Developing Science-Based Tools for Participatory Watershed Management in Montane Mainland Southeast Asia

Final Report to the Rockefeller Foundation

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TRANSFORMING LIVES AND LANDSCAPES

International Centre for Research on Agroforestry (ICRAF)

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Acknowledgements

Research under this grant from the Rockefeller Foundation was conducted by the World Agroforestry Centre (ICRAF) working in close partnership with colleagues in Thailand. It resulted in major advances in innovations applying science-based tools to help strengthen multi-level efforts aimed at improving management of agroforestry landscapes in mountainous watersheds of northern Thailand. It also provides clear and informative examples of the emerging concept of landscape agroforestry, and why it is especially important in contexts such as upper tributary watersheds of the montane mainland Southeast Asia eco-region.

These accomplishments could not have been achieved without sincere and diligent efforts by a highly motivated and dedicated research team able to build effective bridges across several types of disciplinary and institutional boundaries, and push forward the frontiers of collaboration with local institutions and initiatives:

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I. Introduction and Background

Support was requested from the Rockefeller Foundation under this grant for collaborative efforts to further develop key science-based tools that can help improve local participatory watershed management and facilitate its integration into higher-level natural resource management policies and programs. Activities conducted under this project have built on ongoing partnerships and activities, and their previous achievements to take the next steps in pushing forward our knowledge and experience in three closely interrelated priority areas:

1) Building a pilot spatial information network 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 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 1.

Pilot Spatial Information Network
For Participatory Watershed Management

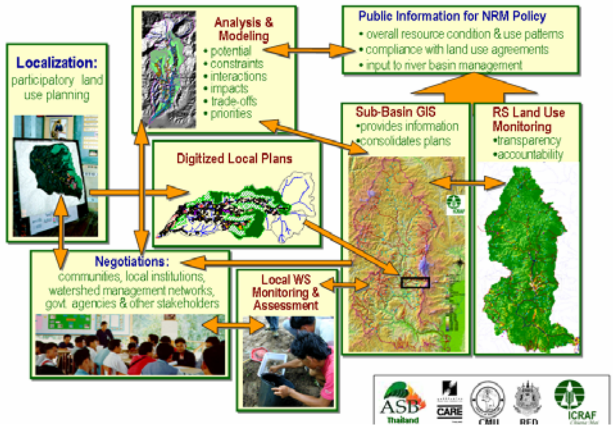


Figure 1 indicates how activities in each of these areas relate to each other and interact in the context of the overall pilot spatial information network that provides the framework for these collaborative efforts. Details on the activities conducted in each area are provided in following sections.

The framework within which these activities have been developed and conducted places heavy emphasis on participation and collaboration at all major levels of implementation. Characteristics of major partner institutions helps assure that implementation activities actually incorporate this emphasis:

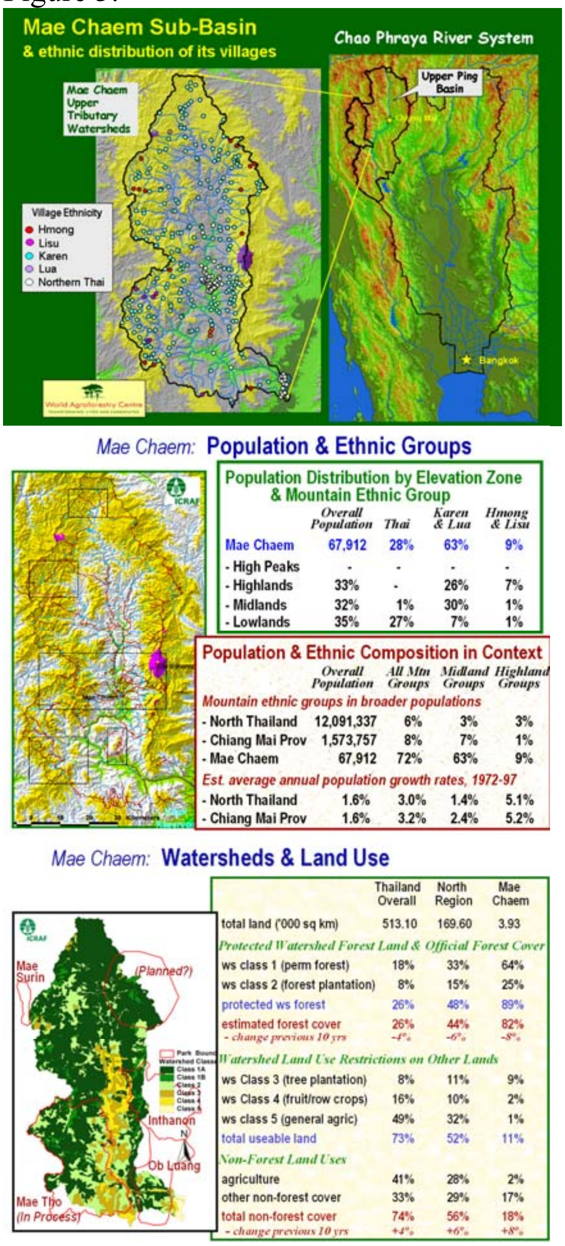
- Care-Thailand / Raks Thai Foundation is a substantial, experienced Thai NGO recognized at local to national and international levels of the NGO community and the general public for its standards and responsibility in efforts to strengthen community-based approaches to development.
- The Queen Sirikit Forest Development Project (*Suan Pah Sirikit*), conducted under the direct patronage of H.M. the Queen, is based on principles that include strong participation by local communities, and the project's highly regarded senior staff were very early proponents of more participatory approaches to development and forest management.
- Collaboration with colleagues in forestry agencies was led by Dr. Pornchai Preechapanya and Dr. Chaweewan Hutacharoen, both of whom are widely recognized as outstanding researchers who seek advancement of knowledge rather than simply confirmation of accepted beliefs.
- Our major university research partners also have well established and widely recognized reputations for the quality and creativity of their research, as well as for their efforts to seek genuine collaboration with local communities.

- Our own staff have been carefully selected to include people whose basic values and instincts would not allow them to drift away from these principles.

Figure 2

This research builds on and further extends earlier research conducted in collaboration with the global CGIAR system-wide initiative known as the Alternatives to Slash-and-burn (ASB) Programme. At the more regional level, we are also seeking to build on the experience of early networks, such as the Southeast Asian Universities Agroecosystems Network (SUAN), as well as more recent sets of linkages emerging among institutions in the region, including the ICRAF-supported Southeast Asia Network for Agroforestry Education (SEANAFE) and our own growing professional relationships in Laos, Vietnam and Yunnan, China, in identifying ways in which we can build on our work in Thailand in helping to strengthen key elements of the scientific infrastructure in the region. These efforts have also been linked with activities under the World Resource Institute's Regional Environmental Policy Support Initiative (REPSI), whose operations in the region have been based in the ICRAF Chiang Mai Office. Together with the SE Asia Regional Office in Bogor and colleagues based in Kunming and the Philippines, ICRAF Chiang Mai plays an important role in developing, strengthening and supporting this web of collaborative partnerships seeking to address major land use issues in the Montane Mainland Southeast Asia (MMSEA) eco-region (Figure 2).

Figure 3.



Study Area

Pilot studies conducted under this grant were located in the nearly 4,000 square kilometer Mae Chaem watershed in northern Thailand's Chiang Mai Province, which also serves as the primary benchmark research site for mainland Southeast Asia under the ASB programme. As indicated in Figure 3, Mae Chaem is a major sub-basin of the Upper Ping River Basin. The Ping Basin is the largest tributary of the Chao Phraya River system that feeds the famous irrigated agricultural production systems of Thailand's central plains region, as well as the Bangkok metropolis with is commerce, industry and 10 million inhabitants.

The biophysical, socio-economic and land use characteristics of Mae Chaem are reasonably representative of conditions commonly found in many upper tributary watersheds in MMSEA:

- About 90 percent of its land area is in midland and highland zones, where more than half of its people live;
- More than half of its population is composed of mountain ethnic minority communities

whose traditional forest fallow agricultural systems have never been legally recognized;

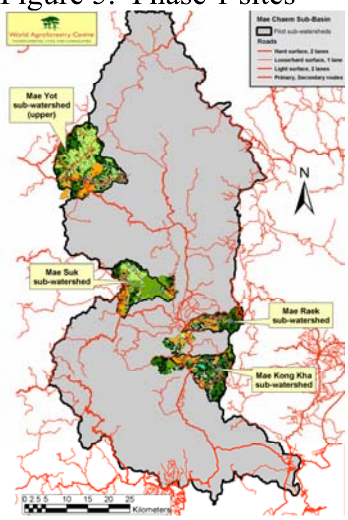
- Former major opium production areas in highland zones have been the target of major opium crop substitution programs;
- About 90 percent of its area is officially classified as reserved forest, national parks and/or protected watershed forest land; and there is no official land tenure in such areas,
- Forest fallow cycles of traditional rotational shifting cultivation systems in midland zones, are believed to be rapidly decreasing, making rice deficits common.
- Overall forest is believed to have decreased during the last decade at rates above national and regional averages,
- Off-farm wage rates are less than US$2 per day, if work can be found.
- Tension has increased as downstream populations blame land use practices in the mountains for floods, droughts, sedimentation of water resource infrastructure, and perceived decline of water quality.
- While some pilot development projects have produced promising results in local areas, substantial skepticism remains among interest groups at various levels of society regarding the viability and effectiveness of scaling up these approaches to cover wider areas with more varied conditions.

These are the intertwined rural poverty and environmental service issues the Royal Thai Government has asked ICRAF and the ASB program to address with its work in Thailand, and dialogues with government colleagues in neighboring MMSEA countries echo their concerns.

Figure 4. Ethnic Groups in Mae Chaem

Within the Mae Chaem sub-basin, implementation of this pilot project was conducted through the progressive scaling up of tests to seek to assure that the scientific tools under development that 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 phases:

Figure 5. Phase 1 sites



Phase 1 Sub-watersheds:.

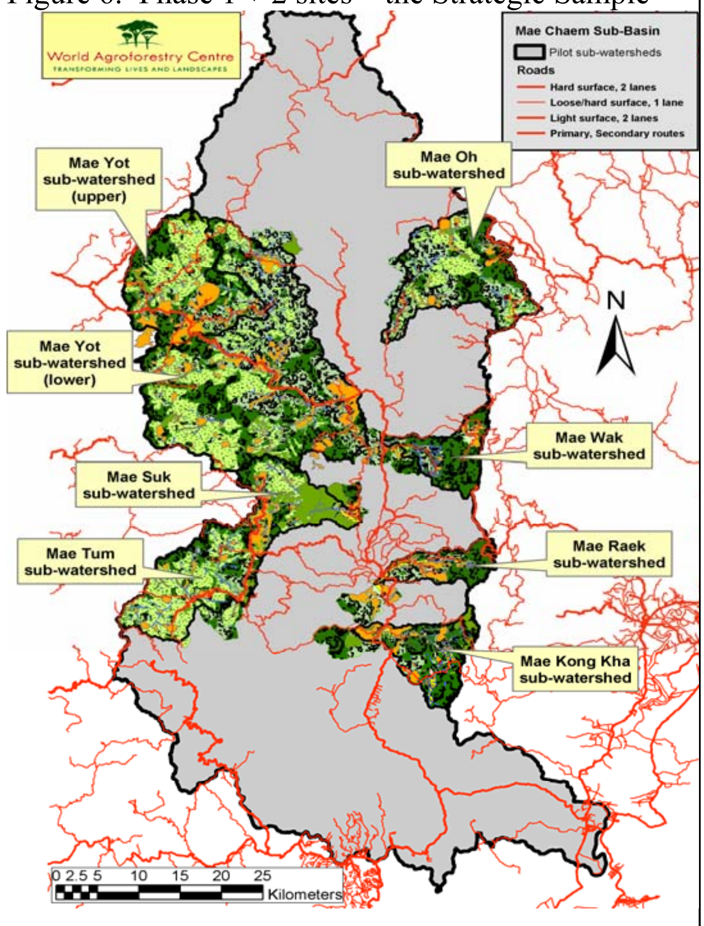
For most components, initial efforts focused on a 4 sub-catchments within the Mae Chaem watershed (Figure 5). Selected in collaboration with research and development partner institutions and projects, this initial set of sub-watersheds included a reasonable range of variation in local conditions found in Mae Chaem:

- **<u>Mae Raek</u>**. 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.
- **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.

Figure 6. Phase 1 + 2 sites – the Strategic Sample



Phase 2 Sub-watersheds:

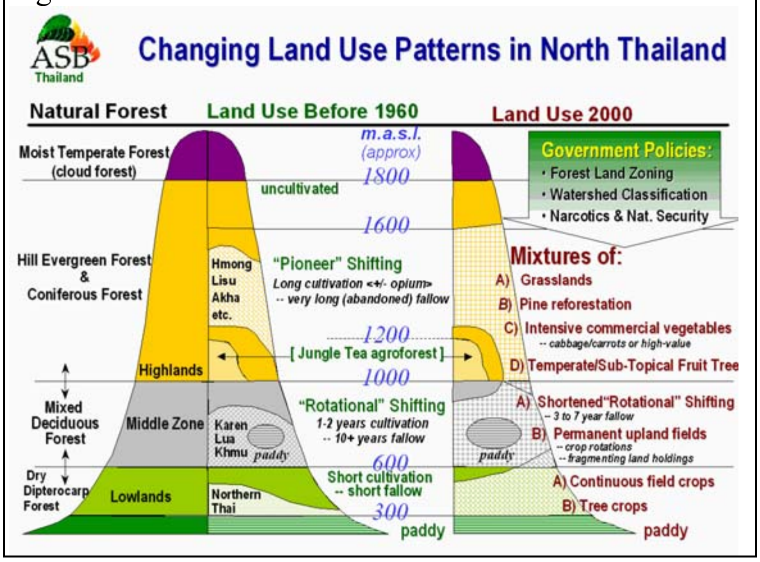
After testing in phase 1 sub-watersheds, we sought to scale up key promising components to what we have referred to as a 'full strategic sample' of Mae Chaem, as depicted spatially in Figure 6. The four additional sub-watersheds include:

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

Figure 7.



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 ICRAF and our colleagues in the Thailand Alternatives to Slash-&-Burn (ASB) consortium in Figure 7. 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.

II. Project Results and Findings

As described in our proposal to the Rockefeller Foundation, the project consisted of three major components: 1) spatial information tools for local land use management networks; 2) tools for community-based watershed monitoring and management networks; 3) analyses and analytical modeling for improved watershed landscape management. The Foundation provided major funding for the first two components of our work with science-base tools, but due to limitations on the availability of funds and its own priorities, the Foundation was unable to provide most of the funds requested for the third component. Accordingly, the vast majority of efforts under this project were directed toward the first two components, as reflected in the content of this report. Progress and findings are summarized in the following sections of this report according to the sets of activities under each of the major project components, as outlined in our proposal.

(1) Spatial Information Tools for Local Land Use Management Networks

The first major project component focused on application of science-based spatial information tools to strengthen participatory watershed management approaches in three key areas: (a) locally-negotiated land use zoning; (b) land use change and accountability; and (c) information for local governance.

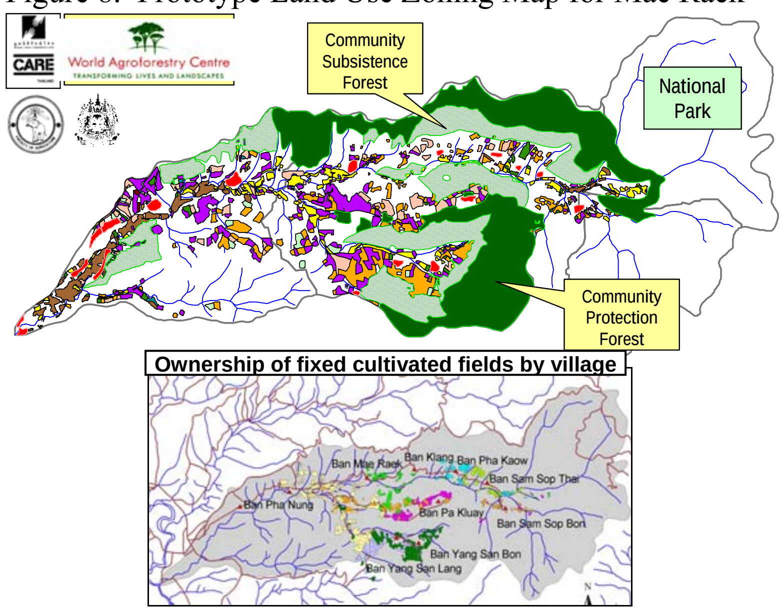
(a) Locally-negotiated land use zoning

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.

Localized Land Use Planning and Zoning

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.

Figure 8. Prototype Land Use Zoning Map for Mae Raek



Evolving approaches to 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 8) 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.

It soon became apparent, however, that given the approach and resource allocations under the new phase of Care-Thailand's project, this approach was 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.

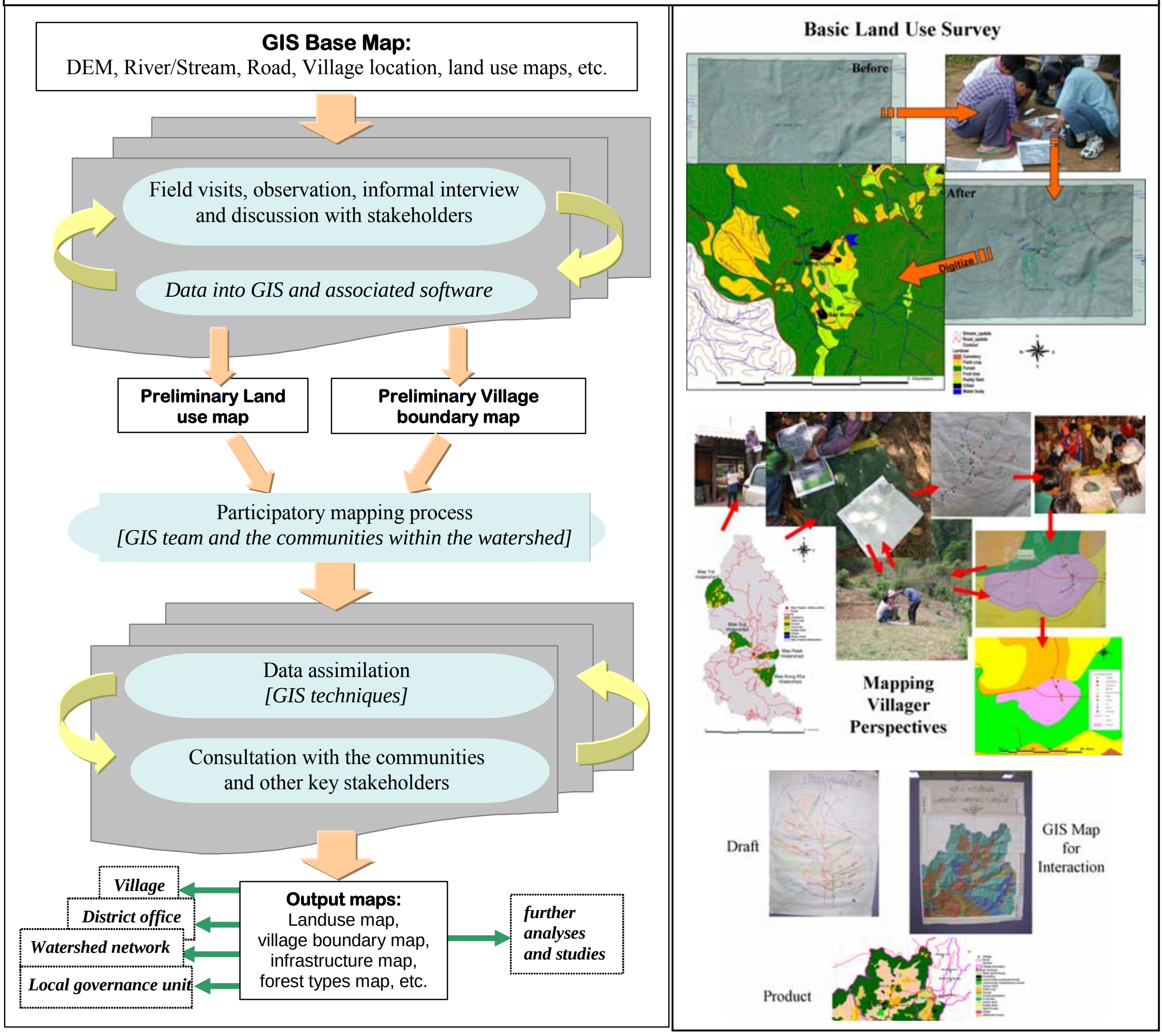
Given the lack of any official land tenure or boundaries of village lands in the vast majority of these areas, as well as the watershed orientation of our project mandate, we also faced the challenge of identifying an appropriate basic unit for mapping local land use domains. After considerable consultation 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 9, beginning with base maps and land use patterns from secondary and fairly recent remote sensing sources, the 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 10 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.

