where this photo was taken, several houses were very seriously damaged, and several people

Figure 122. Villager-Requested Seminar after Severe Local Landslides



very narrowly escaped being killed. Although damage was extensive, fortunately there were no deaths from this disaster.

In response to this event, local communities and their sub-watershed management network joined with their TAO and the District Office to organize a seminar to help assess how this disaster occurred and what should be done as a result. The project was asked to assist with information and supporting analyses. Our staff georeferenced the landslide sites and prepared assessments from our spatial and watershed monitoring information databases, most of which were presented in poster formats, as seen in the background of discussions shown in the remaining photos in Figure 122.

As explained during the seminar, the highest elevation village in Mae Raek was monitoring rainfall as part of our pilot community-based watershed monitoring activities. Data showed that the particular rainfall event with which the landslides were associated was very heavy, but not heavier than several other storms during the last year. What made this event different was a pattern of lighter but continuous rainfall at higher elevations that had thoroughly saturated soils before the heavy rainfall event hit. Thus, to a substantial extent, these landslides were associated with a set of low probability climatic events that would have made the landslides very likely regardless of the land cover.

Figure 123. DLD Landslide Hazard Map

Since the project also had our aerial photo time series for this area, we made land use maps from each point in the time series that also identified the points where the landslides occurred. This allowed villagers and local officials to jointly review the land use history of the areas, which had been preceded by a trip to inspect the sites just prior to the seminar. There was general agreement that there had been various types of previous disturbances in this area, and while there was some disagreement about whether these landslides were a direct result of that activity, there was a general feeling that the severity of the landslides may have been less if the forest on steep slopes had been more mature.

The project also introduced communities and local officials to additional information available from other sources in Thailand, such as the landslide hazard map for northern Thailand produced by the Department of Land Development and shown in Figure 123. This type of information helped move discussions in constructive directions by pointing out characteristics believed to be associated with areas that are prone to landslides. Moreover, it helped the seminar begin to formulate different categories of actions that could be taken in high hazard areas, such as: (a) protection of forest or other appropriate vegetation on steep slopes where landslides are likely; (b) development of capacity to provide early warning of climatic conditions that may produce landslides; (c) arranging settlements and infrastructure so as to the minimize likelihood of catastrophic damage; and (d) assessing sources of traditional and other local knowledge for information that may help avoid or minimize damage from landslide disasters.

After the seminar, local communities began several lines of activity: (a) reaching agreement on strict enforcement of protected forest zones in upper areas of the sub-watershed; (b) exploring means to establish effective communications between upper and lower elevation villages to provide channels for early warning – upper areas are in a reception/transmission ‘shadow’ so that cell phones cannot be used; (c) relocating houses and village facilities out of flood plain areas to higher ground; (d) begin a program to plant trees along stream banks, using species believed to be particularly strong in order to stabilize stream banks and, in the event of another landslide, help ‘filter out’ large trees or debris that caused serious damage and threatened lives during the last event. Members of the emerging upper Ping river basin organization, together with representatives of the provincial TAO network, also joined the seminar, and were very pleased with the process and outcome of these efforts, including the role that our science-based tools have been able to play. Moreover, they have encouraged Mae Raek communities and sub-watershed management network to articulate their ideas and plans in a form so that they can be considered for support from their organizations.

G. Progress Toward Addressing Key Questions About Science-Based Tools

As the conclusion to this chapter, this section seeks to address how the experience working with science-based tools during the second phase of ASB-Thailand activity, as summarized in previous sections, can help answer five key questions posed during development of the project supporting most of that work.:

1. Is it realistic to expect that plans negotiated through the participatory land use planning process can be integrated into broader spatial information systems?

We believe that results of this project quite clearly confirm that plans developed through participatory land use planning processes can be integrated into broader spatial information systems. Indeed, we have demonstrated how a small team can work directly with villagers to produce digital versions of land use zoning plans that local communities have developed themselves in response to conditions and outside pressures and tensions. Local communities in many areas of northern Thailand are believed to have developed, or are in the process of developing, similar types of plans. The basic methods, tools and processes for bringing such plans into GIS format and systems have been developed and tested on a substantial scale covering a wide range of land use zoning strategies.

