

Agroforestry Systems Research: Evolving Concepts and Approaches ^{1/}

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Abstract

The concept of agroforestry is shifting from a set of stand-alone field-based technologies to an emphasis on the role of trees in productive agroecosystems and landscapes. This shift is driving efforts by ICRAF to reform its research and development programs, regionalize its programs, and forge strategic partnerships from global to local levels.

In partnership with the global ASB consortium, this new approach is being applied in the development of collaborative agroforestry systems research for montane mainland Southeast Asia conducted in northern Thailand. Steps have included characterizing the eco-regional context; establishing a partnership framework and a benchmark research site; identifying key driving forces, patterns of change, and policy-related issues; and building an action-oriented research strategy. The strategy includes analytical overlays that focus on food security, livelihoods, environmental services, and institutions. Activities conducted under each overlay employ approaches and tools that help integrate assessments at field, household & community, and landscape & watershed levels. Outputs focus on addressing strategic technological, institutional and policy needs required to achieve significant widespread improvement in the goods and services provided by agroforestry landscapes.

This paper seeks to briefly summarize some of the major implications of recent shifts in conceptual, organizational and analytical approaches associated with research on agroforestry systems. Since a thorough review of the literature cannot be included here, several major review articles and books are cited for those wishing to further pursue conceptual shifts and issues associated with the rapidly expanding and evolving body of agroforestry literature. It is hoped that this brief summary and an example of how new approaches are being incorporated into agroforestry research in mainland Southeast Asia will be useful for the agricultural systems research and development community in Thailand, as they consider their way forward and any potential role for agroforestry systems in that process.

^{1/} Information and data summarized in this paper are based on work conducted in partnership with numerous colleagues who have contributed to activities conducted under ASB-Thailand.

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I. Changes in Agroforestry Concepts and ICRAF's Organizational Approach

This section describes key recent developments regarding the scope and content of what is considered within the domain of the concept of agroforestry, and how the organizational approach of programs conducted by the International Centre for Research in Agroforestry (ICRAF) and its partners have responded to these developments. Some major reviews of literature associated with the evolution of agroforestry concepts have been published by Nair (1993), Sanchez (1995), McDonald & Lassoie (1996), Nair & Latt (1998). For those not familiar with ICRAF, Box 1 highlights some of the major milestones in the evolution of ICRAF and its relationships in Southeast Asia.

Box 1. Milestones of ICRAF and Its Relationships in Southeast Asia.

In 1978, ICRAF (initially known as the International Council for Research in Agroforestry) was established in 1978 in Nairobi, Kenya, with a mandate to promote development and application of the concept of agroforestry in Africa. Much of this early work focused on articulation of the need for research and development that included interactions between fast-growing, multi-purpose trees and annual crops in farm fields. Linear intercrops that became known as "alley cropping" became particularly popular in R&D circles during this period, as well as an approach to problem-solving applied research known as "diagnosis and design" (D&D). Training in these areas began to include people from beyond the region, including SE Asia. While the general legitimacy of the agroforestry concept increased, it also became clear that many important research questions remained.

- In 1991, ICRAF joined the global network of international research centers operating under the Consultative Group for International Agricultural Research (CGIAR). Implications of this move had particular influence on two operational elements:
 - the types of activities conducted by the center shifted from a focus on advocacy to a focus on research. Thus, questions shifted from how to promote and expand agroforestry to how, when, and where agroforestry could be appropriate and effective in reducing poverty and improving rural livelihoods. During succeeding years, CGIAR emphasis on environmental issues encouraged ICRAF to increase attention to relationships between agroforestry and natural resource management.
 - the geographic focus of ICRAF on Africa expanded into a global mandate to conduct and support research on agroforestry worldwide. As part of initial efforts to meet this mandate, Southeast Asia became the initial research priority in Asia.
- In 1992, ICRAF established a Southeast Asia Regional Office to begin implementing these new directions in this region. Located in Bogor, Indonesia, its initial operations focused on developing collaborative research programs in Indonesia and the Philippines. With support from the government of Indonesia, this office is now co-located at the headquarters facility of the Centre for International Forestry Research (CIFOR), which is also a member institute of the CGIAR network.
- In 1995, activities in mainland Southeast Asia began, with a focus on montane mainland Southeast Asia (MMSEA) eco-region. Initial work in this eco-region has focused on northern Thailand, through establishment of a benchmark research site in a sub-basin of Chiang Mai province. Operations are closely integrated into Thai institutions, and are heavily dependent on the vision, experience and skill of our partners in Thailand.
- Late in 1999, the ICRAF Board of Trustees approved expansion with neighboring countries in MMSEA. Initial focus is on Lao PDR, Vietnam and Yunnan, China, where explorations and formulation of proposals are currently underway.