Figure 9. Overview of the Project's Participatory Mapping Process



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 11. 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.

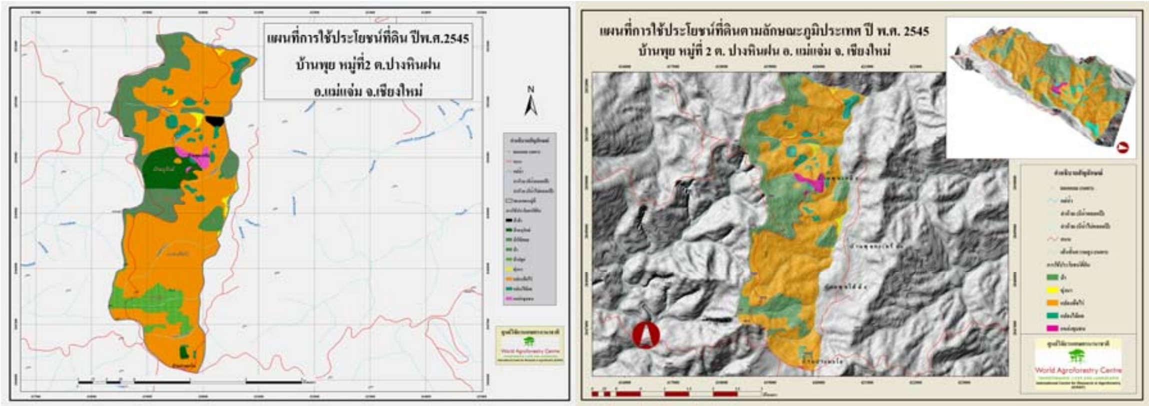
Village land use zones were also aggregated at the sub-watershed level, and maps were produced in a similar format at this scale for use by sub-watershed management networks, local government (TAO) and district officials. An example for the Mae Tum sub-watershed is shown in Figure 12.

Figure 10.

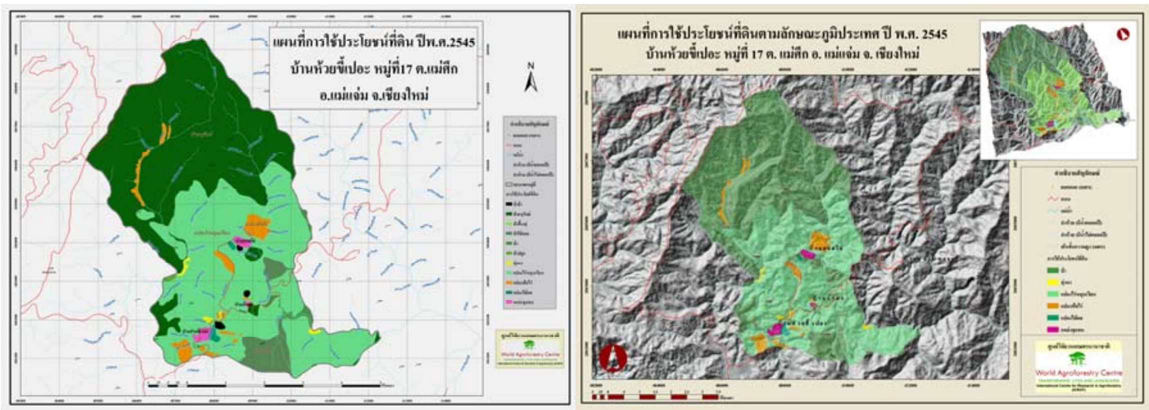
Group, Village & Sub-Watershed Discussions

Figure 11. 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

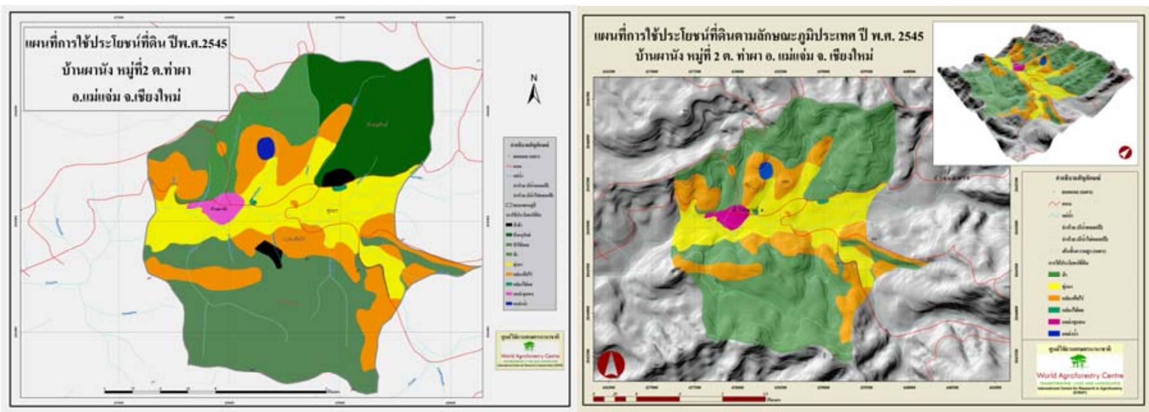
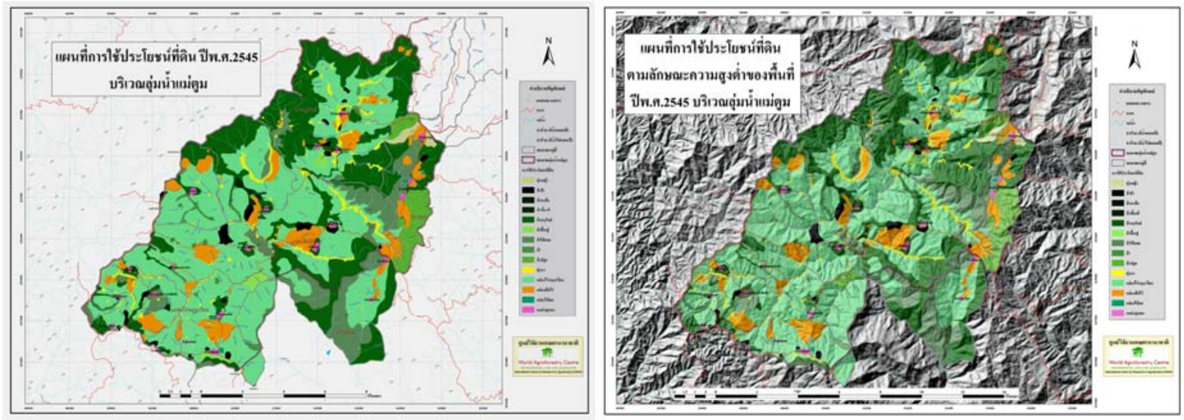


Figure 12. Watershed-Level Land Use Zoning Map for Mae Tum Sub-Watershed



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.[1] 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 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.

Current Land Use Zoning in Pilot Area Sub-waterhes

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] 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.

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 13. 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.

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:

Figure 13. 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

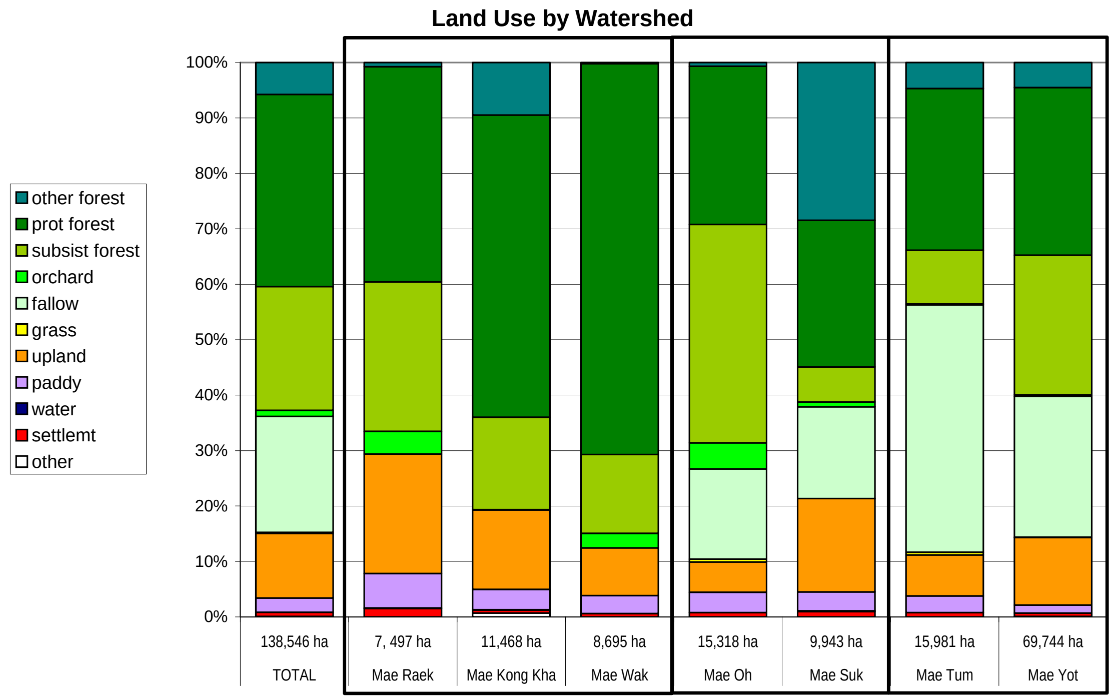
- In order to address major forest land use policy concerns, permanent forest zones are aggregated into three major categories: (1) community protected forest where trees are not harvested; (2) community subsistence use forest where trees may only be harvested for subsistence use with prior permission 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, <u>paddy fields</u> 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) <u>upland fields</u> 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) <u>orchards</u> 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 14 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

Figure 14. 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*

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 14.

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 15 through 21.

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 15 and 16. 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 14, 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

Figure 15a. Spatial Distribution of Aggregate Land Use Zones in Mae Yot

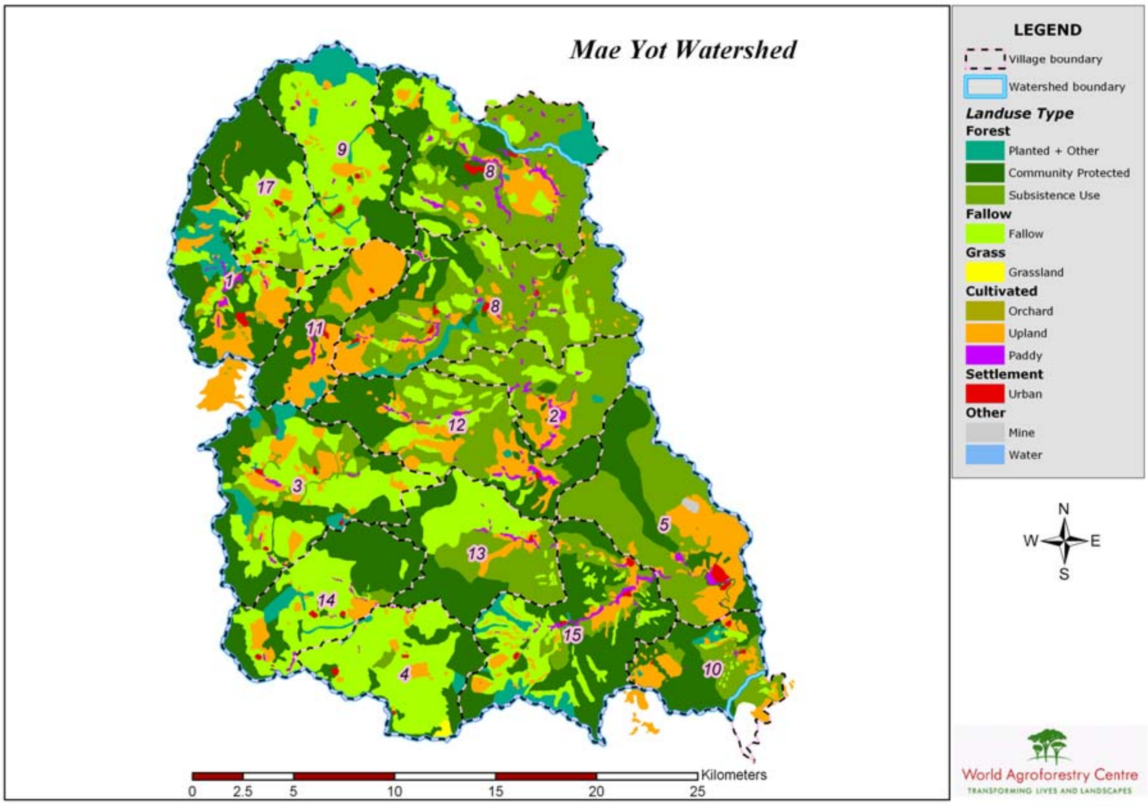
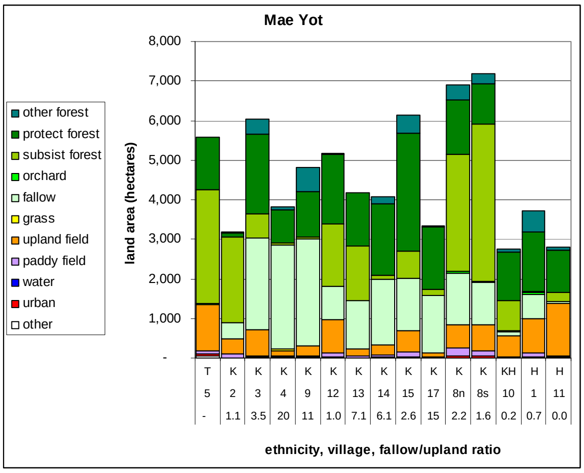


Figure 15b. Mae Yot Distribution by Village and Ethnic Group



	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*

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) <u>Short cycle fallow systems</u>. 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

Figure 16a. Spatial Distribution of Aggregate Land Use Zones in Mae Tum

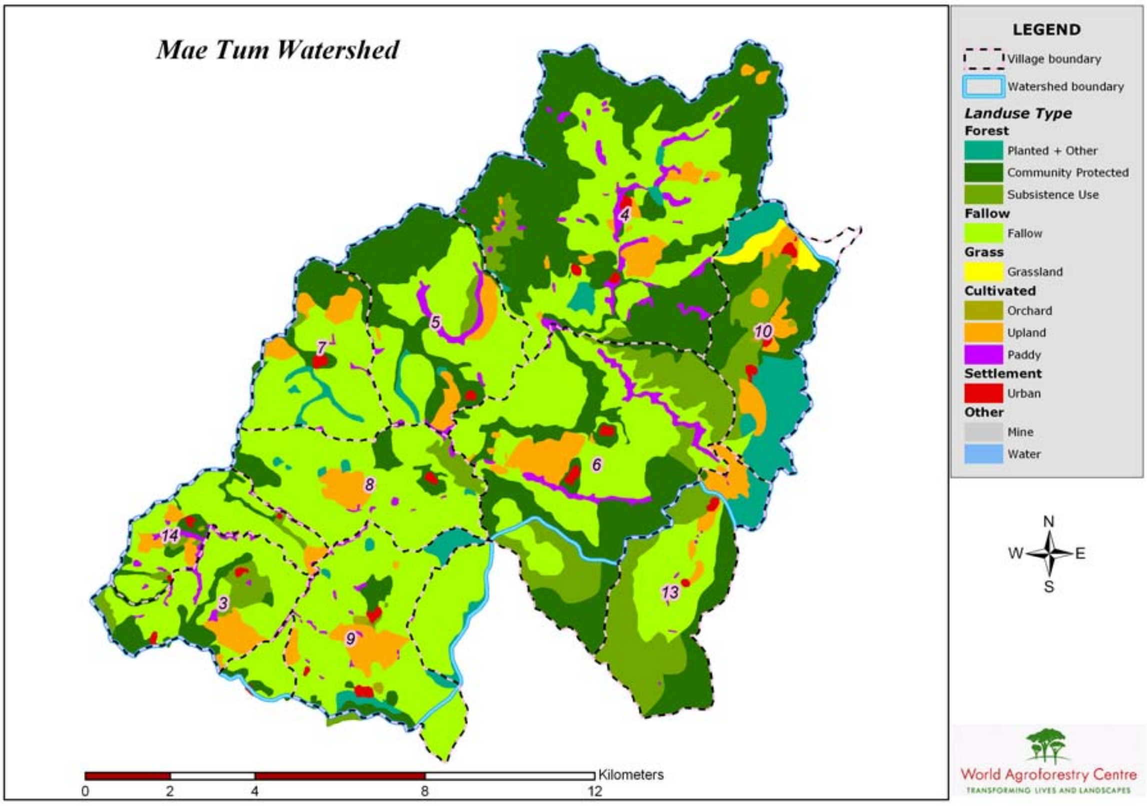
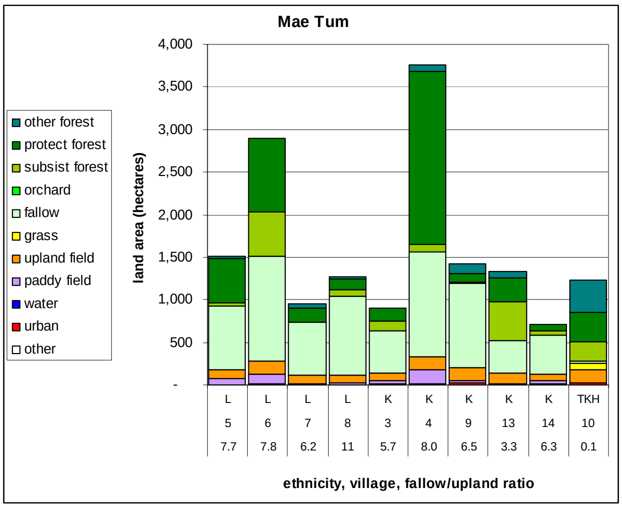


Figure 16b. Mae Tum Distribution by Village and Ethnic Group



	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*

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 14. 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.

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.