Thus, the most important remaining questions related to further scaling up and management of efforts at much wider levels, center on who would do it, and how could such efforts be supported. In this regard, three developments that emerged during this project are particularly encouraging:

- Pilot provincial spatial information management and decision support systems for Chiang Mai, Lamphun and Chiang Rai provinces developed by Dr. Methi Ekasingh and colleagues at Chiang Mai University are very promising for providing a common framework for spatial data use and management at multiple levels within provinces. The user-friendly system already includes most important baseline data, and is designed in a manner that facilitates addition of more data layers and analytical modules. Local land use zoning could become part of this system.
- Efforts by the Chiang Mai Association of TAOs have resulted in approval of sections within TAOs throughout the province – regardless of their capacity classification status – that have clear mandates to work with natural resource and environmental issues and activities. This provides TAOs with mandates to build their previously constrained capacity and activities related to natural resource management.
- Emergence of efforts to build a multi-level management organization for the Ping River Basin is bringing another new dimension to potential interests and institutional mechanisms that could play a key role in integrating, supporting and further expanding this type of activity.

2. Can GIS and remote sensing tools help provide sufficient transparency and accountability to expect that national policy makers and the general public could accept official recognition of land use agreements based on local plans?

This project has demonstrated that local land use zoning can be translated into digital spatial database format, and that overlaying village boundaries and zones on a time series of aerial photos can reveal much detail about land use change. We have also begun overlaying local village and land use zoning unit boundaries on land cover data interpreted from satellite imagery and found that there is very strong potential for using satellite data for monitoring compliance with actual zoning plans. We have also articulated six requirements for applying these tools in a manner that would provide transparency and accountability in the monitoring system, as well as in the process of determining compliance with land use zoning plans. It is clearly feasible to meet these requirements if there is sufficient will and resources to do so. Given the levels of resources being allocated by society to various programs and activities, it is clear that sufficient resources could be made available.

The question of whether there is sufficient will, however, is considerably more complex. In order to help clarify some of the key factors involved, we first need to address the following 'sub-questions':

- *Will local institutions be willing and able to administer and enforce land use zoning plans with credibility, transparency and accountability?* One of the major overall lines of argument used by skeptics of local community-based land use zoning is that even if initial zoning plans appear acceptable by all major stakeholders, local institutions will not be able to maintain zones over time. Moreover, many believe local influential people may have hidden agendas to use zoning to gain access to areas they can subsequently exploit for their purposes and benefits. These concerns are overlaid on a history of efforts under land reform, STK certificate and forest village programs to provide land use certificates conditional on how the land is subsequently used; abuses are considered to have been rampant, and conditions generally proved to be unenforceable.

  These are the types of concerns and lines of argument that can be most directly addressed by the tools tested under this project. Bringing agreed boundaries into a spatial information system that can use remote sensing to monitor compliance using mutually acceptable indicators, and making results available in a timely manner to the full range of stakeholders, could effectively address these types of concerns.

- *Will higher level legal and institutional mechanisms emerge that would be capable of recognizing the plans?* Despite the large amounts of local thought and effort that have been put into land use zoning, in this and various previous projects, there is still no legal means for official recognition. Still pending community forestry legislation is seen as an important means for providing a framework for such recognition, but debate over important technical aspects have prevented its final passage despite a more than decade-long formulation process. The "land reform" process is seen as another alternative, but its provisions are limited to recognition of fixed agricultural field ownership by individual households. It is not clear the degree to which failure to identify means for recognizing community land use zoning is due to the inability to make a decision on how it should be done, or the degree to which it is a reflection of the simple insincerity of people who don't want to be accused of opposing it, but are unwilling to support it. After being simply ignored during initial stages of administrative development of the modern Thai nation state, mountain ethnic minority communities have increasingly been portrayed as recent migrants who are encroaching on forest lands. Moreover, their relatively extensive land use claims are seen as excessive compared to the smaller paddy-centered holdings of lowland ethnic Thai communities, and recently emerging lines of argument say any recognition beyond small permanent fields comparable to lowlanders would be inequitable and socially unacceptable.

  Thus, there are still serious legal and institutional issues that need to be resolved in the public policy arena through political and legislative means before official recognition of local land use zoning can be achieved. Information provided by analyses and tools employed under this project could help provide concerned interests with better information about the nature and implications of types of local land use zoning mountain communities currently have in mind. While the ultimate impact of such information, however, will depend on who is willing to listen, efforts could definitely be made to package and present such information in ways that could reach the widest possible range of stakeholders.