A. Evolving Agroforestry Concepts

One major feature of the development of agroforestry during recent years has been its continuing conceptual evolution (Sanchez 1995; Nair 1996; Nair & Latt 1998). During most of its early years of development, ICRAF used the following operational definition of agroforestry:

Early Definition: *Agroforestry is the intentional use of woody perennial plants in combination with annual crops and/or animals in close enough proximity that there are interactions among them.*

This definition provided direction for a growing body of research based on plant-level to field-level analyses closely related to cropping system studies, but focusing more specifically on tree-annual crop combinations. It might be fair to call the alternating strip intercropping that became known as 'alley cropping' the 'flagship' of this era, since the term 'agroforestry' is still synonymous with alley cropping in the minds of many research and development workers around the world.

As the emerging field of agroforestry began to mature, however, and analysis began to be taken as seriously as advocacy, it began to become apparent that plant competition and complexity were often important issues in such systems (Sanchez 1995, Nair & Latt 1998), and that wishful thinking would not make it go away. And, as global attention to environmental issues grew, natural resources management issues began to be placed on the agenda of the CGIAR system – a central reason for inclusion of ICRAF and CIFOR in the system.

Moreover, many researchers and development workers had already begun to realize that key issues really related to various configurations of trees in farms, communities and landscapes (National Research Council 1993, Sanchez 1995, Nair & Latt 1998). Based on a rather extended review and debate of the issues and implications involved, ICRAF staff and its research and development partners have now adopted the following new operational definition of agroforestry:

New Definition: *Agroforestry is a dynamic, ecologically based, natural resources management system that, through integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic, and environmental benefits for land users at all levels.¹*

One of the most important issues underlying this change in the operational definition of agroforestry is a shift from viewing agroforestry as a set of stand-alone field-level technologies to a view of agroforestry as a phase in the development of productive agroecosystems and landscapes. This new emphasis on ecology and agroecosystems implies needs for a better understanding in each of three important areas:

- 1) **Assessment of complex ecological effects** of both agroforestry and alternative land use systems. Examples would include effects on nutrient capture storage and cycling; water use and hydrological effects; biodiversity patterns and functions; carbon sequestration and greenhouse gas flux; and a range of processes that may become important at landscape levels when analyzing

mosaic patterns of land use, such as watershed functions, pest and diseases dynamics, wildlife habitat, etc.²

- 2) *Integration of socio-economic and biophysical processes*, such as relationships among plant diversity, productivity and profitability; agroforestry effects on stability and risk; effects of resource access, property rights and capacity of related local institutions; effects of infrastructure and market access; and effects of trade and economic policies, including interactions with employment in other sectors of the economy.³
- 3) Approaches for *improving predictions at larger scales and across time*, in order to better account for spatial variation and temporal dynamics; assess the broader potential for and expected environmental effects of agroforestry expansion; estimate the benefits and costs of intervention programs, both on local farmers and broader society; simulate the broader effects of proposed or potential alternative policy scenarios; formulate short, medium and long-term policy and implementation strategies.⁴

It is not accidental that the conceptual evolution of agroforestry is occurring in reasonably close parallel with the evolution in agricultural circles from commodity to cropping systems to farming systems to agricultural systems (National Research Council 1993, Sanchez 1995). There is also a parallel with emergence of the field of community forestry (McDonald & Lassoie 1996), and with growing concern about maintenance of environmental services at local to global levels (Nair & Latt 1998). It is clearly a logical development that agroforestry should take up the challenges that are emerging in areas where these three lines of interest and activity intersect

B. Incorporating Evolving Concepts into ICRAF's Organizational Approach

In order to respond to these changing concepts, conditions and mandate, ICRAF has made major changes in its organizational approach, and further changes are still in progress. ICRAF has published a summary review of progress during 1993-1997 (ICRAF 1998), as well as its current vision for the next 10 years (ICRAF 2000), and further developments are posted on the ICRAF web site (<http://www.icraf.cgiar.org>) as they continue to unfold. Particular emphasis is in 3 areas:

1) Reforming Research and Development Programs. Efforts by ICRAF to integrate new emphasis on ecology and agroecosystems, natural resource management, and global environmental issues, while at the same time seeking to build its capacity in advancing and assessing impacts of its programs, have required major reorientation of its overall programs. While this is still a 'work in progress', the current status of these efforts are reflected in its divisional and program structure, as follows:

Research Division

- *Natural Resource Problems, Priorities and Policies.* Focus is on characterization of regions and problems; valuation of agroforestry production and environmental services; multi-level policy analysis; and impact assessment. This is a relatively new program that draws on a range of fields and tools, including landscape ecology, economics and social sciences, in framing the content and directions of research programs, and in

identifying and helping prioritize gaps requiring attention by researchers in this and other research programs.