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 14 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 17 and 18 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

Figure 17a. Spatial Distribution of Aggregate Land Use Zones in Mae Suk

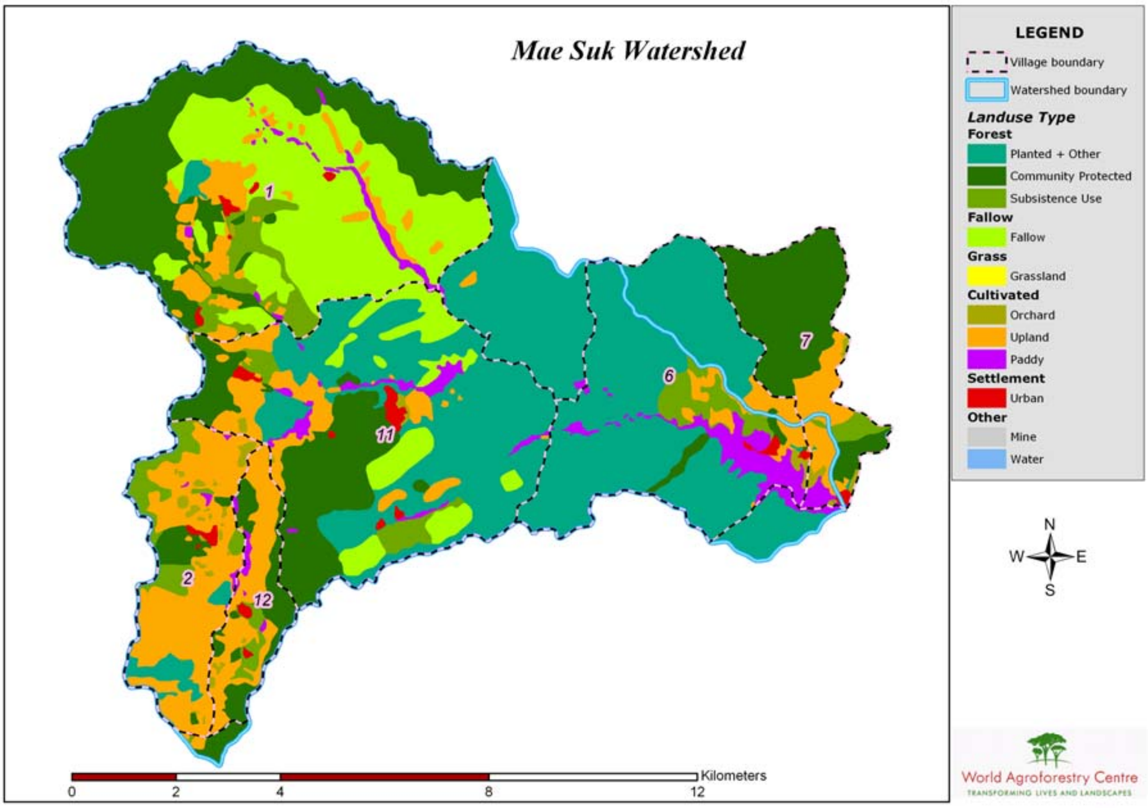
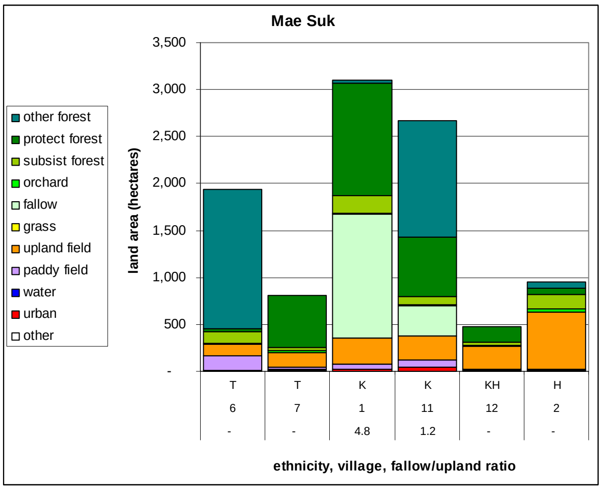


Figure 17b. Mae Suk Distribution by Village and Ethnic Group



	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*	-

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) Short cycle fallow systems. 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

Figure 18a. Spatial Distribution of Aggregate Land Use Zones in Mae Oh

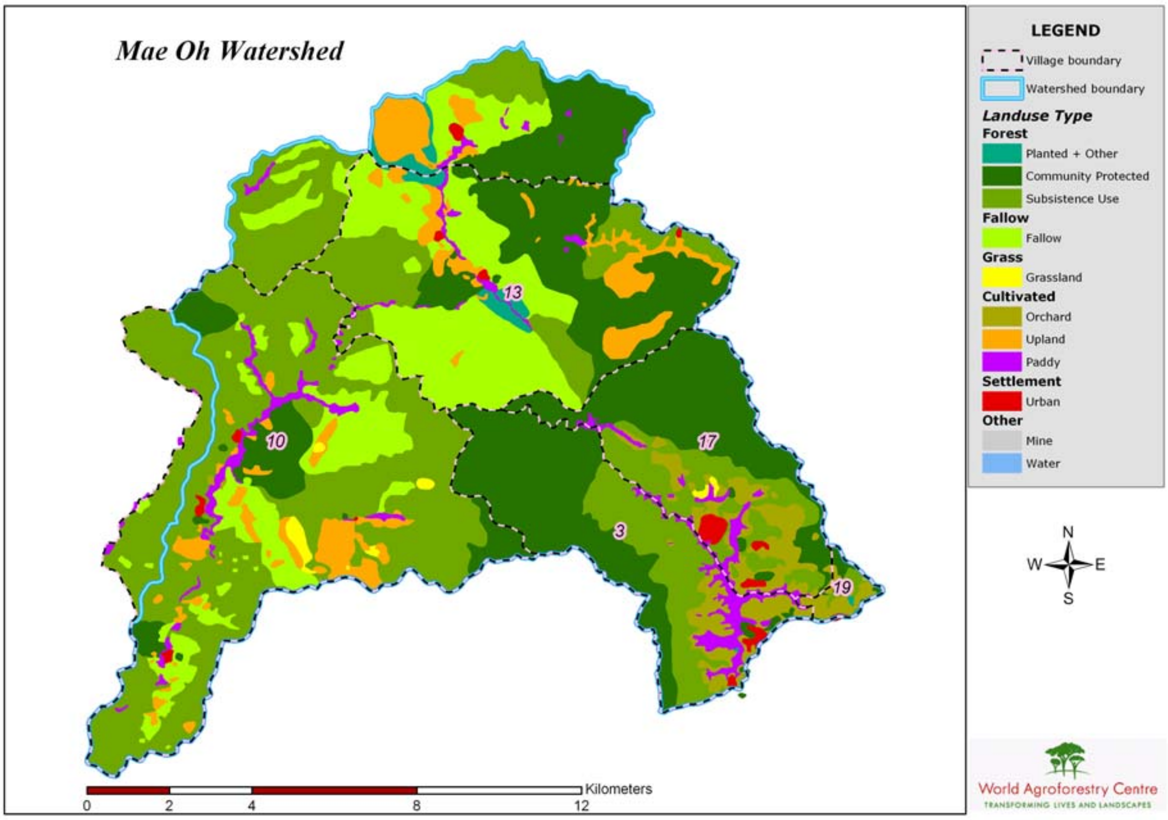
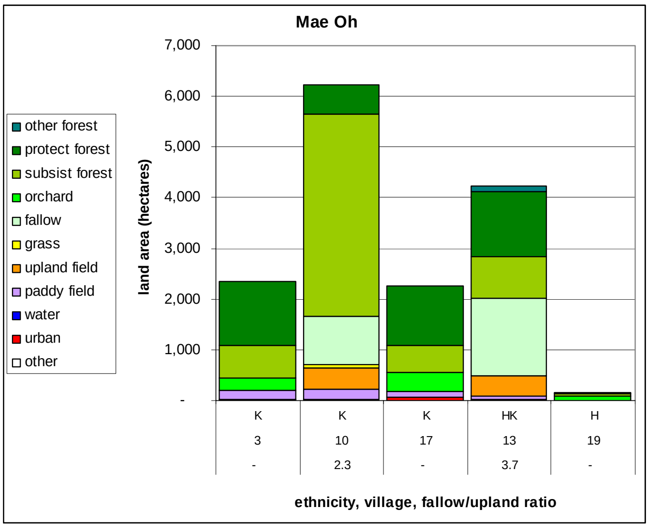


Figure 18b. Mae Oh Distribution by Village and Ethnic Group



	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*

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 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 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 17a. 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 14 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 19, 20 and 21.

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

Figure 19a. Spatial Distribution of Aggregate Land Use Zones in Mae Kong Kha

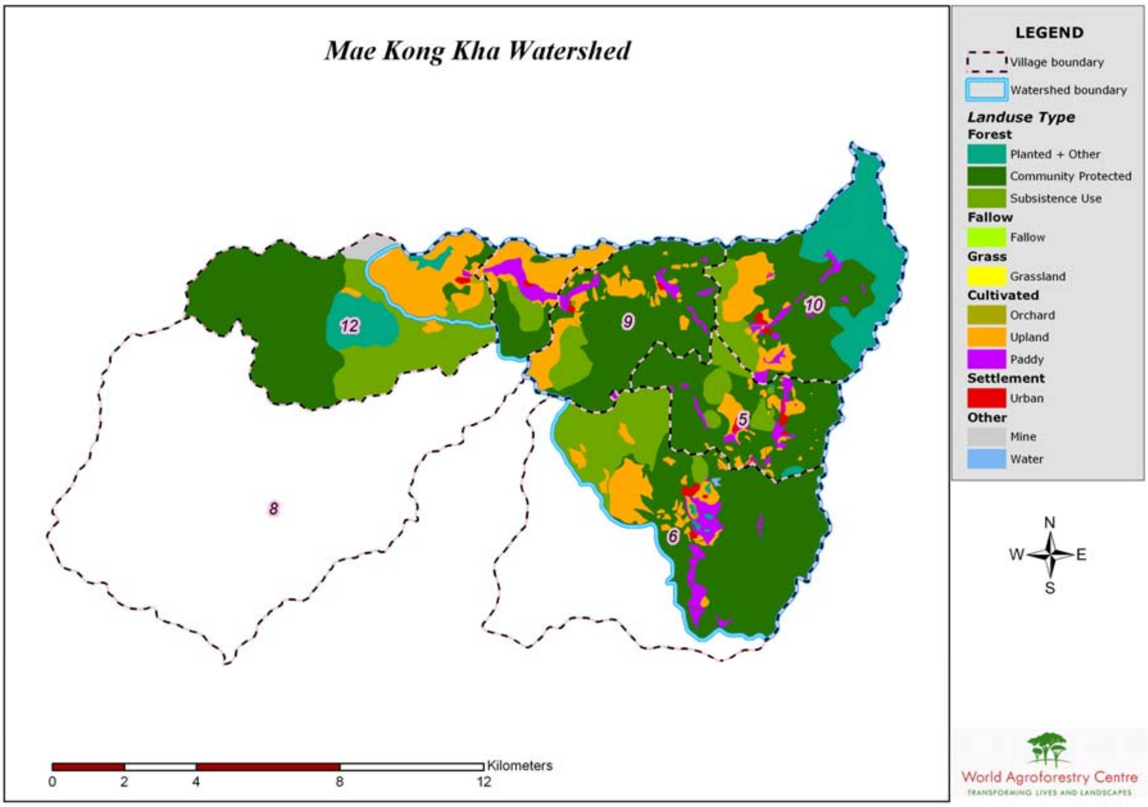
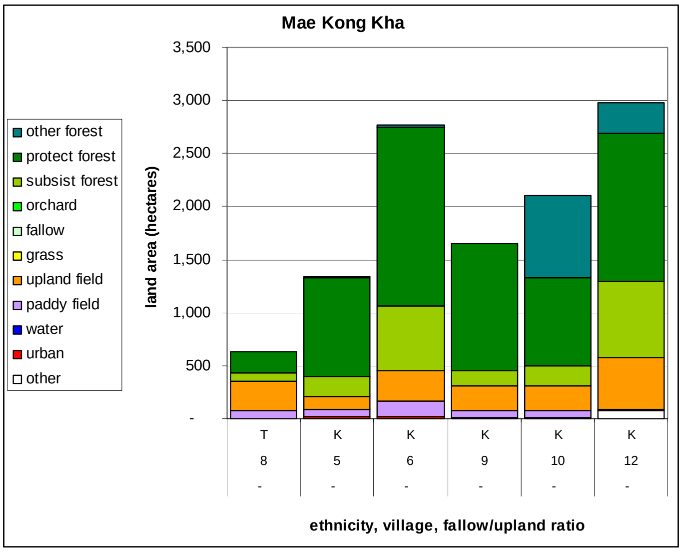


Figure 19b. Mae Kong Kha Distribution by Village and Ethnic Group



	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*

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.

Figure 20a. Spatial Distribution of Aggregate Land Use Zones in Mae Raek

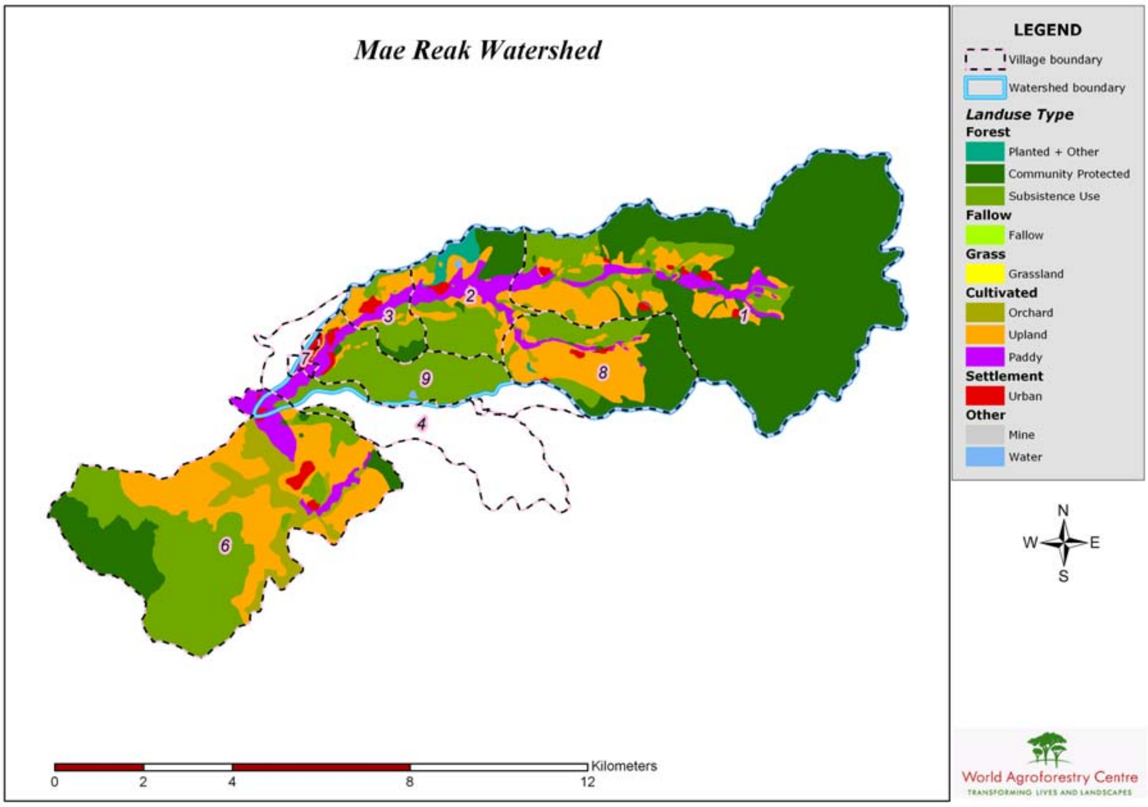
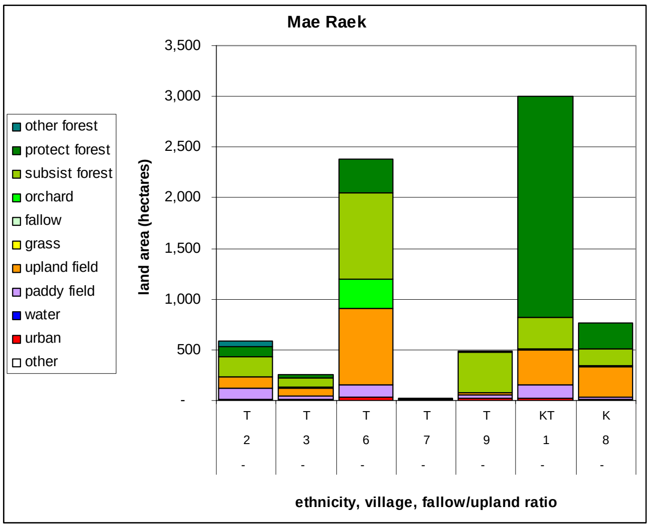


Figure 20b. Mae Raek Distribution by Village and Ethnic Group



	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*	*-*

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.

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

Figure 21a. Spatial Distribution of Aggregate Land Use Zones in Mae Wak

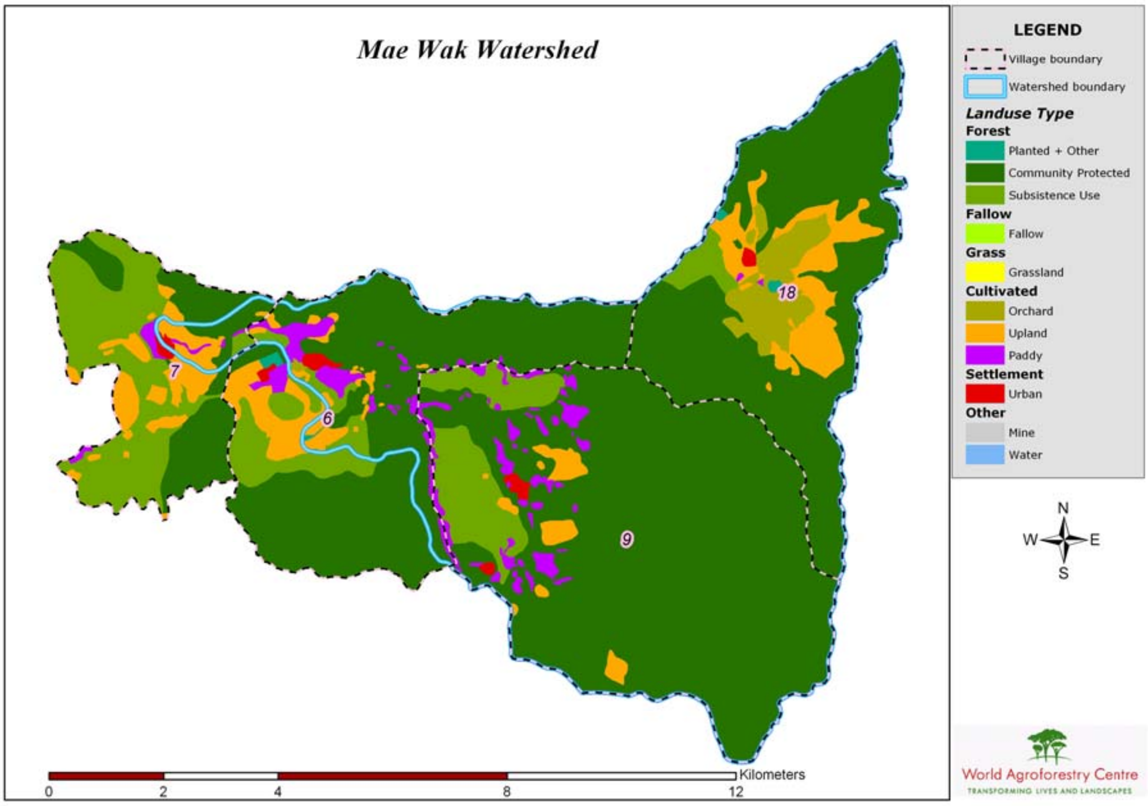
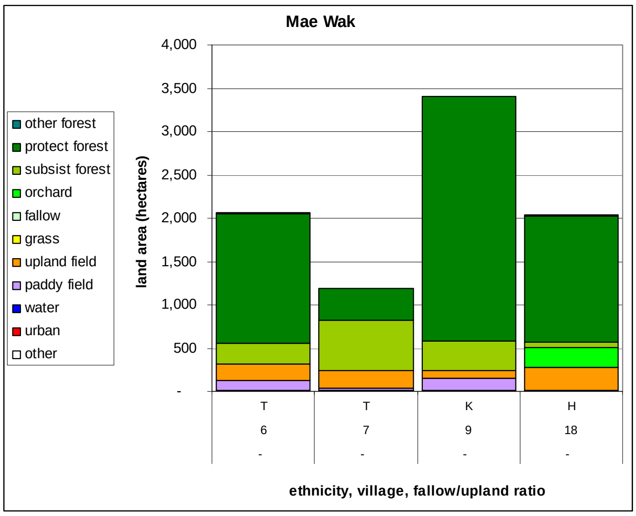


Figure 21b. Mae Wak Distribution by Village and Ethnic Group



	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*

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 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 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.