- *Will appropriate levels of governance be able to articulate clear objectives for constraints on land use, such as maintenance of watershed services, biodiversity, etc.?* While government policies during the last 50 years have been consistent in asserting state ownership of mountain 'forest lands' and denying recognition of any local rights regarding land use in mountain area landscapes, rationales for imposing severe constraints on land use in mountain areas have shifted. Although opium production networks were developed in association with official monopolies, opium was later outlawed and growers became seen as criminals. Initial state claims to mountain area forests were based on tree species valuable in emerging international trade with Europe, but then gradually evolved into claims to the land. In Mae Chaem, early teak logging concessions evolved into reserved forest land covering all but lowland ethnic Thai paddy areas near the district town. Rapid expansion of forest reserves during the 1960's related to visions of massive timber production through use of 'modern' forestry management in unpopulated natural forest concession areas and increasingly intensive even-aged monoculture plantations. With emergence of national parks and wildlife sanctuaries in the 1960's, forest land management began growing into a struggle within agencies and among interests, focused on competition between claims based on conservation or timber production. Expansion of forestry agencies into watershed protection during the 1970's brought new objectives and justifications for limiting mountain land use, which during the 1980's were translated into watershed zoning maps that placed most land in Mae Chaem into categories with highly restricted land use.

After all logging concessions in national forest lands were revoked, during the early 1990's conservation factions pushed for combining national parks, wildlife sanctuaries and class 1 watershed lands into a national 'protected area system', and for expansion of this system to cover all remaining natural forest areas in the country. The preliminary declaration of new national parks covering substantial parts of Mae Chaem is part of efforts to implement this approach. As the 'protected area system' approach became institutionalized in the structure of the new Ministry of Natural Resources and Environment, management objectives became more blurred across the various components of the 'system'. All are being justified by an unspecified mix of perceived needs for biodiversity conservation, watershed services, recreation, carbon stocks, etc., along with assertions that only undisturbed mature natural forest can best provide these services. These increasingly vague objectives for specific areas have made it even more difficult to assess the degree to which any alternative land use approaches or modifications may be compatible with management objectives. Thus, maintaining ambiguity helps strong rhetorical arguments prevail without being subjected to empirical cross-checks, and decreases likelihoods that local land use zoning plans can become 'acceptable' in the public policy arena.

- *Is it more likely that official recognition could only be made available for specific types of land use approaches and zoning strategies?* It may well prove to be the case that official recognition could be available for only some types of the local land use zoning strategies we have studied:
    - Forest fallow systems. These are the most contentious types of systems, and the biggest issue related to their recognition is whether it is possible for them to ever gain any degree of legitimacy. Forestry and agriculture administrative, academic and extension agencies have consistently denied their legitimacy for more than a century, despite landmark international research on their nature and dynamics during the 1960's and 70's that was summarized in *Farmers in the Forest* and other literature. National systems throughout the region, as well as international agriculture and forestry organizations, have been unable or unwilling to accept these systems as anything other than primitive pre-modern subsistence systems for supporting remote low density populations. Foresters admit (informally) that it is not a coincidence that new national parks are being declared in areas where these systems remain.

      Some important elements of factions opposing official recognition of forest fallow systems do so because of their fears that recognition would soon result in large areas of forest fallows being converted to intensive upland crop cultivation using sprinkler irrigation and heavy applications of pesticide. The "pulse" of upland crop expansion observed in 1996 land use data was followed by a reaction from outside public policy forces, which induced a 'response" that reversed changes in some areas and strengthened other portions of local land use management domains. While this type of feedback is instructive, and in many ways promising, it also emphasizes the importance that changes in economic opportunity can have, and raises questions about how effectively community land use zoning plans will be able to function in the face of future economic change that might make intensive cash crops as attractive, or even more attractive than they were in the period just prior to 1996.
    - Midland permanent field systems. These types of systems are probably the most likely candidates for being able to obtain some sort of official recognition. Proponents would,

however, likely be required to provide evidence that the systems are likely to be viable and sustainable. While systems that include upland rice may appear to be the ones least likely to be able to retain their economic viability, some are already making the transition to cash crop-centered systems where reasonably reliable and more profitable alternative cash crops are available. Such a transition would require no change in land use zoning plans, since this degree of flexibility would be inherent in upland field zones. Thus, arguments for recognition appear to be fairly strong and acceptable, but legal mechanisms are thus far limited to recognition of household-level claims to agricultural field components of local land use zones.

- Highland permanent field systems. While most of the arguments pertaining to midland permanent fields would also appear to be applicable in the highlands, at least two issues make this situation more difficult: (a) hill evergreen forest is the native vegetation in most highland areas, and this is the forest type most highly valued by conservationists; (b) there is considerable fear (that often takes on ethic overtones) among many lowlanders about the environmental impacts and expansionist intentions of highland communities involved in intensive commercial agriculture. Thus, one can expect some opposition from lowlanders, as well as disputes about the size of recognized land holdings that could be allowed.

Regardless of how issues related to particular systems are resolved, if any resulting recognition involves conditionalities related to how the land is used, the tools tested under this project could be used for monitoring compliance to assure transparency and accountability.

3. Are local communities willing and able to conduct effective monitoring of watershed and other environmental services? If so, can they be scaled up into broader monitoring networks?

We believe the project has demonstrated quite clearly that members of local communities are very capable of using simple science-based tools to monitor watershed functions that can indicate both the quality and quantity of watershed services flowing from the landscapes that they manage. We also see reasons to believe that more types of indicators could be developed that build on and integrate both scientific and local knowledge. Moreover, these monitoring activities can be directly linked with local watershed management networks, which in turn could be coordinated through federation of local networks that could conduct larger scale syntheses and assessments.

The effective establishment and management of regular monitoring, as well as the quality and completeness of data records that are generated, are dependent on sufficient motivation and support. Motivation for participating in monitoring activities appears to be directly related to the level of awareness and tension in the area, at least up to a threshold of tension and conflict beyond which different factions have set their positions, geared up to do battle to advance those positions, and are no longer willing to listen to information that will do anything less than provide complete support for their positions. Thus, effective use of monitoring data in managing tensions and conflict related to the factors being monitored also depends on sufficiently receptive attitudes – within and among local communities, as well as among relevant government officials and environmental and business interests. One can expect a reasonable degree of variation among areas based on different levels of tension and conflict, but it also appears possible to promote awareness and interest in monitoring in areas where tensions are not yet high. In any event, there are clearly opportunity costs associated with collecting, maintaining and using reasonably complete and high quality monitoring data, so that those who engage in this work deserve to receive a suitable level of compensation from the various stakeholders who benefit from their work.

Given the multiple levels at which this information could be useful, more systematic considerations may be necessary to identify the most appropriate funding and management mechanisms. The project already began exploring potential roles for TAO in at least providing some of the institutional infrastructure required to make any such mechanism operational and reasonably durable. The multiple levels of organization associated with the Ping river basin initiative would appear to be the most likely candidate for making complementary links among watershed networks and management operations.

Where there is potential for multi-level acceptance of monitoring measurements, it would appear that a mixed system consisting of a few well-located stations with sensors and data loggers, combined with a much larger number of strategically-located points monitored by community members using simple tools to measure key indicators, would be ideal. Such a system could provide sufficiently wide and high-resolution coverage, complete with confidence-assuring cross-checks, at a reasonably low cost. Moreover, such a system could provide widely acceptable and comparable data, while at the same time helping build awareness and support collective action that could help assure more sustainable and equitable management of natural resources and the environment over time.

4. Are analyses and analytical models likely to be useful in helping both local and higher level resource managers interpret and utilize spatial information system technology in their decision making processes? If so, what types of models show the most promise?

We believe the project has also demonstrated how analyses of data from local community land use zoning, from aerial photos and satellite imagery, from monitoring by agencies, researchers and local communities, and from compiled sources of scientific knowledge can be brought to bear in better informing social decision making process at various levels. Such analyses have also helped identify gaps in our current knowledge, as well as areas where unsubstantiated assertions are widely accepted without questioning. In our collaboration with local actors, groups and institutions in Mae Chaem, we have also received widespread positive response to analytical findings. Indeed, we have been strongly encouraged to help villagers, local leaders, and local officials to use simple tools and approaches to help them collect, process and analyze information themselves, and to be able to interpret and present the results in a manner that can effectively assist with understanding, negotiation, and decision making processes. They are also eager for assistance from outside technical specialists, but they clearly want to be as directly involved as possible, so that they can clearly understand, make their input, and play an active role, rather that to be the passive recipient of orders from outside experts who are expected to always know best because they are called experts. In short, we believe there is a lot of opportunity for such approaches, but that the current demand is already much greater than the available supply.

Our modeling work has demonstrated the divergences between requirements for managing biodiversity services and watershed services in upper tributary landscapes. This helps point out the importance of clarifying natural resource management policy objectives for specific areas in order to accurately identify impacts, trade-offs and complementarities of existing local land use strategies and potential modifications to them, to facilitate negotiation of land use and zoning agreements that are acceptable to the range of key stakeholders, and to establish widely acceptable criteria for monitoring impacts and compliance with agreements.

We have also shown that there are scale differences in various types and components of watershed services that have close parallels to emerging levels of watershed management networks and organizations. Such findings indicate that modeling may be able to help identify responsibilities at various levels of management and governance that can be closely matched with particular types of resource management issues and problems most appropriate and amenable to resolution at that level. Modeling may also be able to provide some useful tools to help facilitate achievement of their goals.