Cross-Watershed Assessment of Current Land Use Zoning Patterns

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.

Village Land Use Zoning Pattern and Strategies

From these examinations of administrative village land use zones 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 22 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:
    - Long fallow systems 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.
    - Medium fallow systems 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

Figure 22. Overall Land Use Strategies Reflected in Administrative Village Land Use Zoning Maps of the Seven Study Sub-Watersheds

						average land resource use per household									size of examples in sample					sample share		system footprint			
	major village system components				ratio	cultivated land					uncultivated land (ha)				villages practicing system					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	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

- Short fallow systems 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.

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

Variation in Land Use Zoning Patterns 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 23. 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 23. 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					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	TOTAL Land Area (ha)	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

(b) 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.

Assessment Approach and Methods

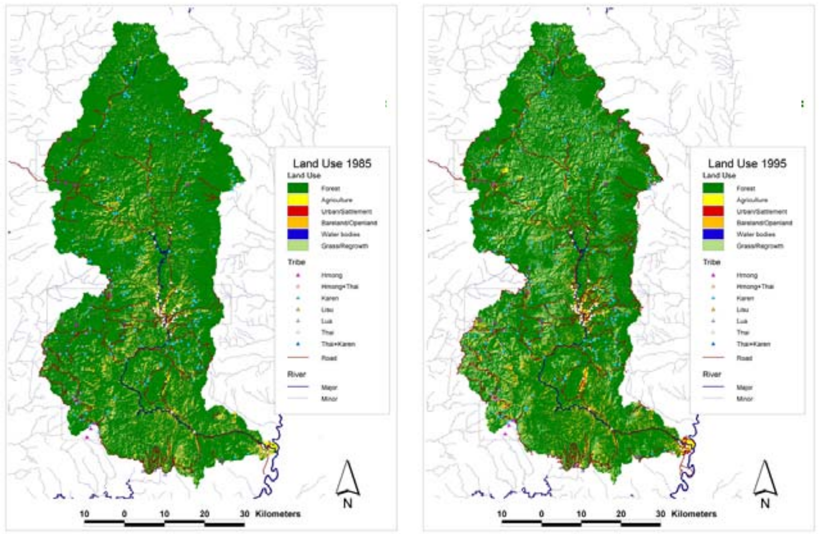
Before examining the project's findings on land use change, we first need to summarize key aspects of the approach and methods used in project analyses.

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.

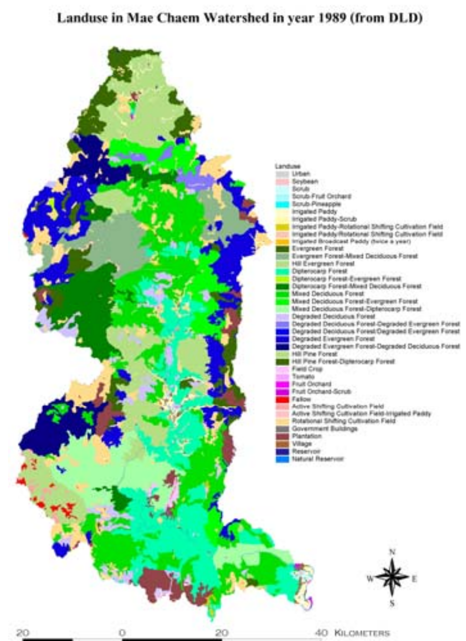
This type of apparent contradiction is also common in debates regarding natural resource management seen and heard in the mass media and other components of the public policy arena. One side in the debate tells us that natural resources are vanishing rapidly, and only radical efforts to stop massive 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 24. 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 23. 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 25, 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 25. 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.

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 26. 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.

Figure 26. Land Use Aggregations and Colors

aggregate	air photo categories	aggregate	local categories
Forest Areas			
Planted + Other	140 forest plantation	***Planted + other***	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	321 young fallow	***Fallow***	320 regenerating forest fallow areas
	322 old fallow		
Grass	330 grassland areas	***Grass***	330 grassland areas
Cultivated Fields			
Orchards	242 fruit trees	***Orchards***	242 fruit tree gardens and orchards
Upland fields	220 upland crop fields	***Upland fields***	220 current cultivated field crop areas
	230 upland vegetables		230 specific upland vegetable areas
	310 bare soil		
Paddy fields	210 bunded paddy fields	***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

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:

- **<u>Baseline: 1954.</u>** 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.

- **<u>Change Period 1: 1954 – 1976.</u>** 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.

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

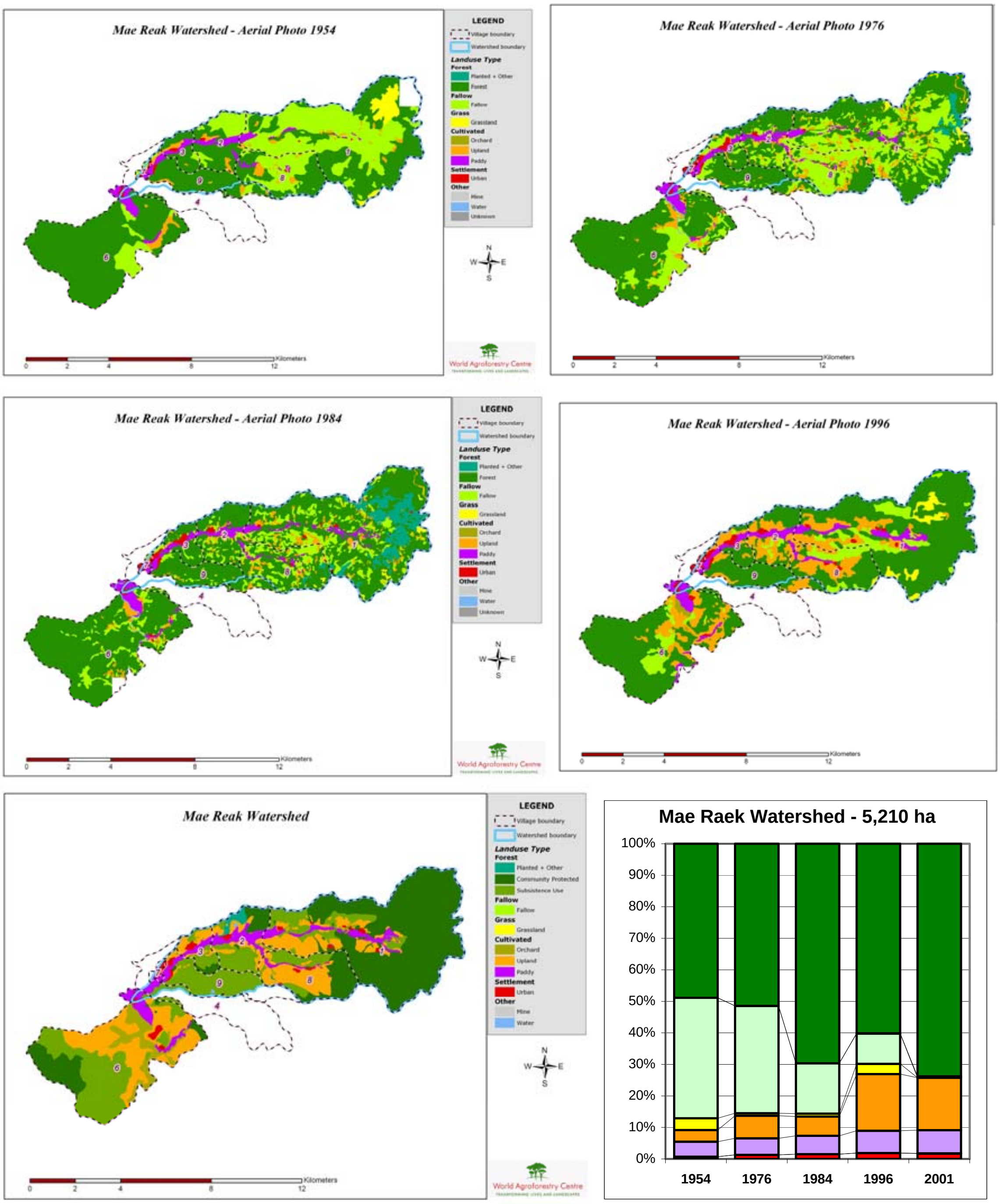
As presented in considerable detail in the previous section of this report, the Mae Raek sub-watershed is a clear example of an area where all village land use zoning strategies center on agricultural production in permanent fixed fields. While the majority population of the area is lowland Northern 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 27 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

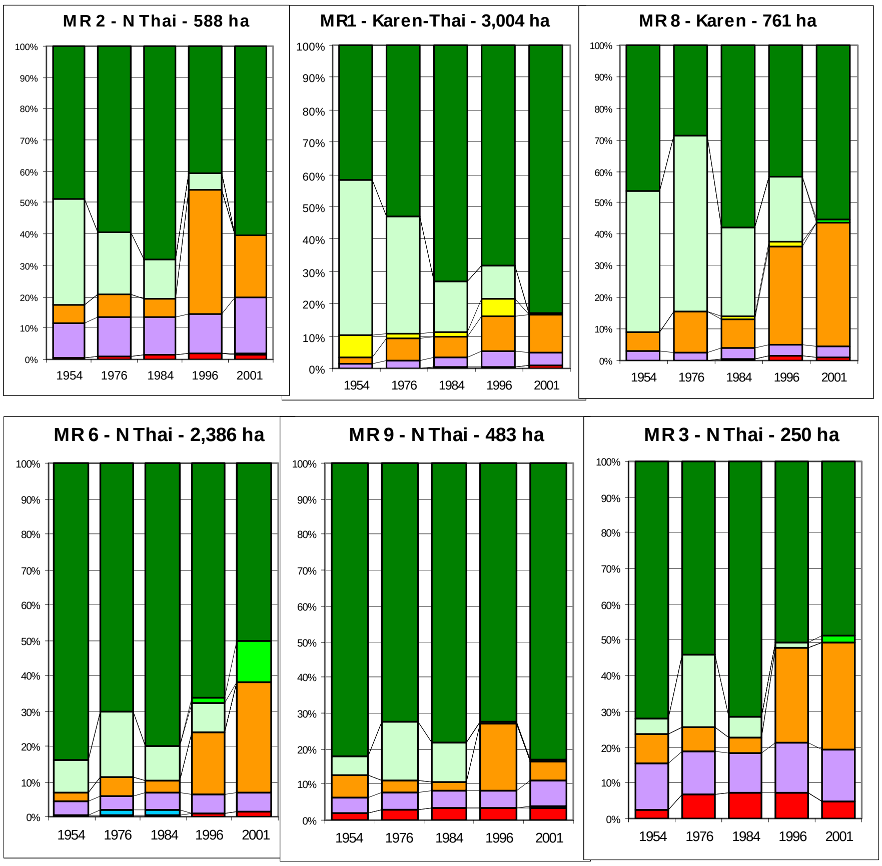
Figure 27. Land use change in the Mae Raek Sub-Watershed, 1954 – 2001.



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.

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 28 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

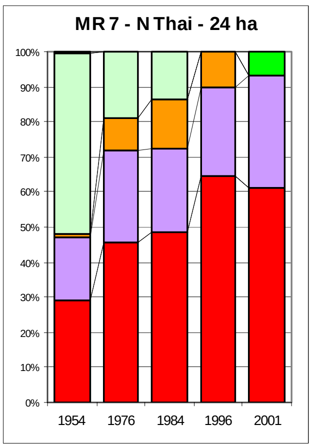
Figure 28. Land Use Change in Major Mae Raek Villages, 1954-2001



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.

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.

Figure 29. Urban Fringe

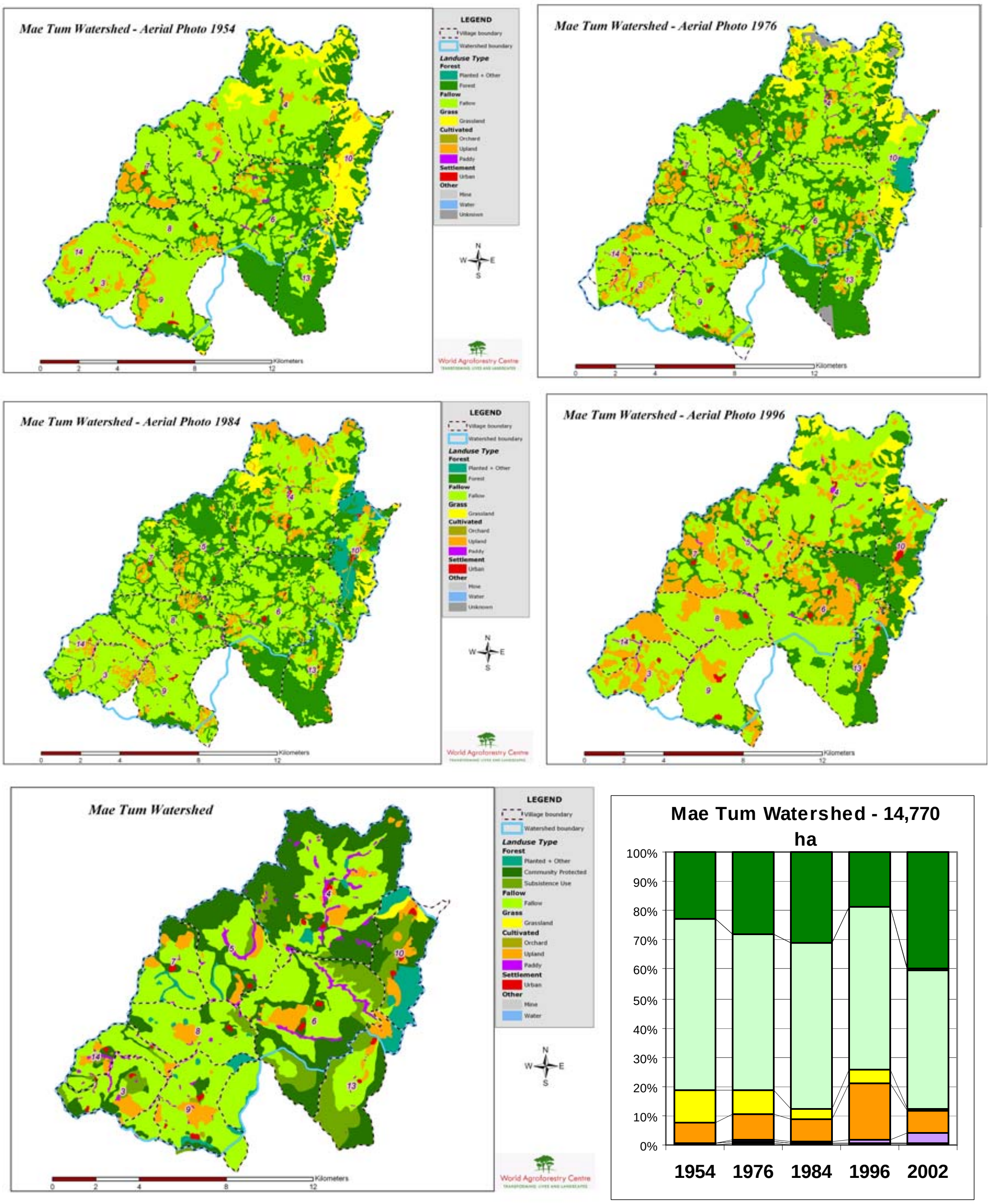


As somewhat of a footnote to land use change in Mae Raek, Figure 29 shows the pattern of land use change in a small village that has entered the urban fringe of the modestly growing district town of Mae Chaem. This data charts its change into the type of densely populated area interspersed with irrigated paddy and home gardens that characterizes much of the area in the immediate vicinity of the district town.

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 30 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 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.

Figure 30. Land use change in the Mae Tum Sub-Watershed, 1954 – 2002.



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:

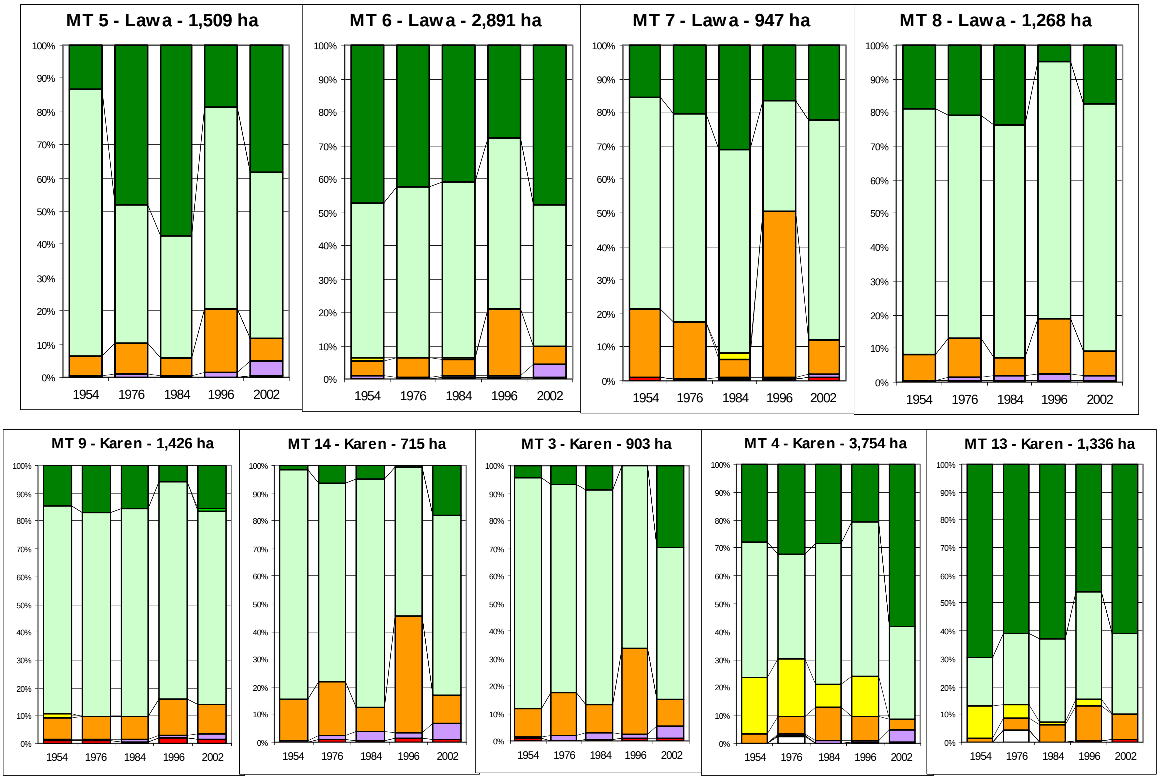
- In 1954, land use in the Mae Tum sub-watershed was already strongly dominated by land use systems that clearly must have had quite long periods of rotational forest fallow. The ratio of our estimates for forest fallow and upland fields indicate an overall system cycle length of at least 10 years (older 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 31 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 actively involved with re-thinking how to retain their traditional land use systems and way of life by

Figure 31: Land Use Change in Major Mae Tum Villages, 1954-2002.



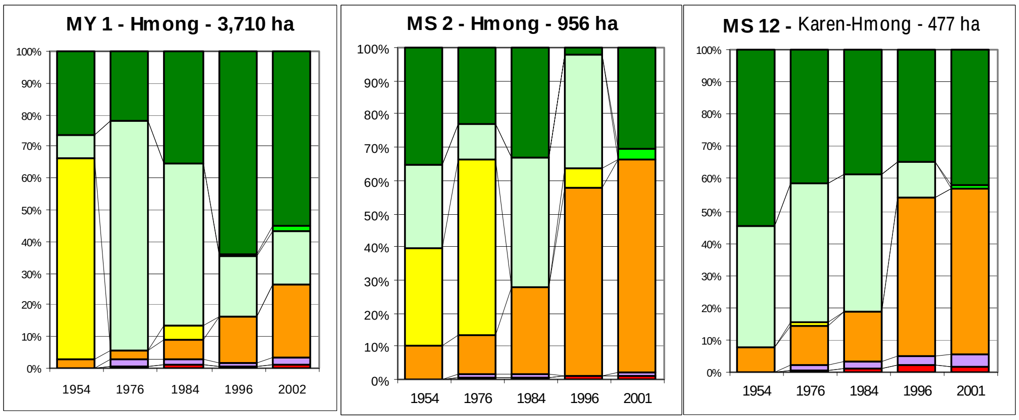
formulating land use zoning plans that counter many of the criticisms used to justify forestry agency plans for radical transformation to permanent field land use systems.

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 32. 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 32. 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.

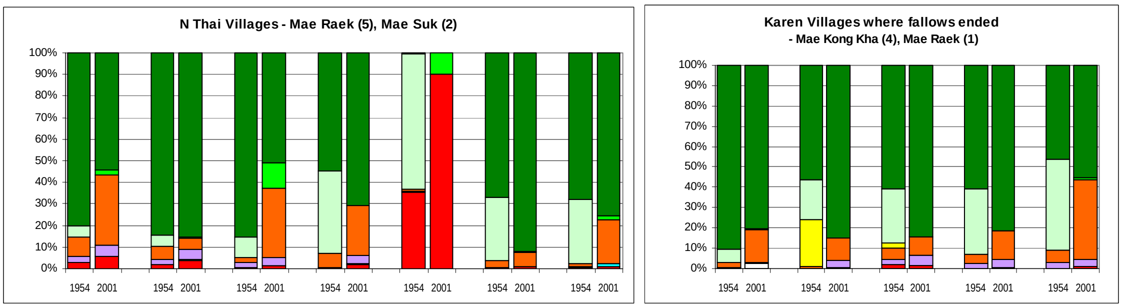
From a broader environmental point of view, a number of issues again appear. Data from ridgetop locations indicate mature forest is greater than it was in 1954, and that highland upland crop expansion has been due much more to the net displacement of grassland and fallow (or 'fallow-like' regenerating 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.

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.

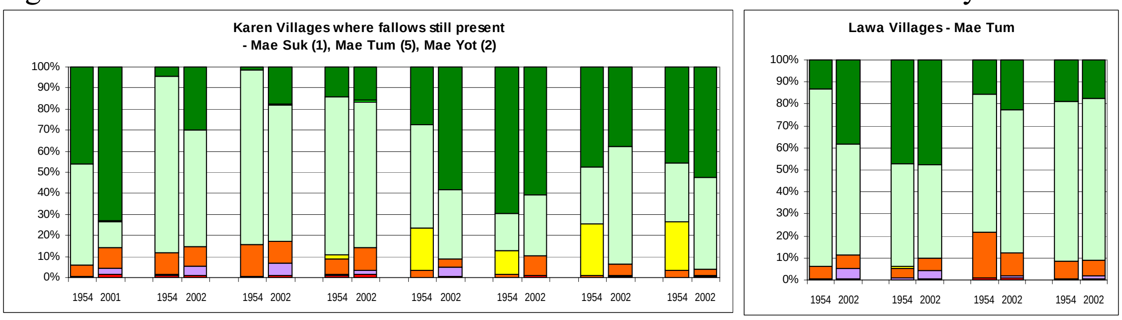
Overall summaries of aggregate data comparing current land use zoning with 1954 land cover in twelve Northern Thai and Karen administrative villages where permanent field systems are now used (including our one 'urban fringe' village) are displayed in Figure 33. Patterns consistently indicate that in 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 33. Current Land Use Zone & 1954 Land Cover 1: Thai & Karen Fixed Fields



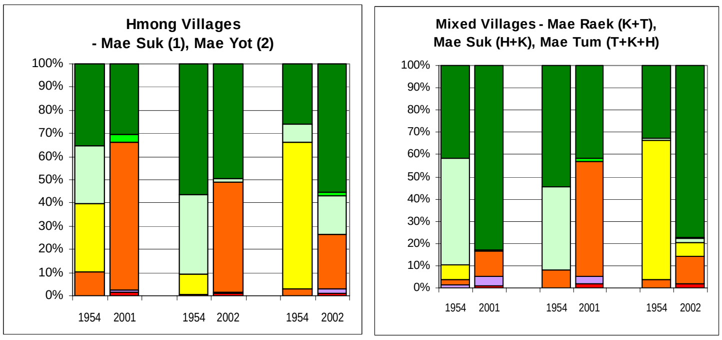
Similar data for twelve ethnic Karen and Lawa villages that continue to employ rotational forest fallow systems is displayed in Figure 34. There is again a net gain in mature forest cover over 1954 in nine of the villages, no change in one, and a modest decrease in the remaining two. It is also clear 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 34: 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 35. 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

Figure 35: Current & 1954 Land Cover 3: Hmong & Mixed Villages



change 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.

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?

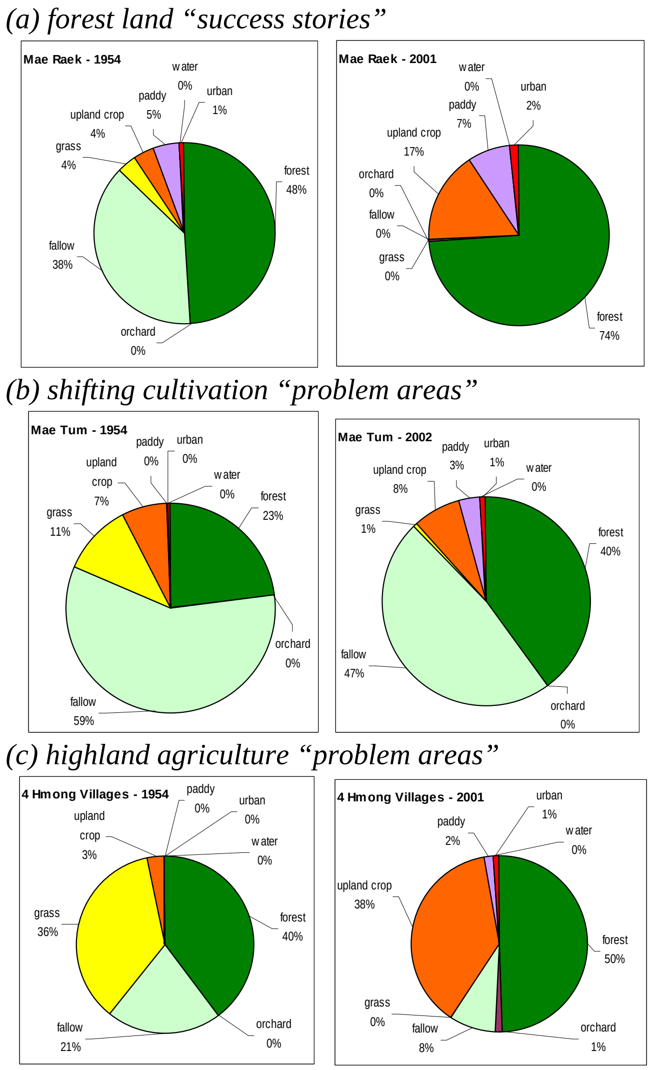
Evidence from our study suggests that the central issues associated with sustainability of these systems relate to key thresholds of system cycle length. Most everyone agrees that systems with long cycles are most productive and agro-ecologically sustainable without chemical inputs. And, there is much 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 36 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 36. 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 36 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.

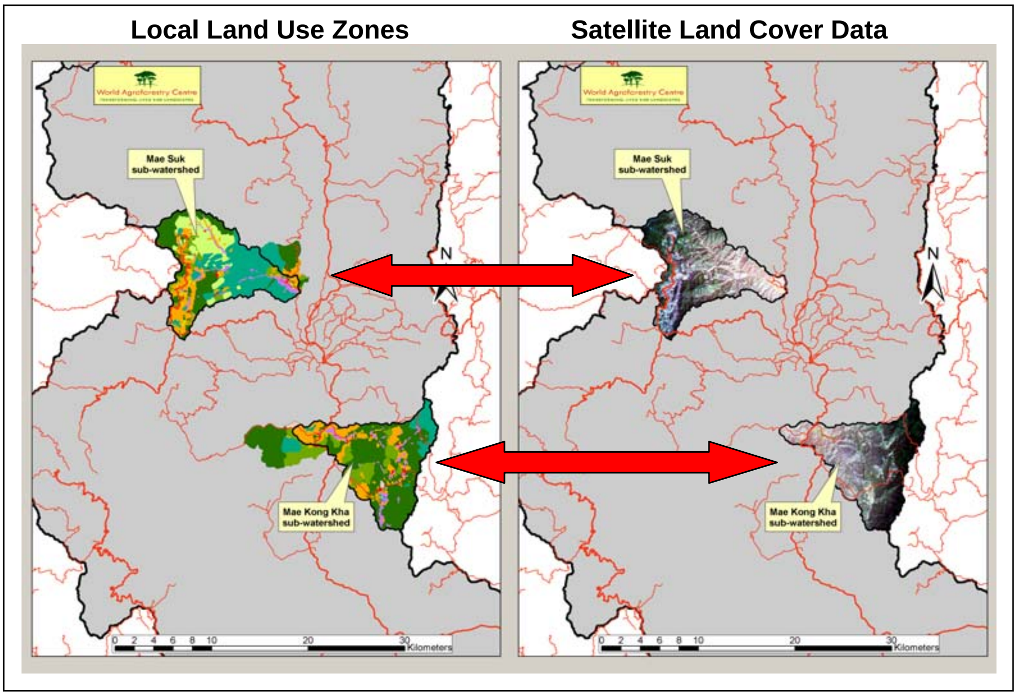
Clearly, one of the key challenges for local land use zoning approaches is how can transparency be assured in ascertaining the extent to which the key actors are indeed complying with zoning plans. Given the often dramatic differences in views and opinions of key stakeholders at the various levels involved, 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 37. 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 37 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. Remote sensing data that can be routinely obtained at suitable intervals. 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. An institutional unit capable of conducting analysis of remote sensing data at these intervals. 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.

(c) 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.

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.[2]

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 38. These 24 organizations are listed under five

[2] 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.

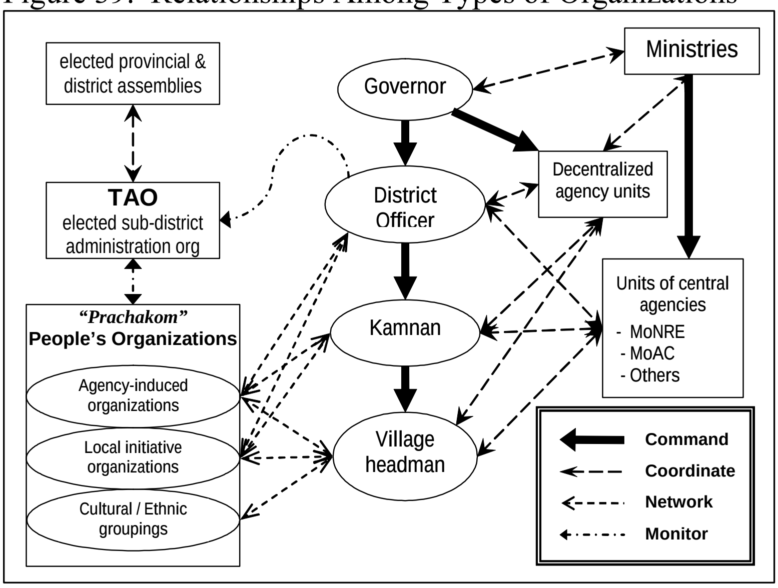
categories that can help us see more clearly the sources of mandates, authority and initiatives underlying the various organizations. The first column after the organization's name indicates whether or not it has a mandated role in coordinating with others. Thus, it becomes rather clear that local units 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 38. 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 39 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 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

Figure 39. Relationships Among Types of Organizations



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 39, 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.

Ping River Basin Organization Initiative: Toward 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 38 and 39.

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.

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.

Figure 40. System Demos for TAOs

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 40.

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

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.

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.[3] A few examples of maps generated during this process are shown in Figure 41. The project also provided advice and assistance for an American doctoral student who conducted her dissertation research in a portion of this area.[4]

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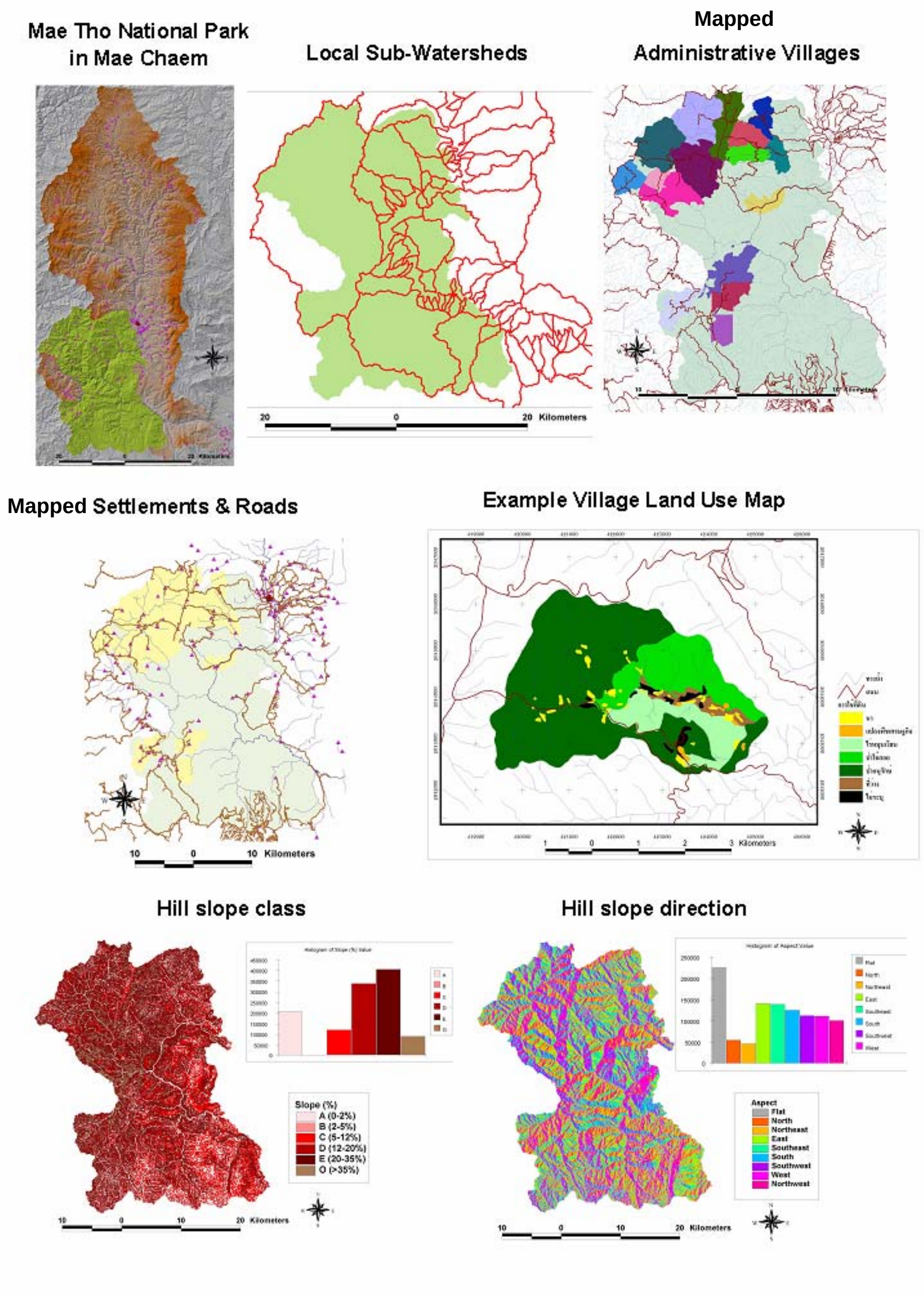
[3] พรวิไล ไทรโพธิ์ทอง, วุฒิกร โคจรรุ่งโรจน์, อนันทิกา รัตน์น้ำหิน, ประภัสสร พันธ์สมพงษ์ . 2002. รายงาน โครงการการจัดทำและประยุกต์ใช้ข้อมูลจากสารสนเทศทางภูมิศาสตร์ (Geographic Information System, GIS) เพื่อสำรวจการใช้ที่ดินในพื้นที่เตรียมจัดตั้งอุทยานแห่งชาติแม่โถ (บางส่วน). มูลนิธิแคร์-รักษ์ไทย, ศูนย์วิจัยวนเกษตรนานาชาติ

[4] 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 41. Examples of data for Mae Tho negotiation processes



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.

(2) 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.

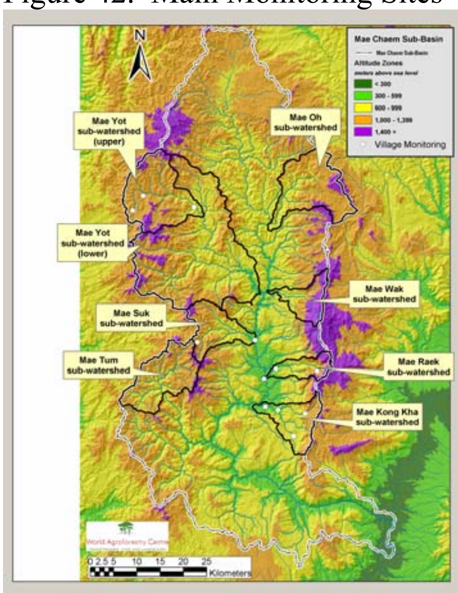
(a) Watershed monitoring tools

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 42 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 42. Main Monitoring Sites



Testing the Monitoring Toolkit

Four basic sets of tools were selected for this initial exploration in community-based monitoring.

Figure 43

Rainfall, Temperature & Relative Humidity

Climate and Stream Flow

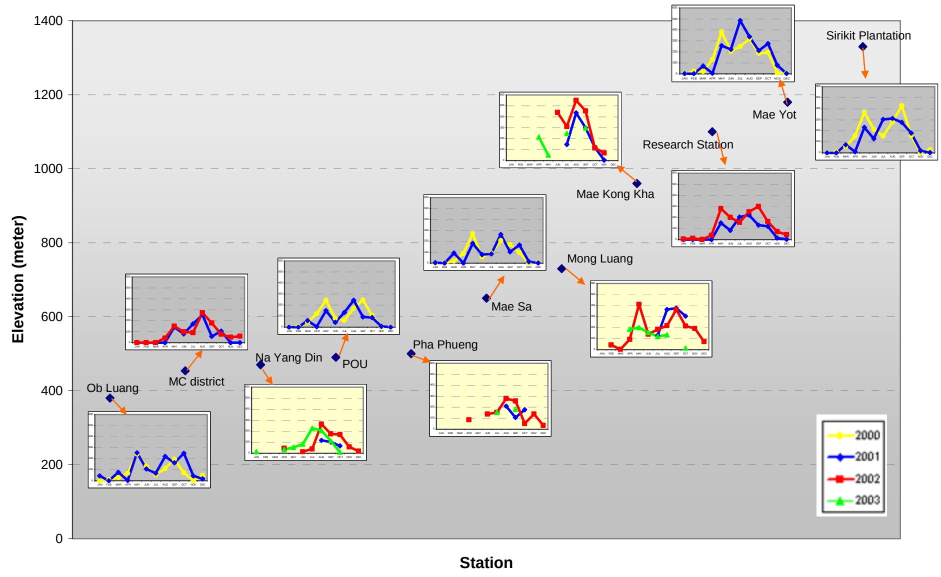
The first set of tools focused on daily measurements of basic climatic variables, including rainfall, maximum and minimum temperatures, and relative humidity, along with weekly indicators of stream flow. As indicated in Figure 43, rainfall was measured with a very simple device constructed from a used 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 45 displays 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 46 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.