Moreover, modeling has helped identify several popular myths about land use impacts on watershed services that do not stand up under systematic analytical scrutiny. While some interest groups may choose to ignore or reinforce such myths when they work to the advantage of their interests, they risk exposure that could undermine their credibility in the longer term. Perpetuation of such myths is often dependent on limited access to information, whereas the types of modeling approaches pursued under this project place major emphasis on opening and expanding access to information.

Various well-defined, user-friendly modular models that can assist management decision-making is one area that appears particularly promising, especially in the context of the emerging pilot provincial spatial information and decision support systems that could provide both an operational framework and access to a common input database. The system already includes several such modules, and is designed to be open for additional modules that can help meet specialized needs.

More complex simulation models require a higher level of expertise for operation and maintenance than is likely to be available in most local areas in the near future. Thus, higher level institutional homes need to be found for such operations. Particularly promising directions at this level include simulations of complex processes that can help promote more widespread common understanding by helping simplify and visualize important components, mechanisms and processes. Availability of and access to such tools could significantly help improve debate, negotiation, and decision making processes at multiple levels.

There also appears to be considerable promise for companion modeling to help systematically identify and estimate impacts of alternative policies and decisions on different resources and components of society at different scales and over time. This can assist proponents of one alternative or another to more fully think through the implications of their position and assure that the likely impacts are consistent with their intentions. It can also help identify trade-offs that are virtually inevitable when different interests in society compete over how society could best utilize and conserve its scarce natural resources.

In order for such models to maximize their effectiveness, however, there needs to be strong emphasis on the sources, quality and acceptability of input data; on openness to scrutiny by stakeholders with sufficient knowledge and skill; and on outputs that can be spatially explicit and/or easily visualized by the full range of potential consumers of that information.

5. Can science-based tools be expected to help manage competition and reduce upstream-downstream conflict?

Our efforts to address the previous four questions have already disclosed our view that there are quite considerable potential roles for science-based tools in helping to manage resource competition and reduce upstream-downstream conflict.

Competition, tension and conflict processes and issues occur and must be managed at multiple levels. These multiple levels also relate to scale issues associated with biophysical processes, as well as to subsidiarity issues associated with forms of governance and social decision-making processes. We believe we have demonstrated through activities conducted under this project that science-based tools can provide valuable information, insight and understanding that can be used to assist in operating and matching both biophysical and social decision-making components of the management processes at these various levels. As application of the science-based tools we have tested needs an institutional home if they are to become a more integral part of management processes, interests in, needs for and capacities to utilize science-based tools also need to be assessed and acted upon at multiple levels.

People draw on different traditions, beliefs, experience, knowledge, needs, interests, opinions, desires and expectations in establishing the views that underlie their positions and roles in resource competition and conflict. Thus, one of the first major challenges is to establish effective communication, followed by a clear understanding of the differences in positions others are taking. We understand that science is not the only repository of human knowledge, and that scientific methods are not the only means through which significant contributions of knowledge can be made. We do believe, however, that carefully selected and applied science-based tools have very strong potential for helping to build a common vocabulary and framework for comparisons and cross-checks that can help facilitate communication among divergent interests, to build mutual understanding and transparency, to clarify both points of common interest and points of contention, to identify trade-offs that must inevitably be resolved through the social and political processes that society deems acceptable, and to help build and maintain trust by assuring accountability and compliance with negotiated agreements.

In order for science-based tools to be effective in helping achieve these goals, there needs to be an environment of sincerity, openness, and common desire to reduce or avoid strong to violent conflict. Tools cannot be effective if there is no interest in their outcome. In such situations, confrontation, conflict and one form of social warfare or another are inevitable, and presumably to the victor will belong the spoils, or at least until the next battle.

Moreover, we believe the project has demonstrated that science-based tools provide means for strengthening capacities for more effectively dealing with complexity, which can help natural resource policy makers and managers be able to accept and effectively deal with ecological, cultural, social and economic diversity. The actual utility of such tools, however, will depend on society's interest in and willingness to accept such diversity, as well as how it views relationships between particular forms of diversity and broader social equity. Various sections of this report document the basis for our belief that these rather abstract notions have quite concrete manifestations in the context of upper tributary watersheds

Overall, it appears that there is clearly much scope for further efforts by many actors in natural resource policy, governance and management processes to improve the strength of their analyses, the transparency and clarity of their logic and conclusions, and their ability to communicate and negotiate with other stakeholders, at least some of whom are likely to have quite different ideas. In a context with sufficient will, openness and sincerity, we believe the types of tools we have tested under this project have strong potential to help manage competition and reduce upstream-downstream conflict through applications that help address these types of issues.

VII. Future Directions and Further Challenges

<<< Under Construction >>>