Figure 44.
Water depth & surface flow velocity

Figure 45. Rainfall Data Compared with Other Sources of Data

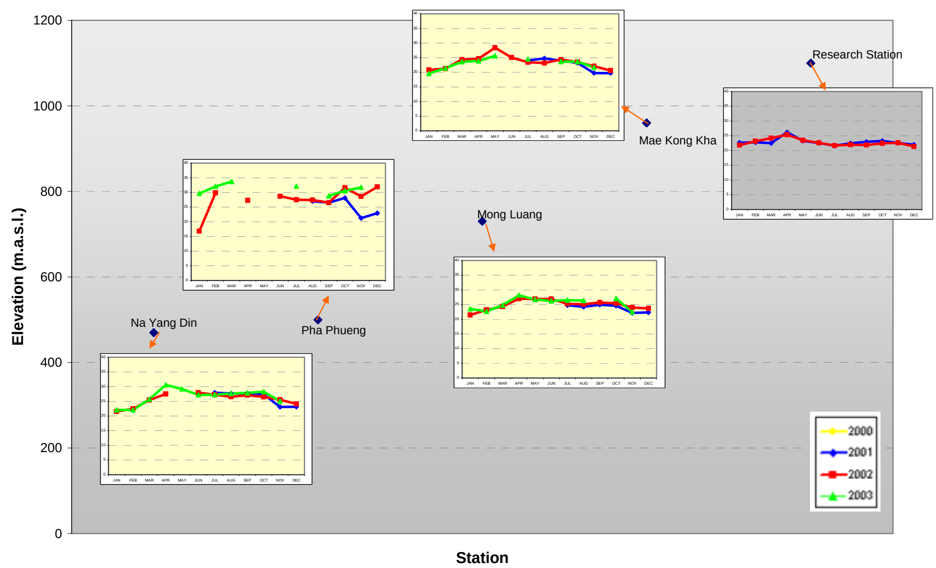


While daily values appear to be very reasonable and consistent in comparison with official data, official or research sources employing sensors attached to data loggers are able to provide much more fine resolution data associated with variation within the daily time step, including important data associated 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[5]. 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

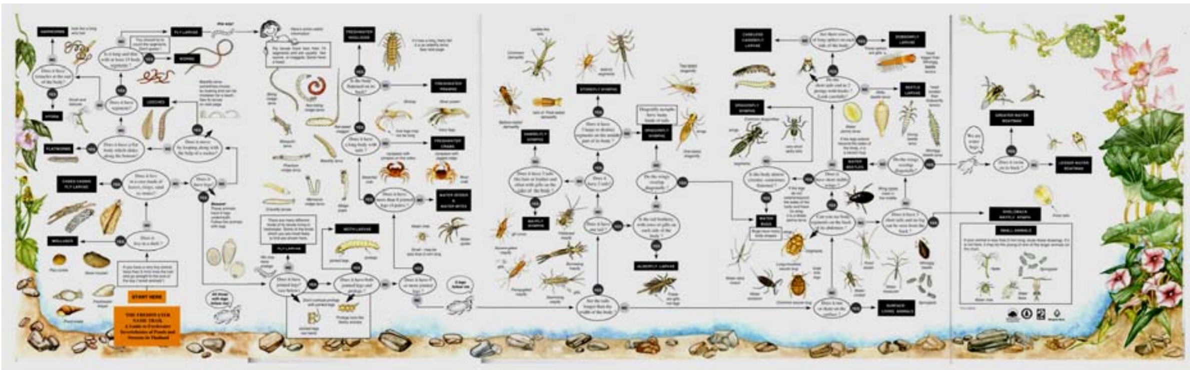
Figure 46. Temperature Data Compared with Data Logger



[5] 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 47. Water Quality using Aquatic Invertebrates as Biological Indicators

Identification Key Published by the Green World Foundation

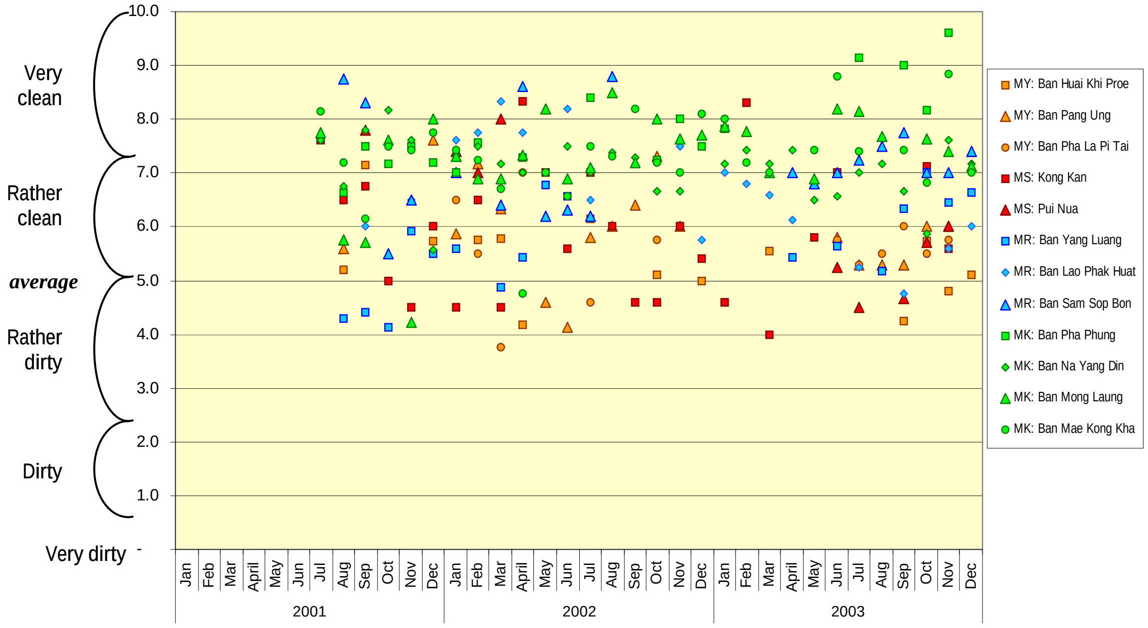


based in Bangkok. These materials were developed under GWF's River and Stream Investigation Project for Youth (RSPY), initiated in 1998 with financial support from DANCED to promote active learning to empower teachers and students of secondary schools in the Ping River catchment to evaluate the state 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 47, 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 46.

Mean monthly values of the water quality index as measured by villagers at each of the 12 main monitoring sites (Figure 42) during a thirty month period are also displayed in Figure 48. 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 48. Mean Monthly Water Quality Indicator Index Values, 2001 - 2003

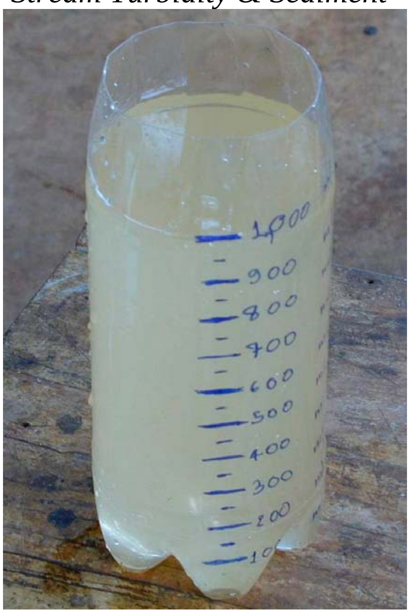


Soil Erosion and Stream Sediment

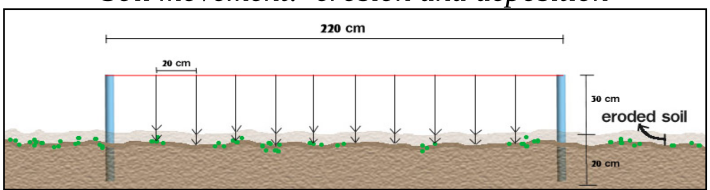
The third category of data focused on simple measurements of stream sediment, and on soil movement in cultivated fields. This approach began with villagers taking a one liter sample of stream water from below the surface at mid-stream, filling a calibrated plastic water bottle with its neck cut off, as indicated in Figure 49. 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 49. 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 49. 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.

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 50. 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.[6] 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 51.

[6] ธนัตถ์ พรมด้วง, นงลักษณ์ แก้วโภคา, โสนัฐ นที, Pornchai Preechapanya, David Thomas.. 2004. การพัฒนาเครื่องมือวิทยาศาสตร์อย่างง่ายเพื่อการจัดการลุ่มน้ำโดยชุมชนมีส่วนร่วม. รายงานการวิจัย ศูนย์วิจัยวนเกษตรนานาชาติ (World Agroforestry Centre,. Chiang Mai).

Figure 50.

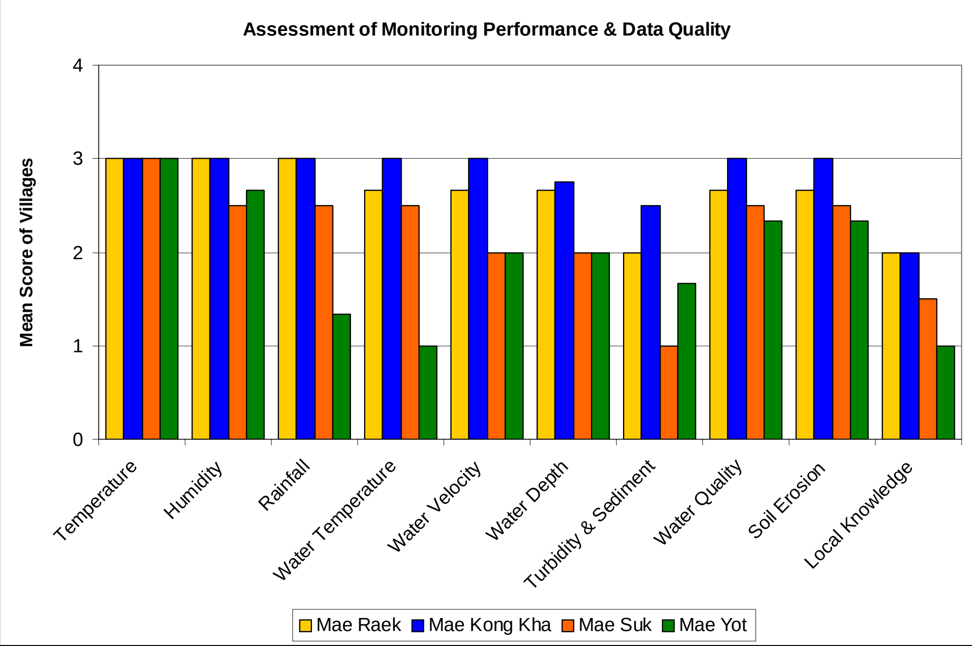


Figure 51. Problems Encountered in Collecting Monitoring Data

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 52. 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

Figure 52. 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	-

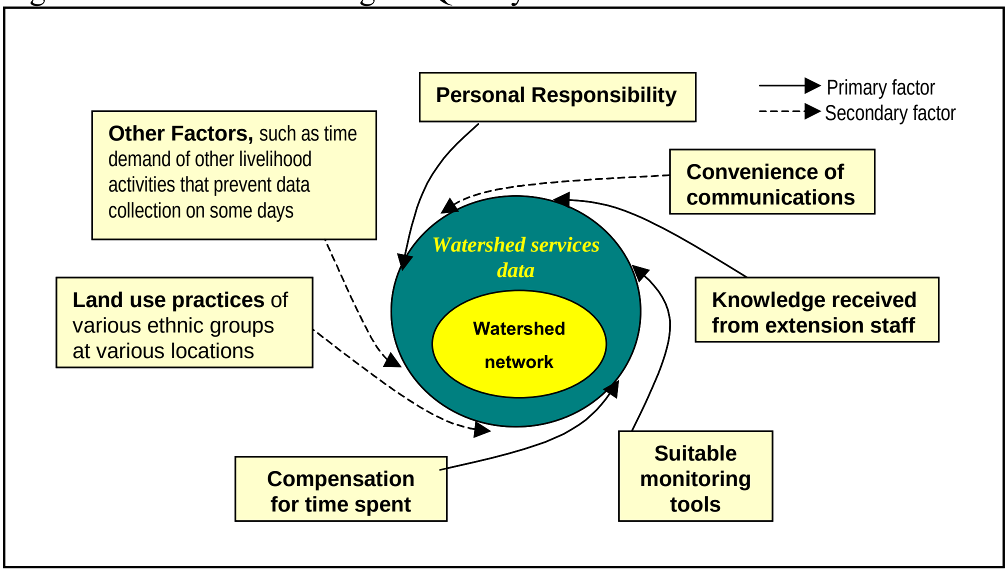
stream velocity, soil erosion or stream water turbidity and sediment, many also expressed the opinion that data on soil erosion and stream sediment are likely to become more important in the future. As indicated in Figure 51, their problem with turbidity and sediment measures were that they did not yet 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 53 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 53. 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 54. 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 54. 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.

(b) 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 55.

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 55. Examples of additional biological indicators of environmental quality

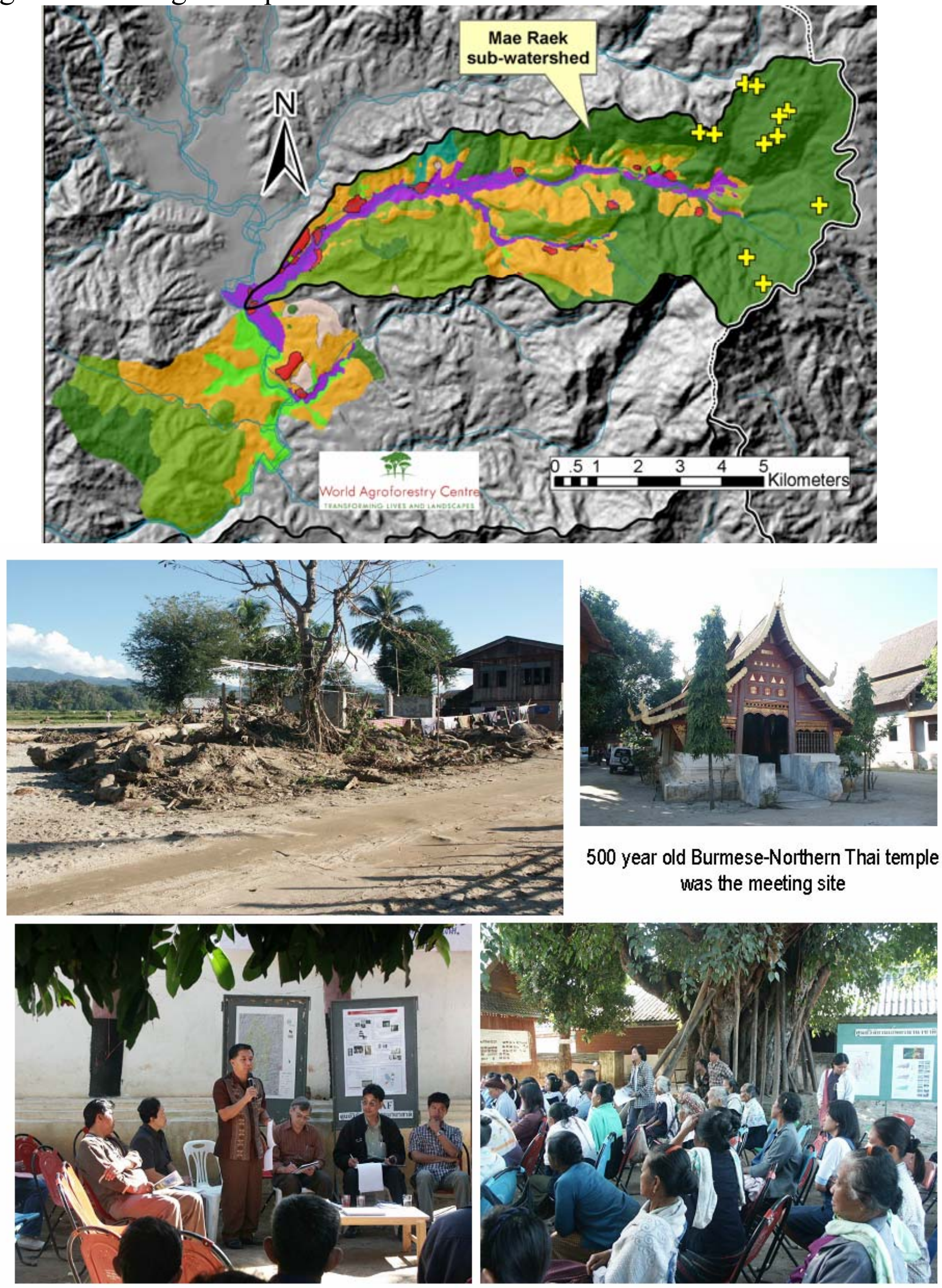
Local response to landslide disaster

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 56 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

Figure 56. Villager-Requested Seminar after Severe Local Landslides



people 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 56.

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 57. 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.

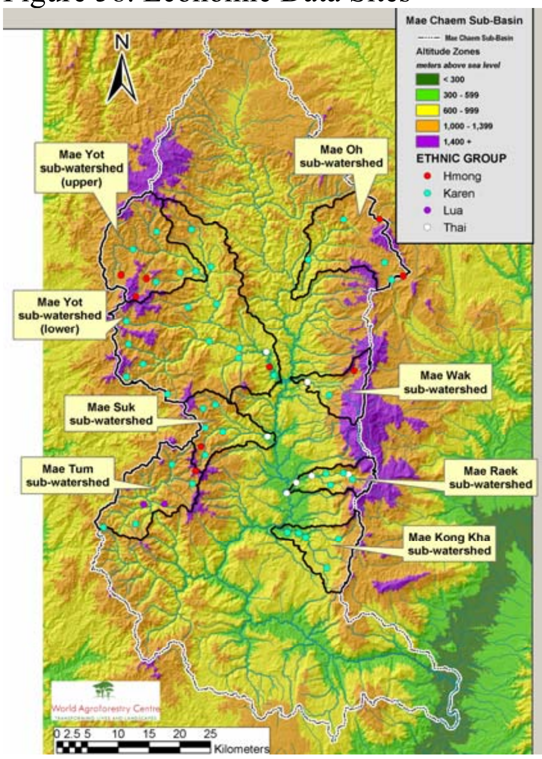
The project also introduced communities and local officials to additional information available from other sources in Thailand, such as the landslide hazard map for northern Thailand produced by the Department of Land Development and shown in Figure 57. This type of information helped move discussions 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.

Economic profitability of agricultural crops

We have seen in previous sections of this report that economic integration of mountain communities and expansion of commercial crops play a very important role in the changing landscapes of Mae Chaem and similar upper tributary watersheds. 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 study was conducted under this project by Ms. Thitiya Angsajjapong to collect crop production information from a substantial sample of villages in our pilot sub-watersheds, and to conduct a preliminary assessment of profitability using the policy analysis matrix approach.

Figure 58. Economic Data Sites



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 59, 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

Figure 59. 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

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.

Land use impact on sub-watershed streamflow

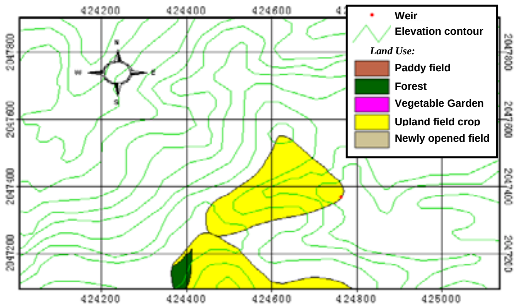
During studies conducted by ICRAF and our colleagues in the ASB-Thailand consortium prior to this project, we had already identified gaps in empirical data and our current understanding related to impacts of mosaic land use patterns on environmental services provided by upper tributary agroforestry landscapes. Moreover, impacts on watershed services are a particularly important element in the context of northern Thailand and MMSEA, since many land use constraints being imposed on many mountain areas are justified in terms of efforts to maintain and improve watershed functions.

As part of our initial efforts to address this knowledge gap, a set of four small catchments 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. Basic characteristics of the four sites are shown in Figure 60.

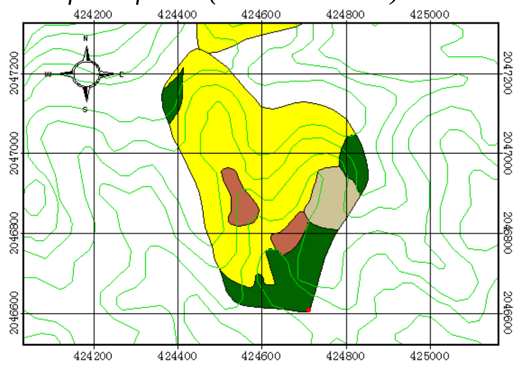
Each catchment was instrumented with a weir at the outlet equipped with a water level sensor, and sites also included rainfall, temperature and relative humidity sensors, all attached to data loggers. Data were collected for a three-year period beginning April 2000. Basic findings are summarized in Figure 61, and detailed in a Thai language report to ICRAF.[7]

Figure 60. Measured sub-catchments

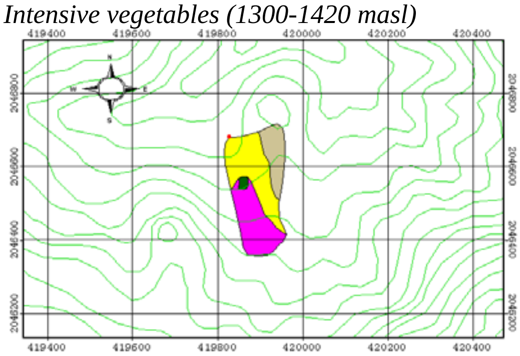
Upland crop rotation (1230-1290 masl)



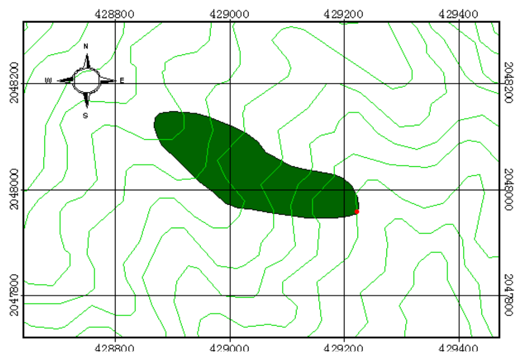
Short forest fallow (1170-1290 masl)



Intensive vegetables (1300-1420 masl)

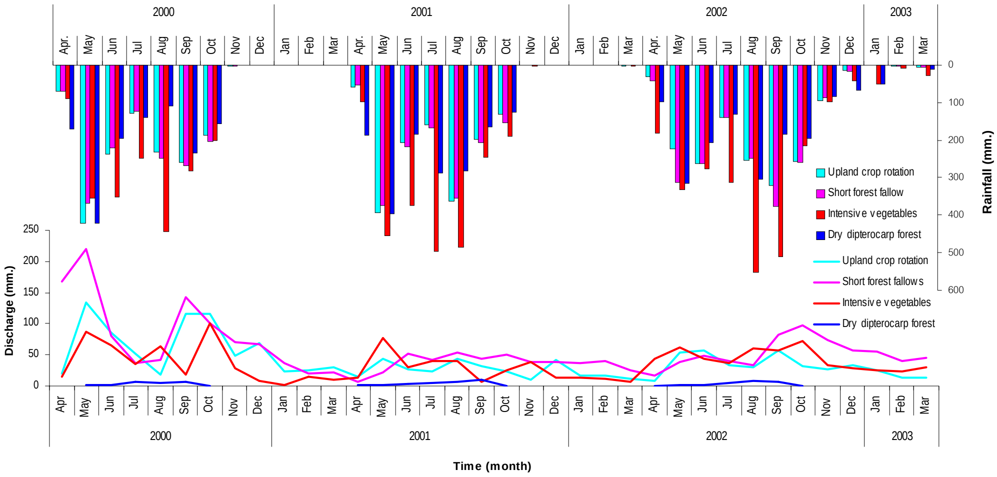


Dry dipterocarp forest (740-1030 masl)



[7] โสณัฐิ นที, พรชัย ปรีชาปัญญา, David Thomas. 2003. สมดุลน้ำจากการใช้ประโยชน์ที่ดินบริเวณลุ่มน้ำแม่แจ่มตอนล่าง เชียงใหม่. ศูนย์วิจัยวนเกษตรนานาชาติ

Figure 61. 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

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.

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 modeling and associated activities described in the next section.

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.

(3) Analyses & Analytical Modeling for Watershed Landscape Management

As indicated in an early section of this report, the Rockefeller Foundation was able to provide only a small portion of the funds requested for this component of the project. Thus, Foundation staff advised us to cut back on these activities and the outputs expected. Moreover, the original formulation of this project component included several activities that were contingent on receiving support from other sources that we were seeking at that time. Unfortunately, some of the key elements of support we were seeking from those sources also failed to materialize. During implementation of the project, however, some previously unanticipated opportunities also emerged, which have been able to provide support for various activities under this component. The net result has been some shifts in how work under this line of activities has been organized and directed. This section seeks to provide some very brief summaries of the resulting activities to which work under this project has made contributions.

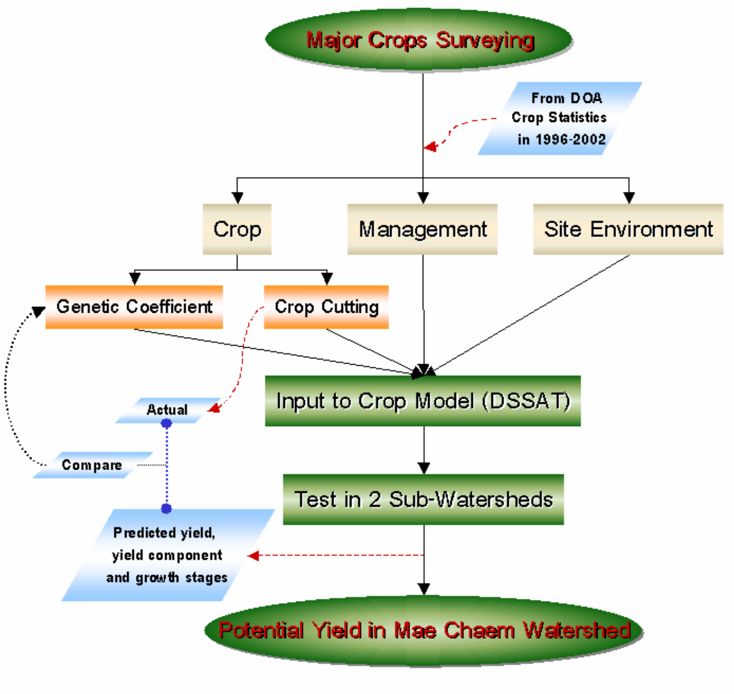
(a) Crop Trials and Modeling

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.

Crop modeling to improve agricultural productivity, profitability and site selection

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 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.

Figure 62. Framework for crop modeling activities.



The basic framework for this line of activity is outlined in Figure 62. 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.

Figure 63. Crop Modeling Data Sites

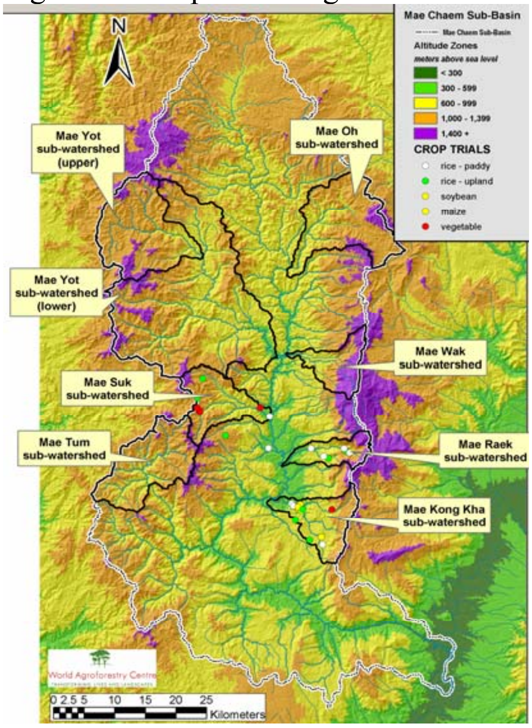


Figure 64. Crop model data collection

Upland and paddy rice

Upland soybeans and maize

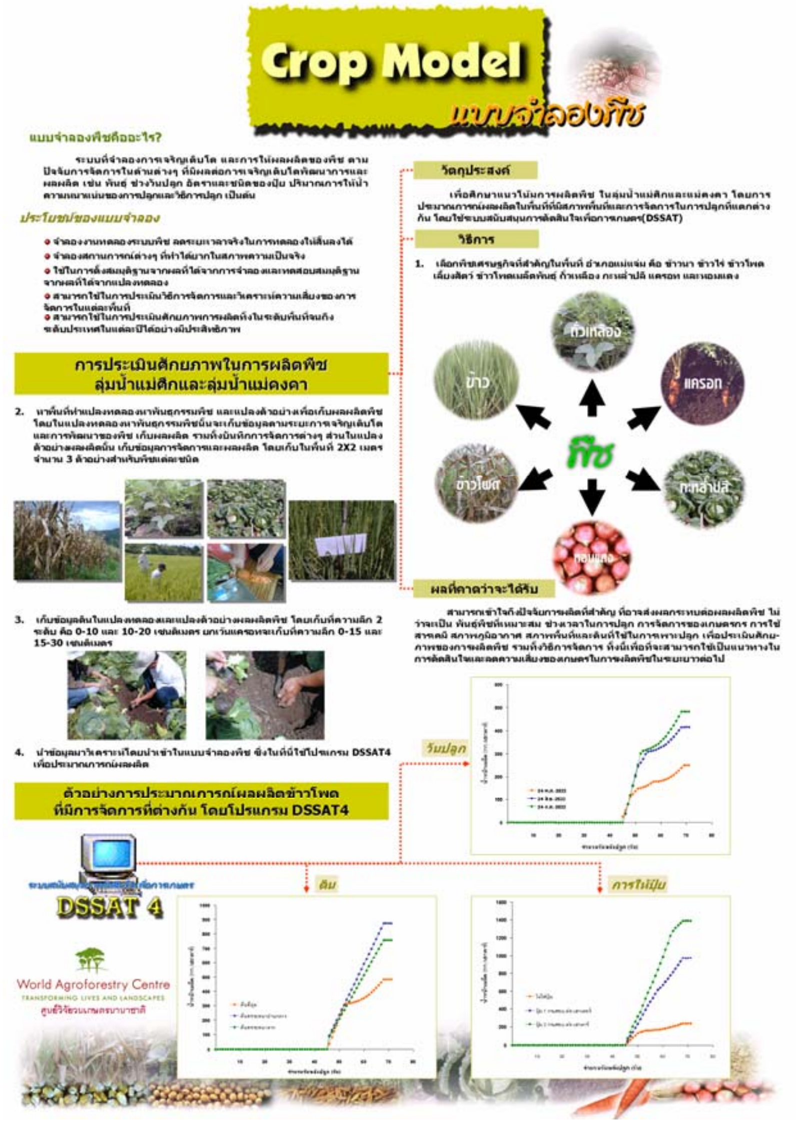
Highland cabbages and carrots

Collecting plant data to calibrate models

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 63, and images of some of the major crops being studied at these sites are shown in Figure 64, 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.

Figure 65. Explaining crop model work



(b) 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[8], 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.

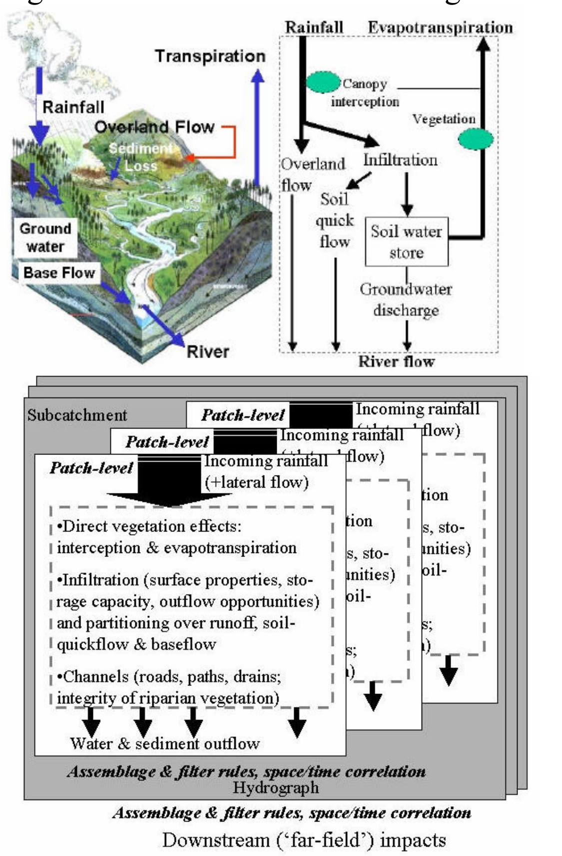
[8] Meine van Noordwijk, Jeffrey Richey, David E. Thomas. 2003. Landscape and (Sub) Catchment Scale Modeling of Effects of Forest Conversion on Watershed Functions and Biodiversity in Southeast Asia. Technical Report for Activity 2. Functional Value of Biodiversity (Phase II). Alternatives to Slash-and-Burn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

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.

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.

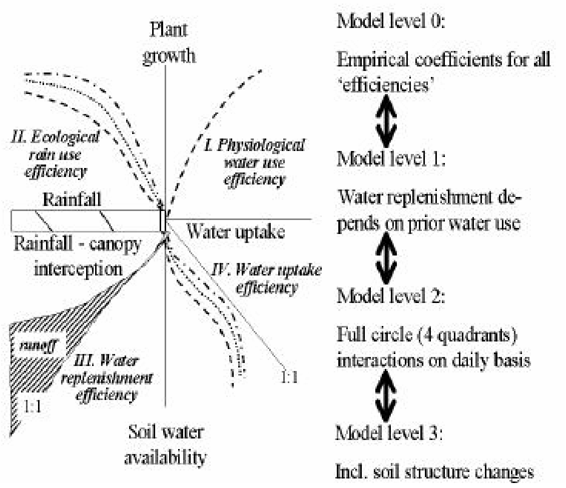
The basic logic of a water balance that follows water in its passage through vegetation, soil and rivers to either the atmosphere or the ocean is easily captured in quantitative models. All of the models tested under this project are based on a similar ‘water balance logic’, but they differ in the details of the assemblage and filter rules that are used to predict river flows. Figure 66 diagrams links between patch-level water balance and catchment level hydrological functions.

Figure 66. Water balance model logic.



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.

Figure 67. Water use and model complexity



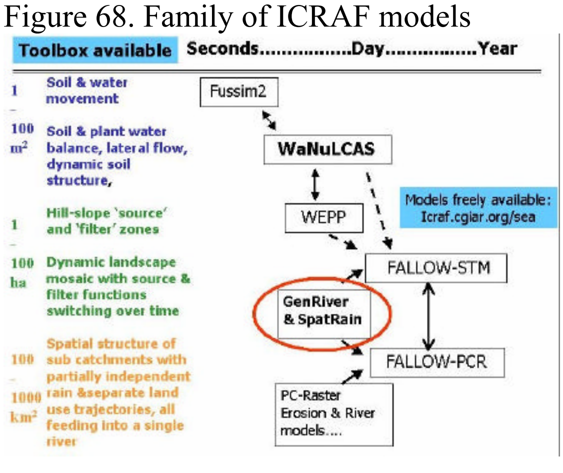
While most models follow a water balance logic, there are substantial differences in model complexity based on the number of feedbacks that are included in the interactions among vegetation, soil and rainfall. Figure 67 shows a four-quadrant representation of the relations involved in water use efficiency, 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

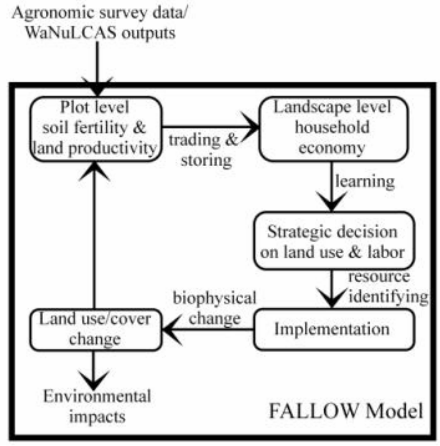


Main relations among the 'family' of models developed and/or used by ICRAF are shown in Figure 68. The models and technical descriptions (except for WEPP) are available on the ICRAF website. Four applications used here include:

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 69):

- 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;

Figure 69. The FALLOW model



- 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; and
- 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.

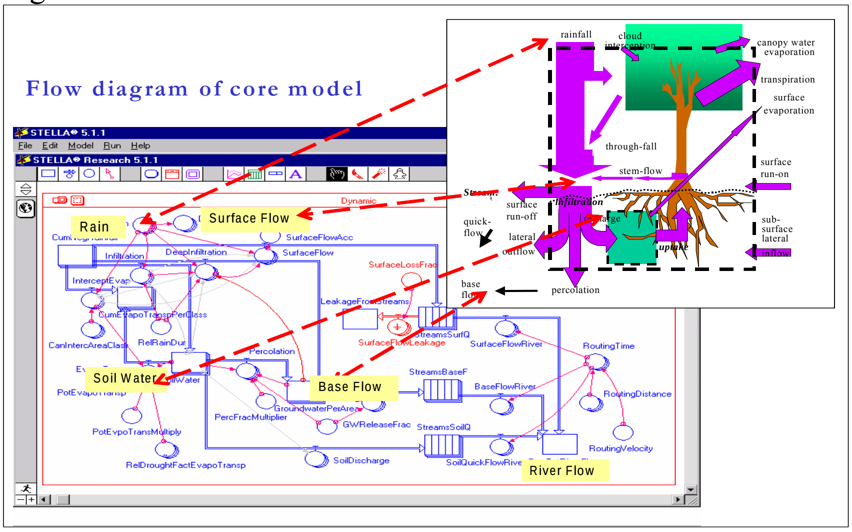
Staying essentially at a yearly time step, the FALLOW model differs from the hydrological null-model in that it:

- 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 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, 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

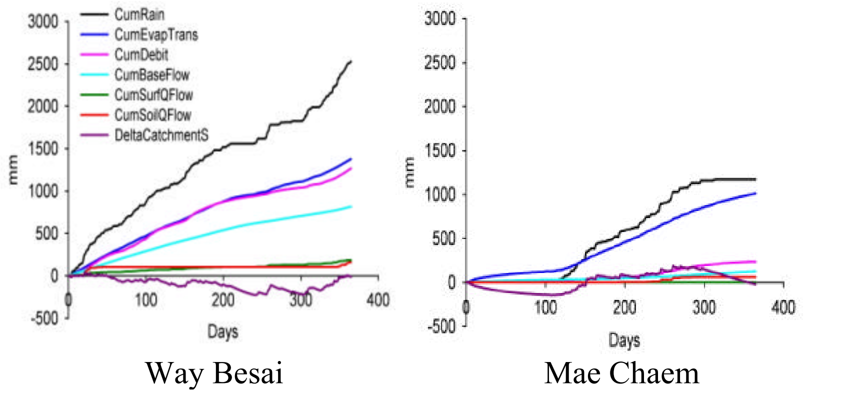
Figure 70. GenRiver



release of groundwater. The overall water balance of the model is, summed over space and time (Figure 71):

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.

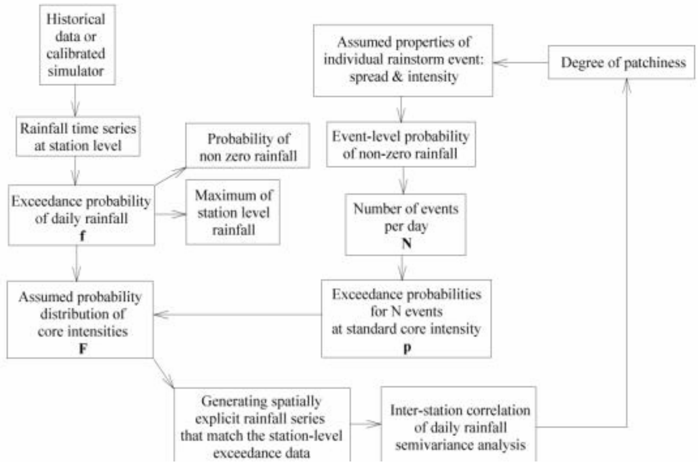
Figure 71. Cumulative water balance of current land use mosaics



In GenRiver, a ***river*** is treated as a summation of ***streams***, 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

Figure 72. SpatRain model calculation flow diagram



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 72).

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.

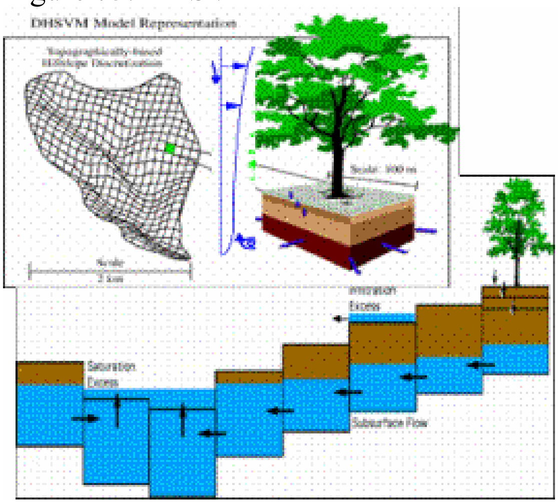
WaNuLCAS, For a number of simulations reported here we made use of the detailed ('level 3') water module of tree-soil-crop interactions in WaNuLCAS (Water, Nutrient, and Light Capture in Agroforestry Systems). The WaNuLCAS model was developed to simulate a range of tree–soil–crop interactions in agroforestry 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 Hydrology, 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. 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)

Figure 73. DHSVM



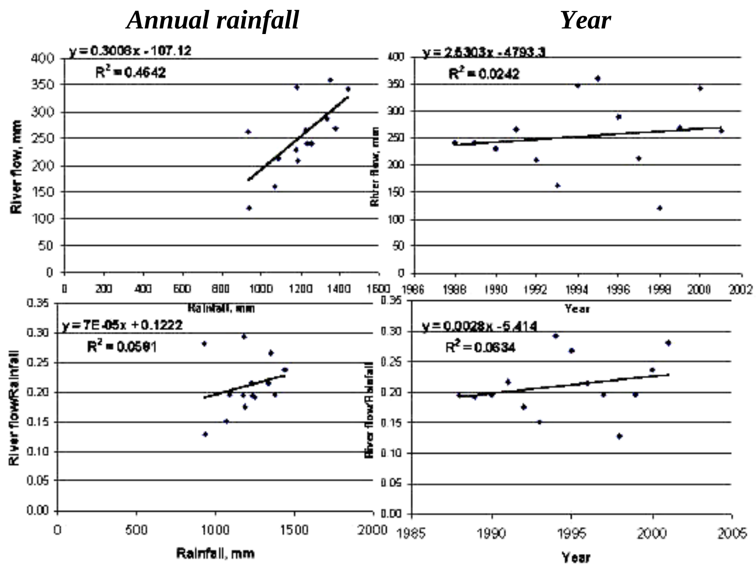
Unlike VIC, DHSVM is intended for small to moderate drainage areas (typically less than about 1000 km^2), over which digital topographic data allows explicit representation of surface and subsurface flow. Like VIC, it represents runoff generation via the saturation excess mechanism. Unlike VIC, it explicitly 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.

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

Figure 74. Relations between river discharge *(upper)* and discharge per unit rainfall *(lower)* of the Mae Chaem River



higher than the data for the rainfall station suggest. Figure 74 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.

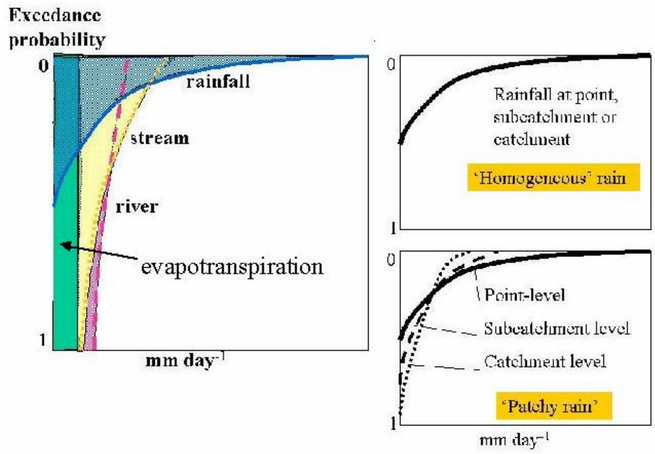
While the various hydrological models broadly agree on the direction and size of these effects on total water yield, public policy and investment remain often based on expectations of increases in total water yield as effect of 'reforestation'. In the absence of effects of such land cover change on rainfall,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

River flow fluctuations

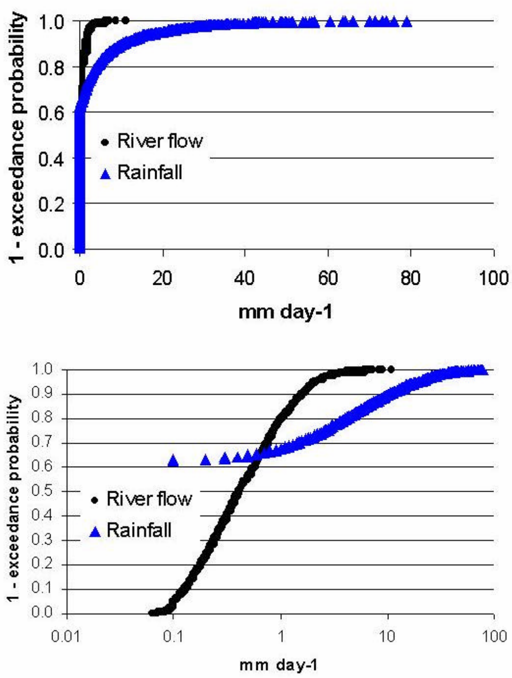
More controversial is the impact of land use change on the 'evenness' of river discharge or the degree to which river discharge is buffered relative to rainfall peaks. Both high peak discharge, that leads to flooding of downstream areas and is generally linked to reduced infiltration into the soil and 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 75). 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

Figure 75. Exceedance value as buffering indicator



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



(based on data during 1988 – 2001)

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.

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.

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 76). 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 77).

Figure 76. Framework for landscape evolution scenarios

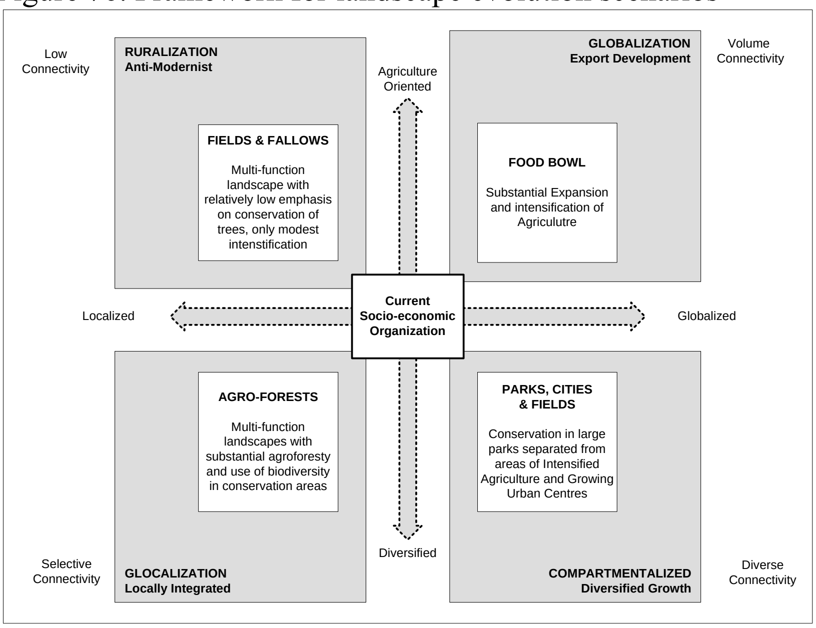
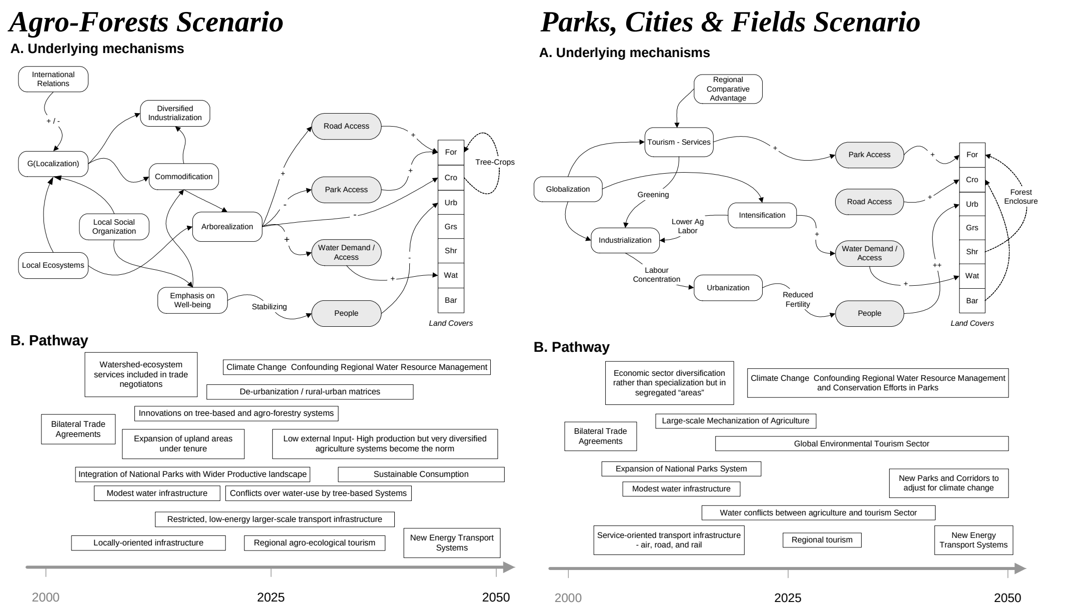


Figure 77. Examples of scenario mechanisms and pathways



- Third, a platform for modeling and visualization landscape evolution was built in Visual C++.

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

Figure 78. Projected 50-year land use change under plausible scenarios

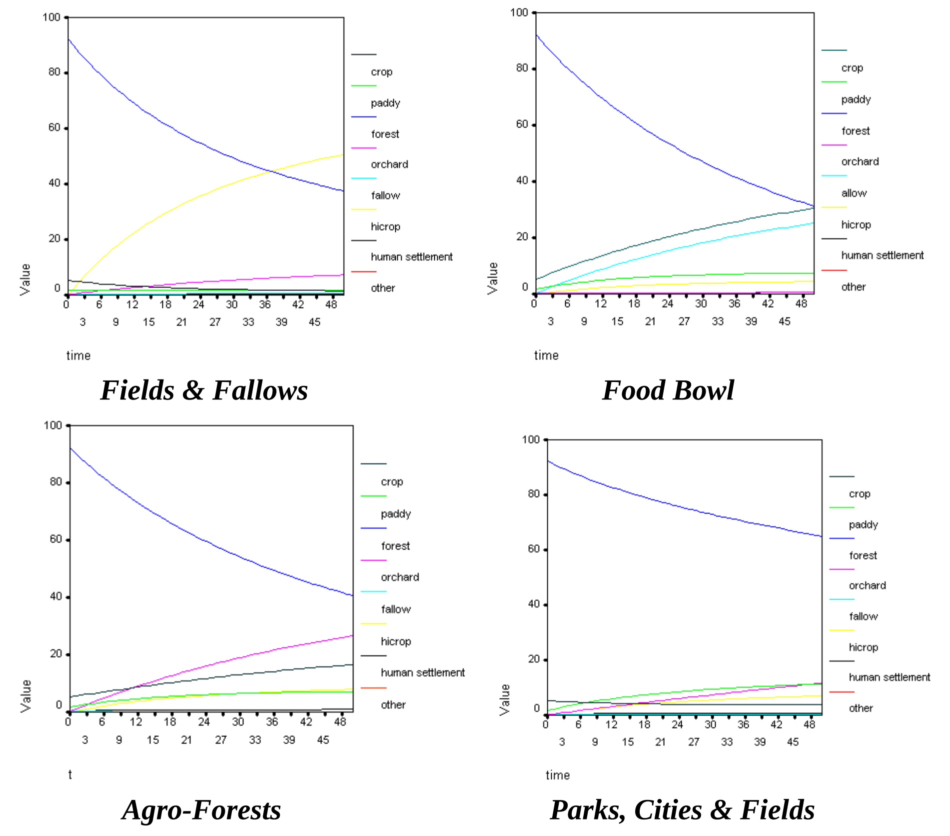


Figure 79. GenRiver estimates of impacts of alternative scenarios on hydrological functions

	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

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 78). 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 79).

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:

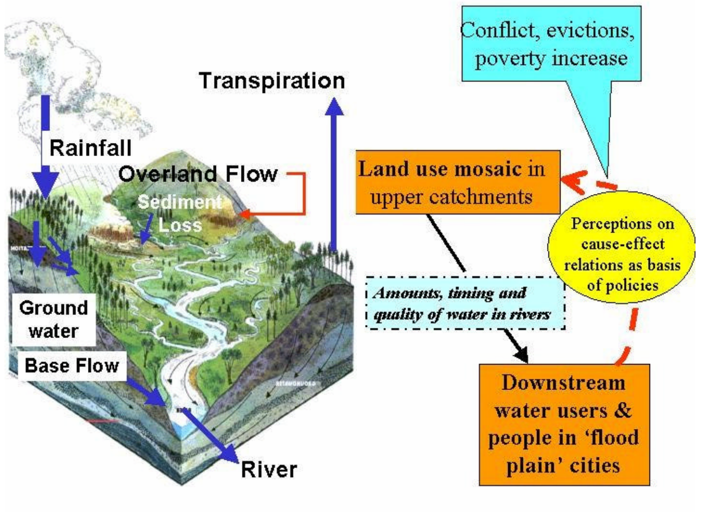
- From a natural resource management perspective 'watershed functions' and 'biodiversity conservation' are clearly separate issues, as the thresholds for change during land use intensification differ substantially; indicators at plot, landscape, sub-catchment and catchment scale of the historical land 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 80). 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 80. Where is the watershed service problem?



(c) Impacts of Changing Agroforestry Landscape Mosaics on Watershed Functions

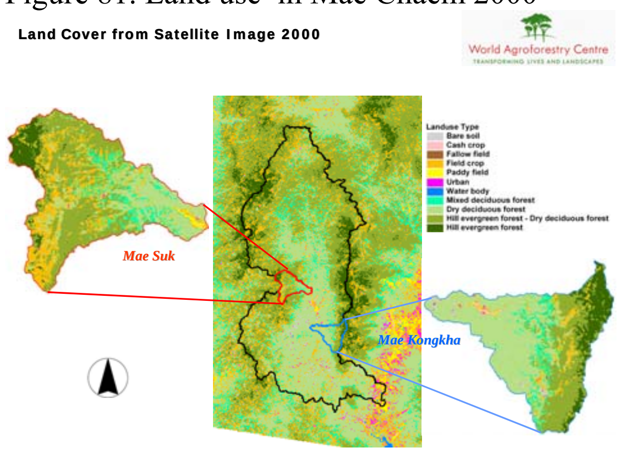
This further line of modeling work is still very much in progress, and is allowing us to pursue in considerably more detail various important lines of work begun under activities summarized in the previous section. The following activities are being conducted under a project entitled How do changing 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 (Figure 17) and Mae Kong Kha (Figure 19) sub-watersheds. Thus, these activities demonstrate our efforts to further build on results of work supported under this initial grant from the Rockefeller Foundation.

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 81.

Figure 81. 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 82.

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 83).

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. This is a continuation of work discussed in section 3(a), above.

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 82. Soil classification approach

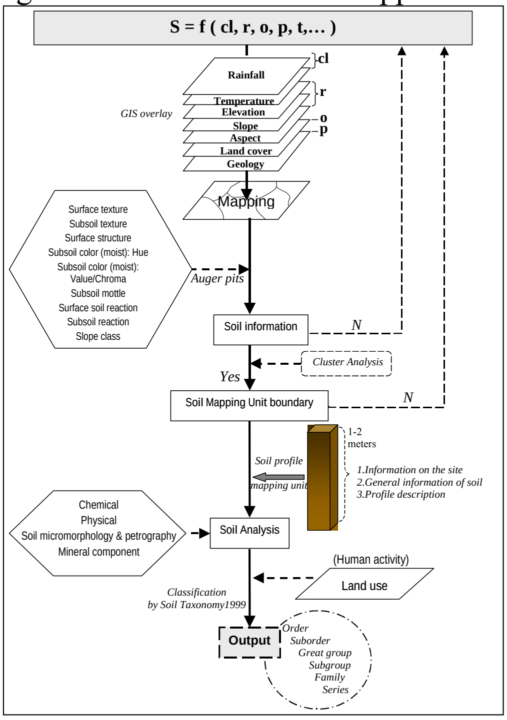
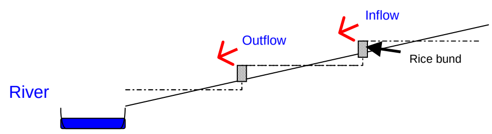
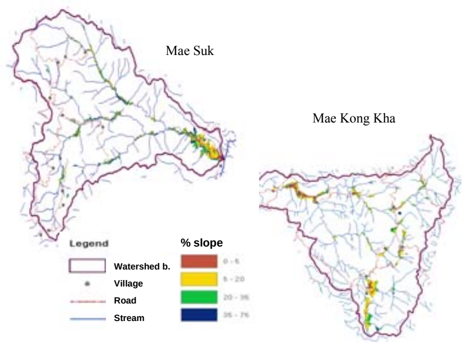


Figure 83. Landscape filter studies

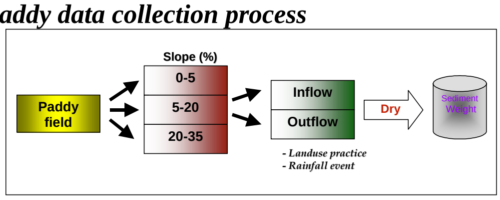
Paddy fields in sloping areas



Paddy fields in Mae Suk and Mae Kong Kha



Paddy data collection process



Riparian vegetation survey

III. Progress Toward Addressing Key Questions

As the conclusion to this report, this section seeks to address how the experience under this project summarized in previous sections can help answer the five key questions posed in our original proposal to the Rockefeller Foundation:

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.