- **Domestication of Agroforestry Trees.** Focus is on the management, improvement, propagation, and field testing of agroforestry tree genetic resources. This program builds on earlier work on fast-growing and multi-purpose tree species, with increased attention to genetic diversity, including indigenous species and a wider range of tree characteristics, as well as genetic management at landscape and higher levels.
- **Ecosystem Processes and Management⁵.** Focus is on water-use; nutrient cycling; carbon and biodiversity; and local knowledge. This reflects continuing reformulation of biophysical process research essential for understanding, modeling and addressing key agroforestry issues at plant, field and landscape levels, as well as wider environmental issues at regional and global levels.

Development Division

- **Advancing Innovation and Impact.** Focus is on assessment of agroforestry innovations (both technological and institutional), policy dialogue, and appropriate improvements in germplasm supply and market development for agroforestry products. These efforts are conducted in close partnership with governmental and/or non-governmental development organizations active at national to local levels, who can help provide implementation pathways for promising innovations, as appropriate in each participating region.
- **Training and Education.** Focus is on group and individual training, developing agroforestry curricula and training materials, and information & creative support services, with increased emphasis on regionalization and localization of these services and products.

It may be worth noting that both research and development divisions now exist within ICRAF. While ICRAF is fundamentally a research institution, recent establishment of the development division is clear recognition of the need to more closely link our research with activities of our development-oriented partners. These efforts are intended to increase the effectiveness and efficiency with which research can help solve significant real-world problems underlying rural poverty and environmental degradation, with direct input to and feedback from those working in the implementation pathways necessary to achieve significant widespread impact.

2) Localizing Operations to Meet Regional Needs. Given the combination of a greatly expanded geographical mandate and the growing relative complexity of emerging programs, it became apparent that effective implementation of these new directions would require more operational decentralization at strategically selected locations. Thus, an eco-regional approach is being used to select priority locations where multi-disciplinary teams are building programs tailored to needs in those regions. Current regions include at least portions of the following countries:

Semi-Arid Tropics

- **African Sahel:** Burkina Faso, Mali, Niger, Senegal

Sub-Humid Tropics

- *East & Central African Highlands*: Kenya, Uganda, Ethiopia, Burundi, Rwanda & Madagascar
- *So. African Plateau (Zambezi Basin & Miombo Forest)*: Malawi, Tanzania, Zambia, Zimbabwe

Humid Tropics

- *Western Lowlands of Africa*: Cameroon, Nigeria
- *Equatorial Lowlands of Southeast Asia*: Sumatra, Indonesia
- *Hilly Uplands of Southeast Asia*: Mindanao, Philippines
- *Montane Mainland Southeast Asia*: North Thailand, Lao PDR, Vietnam, Yunnan, China
- *Amazon Lowlands of South America*: Brazil, Peru

3) **Building Strategic Partnerships and Alliances.** It also became apparent that for such a complex integrated approach to be effective, in terms of relevance, analytical depth, efficiency and potential impact, it would need to be conducted through partnerships at various levels of the systems hierarchy in participating regions. Thus, systematic efforts have been made to build interdisciplinary, multi-institutional efforts that include:

- *International level partnerships* through global CGIAR system-wide initiatives, such as the Alternatives to Slash-and-Burn (ASB) Initiative and the African Highlands Initiative (AHI), as well as alliances with programs under GCTE and other global scientific programs, independent international institutes, and regional programs and institutions.
- *National level partnerships* in participating countries, that may include various national research and extension system components, such as government agencies, academic and independent research institutions, non-governmental organizations, etc.
- *Local level partnerships* at selected benchmark areas, such as local government agencies and development projects, local governance institutions, local non-governmental organizations, etc.

As most research and development activities in Southeast Asia are being conducted in association with the global ASB Initiative, Box 2 presents some of the major highlights of this program.

Box 2. The Alternatives to Slash-and-Burn (ASB) Initiative [<http://www.asb.cgiar.org>]

The Alternatives to Slash-and-Burn Consortium works on two interlinked global problems: the environmental effects of forest destruction and persistent rural poverty in the tropics. Slash-and-burn is a technique used by a wide range of actors – in many sectors operating at many scales – who convert forests to other uses. Traditional long forest fallow rotational forms of shifting cultivation have demonstrated that slash-and-burn can be a tool in a sustainable land use system where population densities are sufficiently low. However, such traditional systems tend to come under heavy stress as rural population densities and market integration increase, and local innovation may or may not be able to maintain sustainability under such rapidly changing conditions. The focus of ASB is where environmental problems and poverty coincide at the margins of the remaining tropical forests.

Basic Goal: to identify and articulate combinations of policy, institutional and technological options that can raise productivity and income of rural households without increasing deforestation or undermining essential environmental services.

ASB is a global partnership of more than 50 institutions around the world. ASB was founded in 1994 as a system-wide program of the CGIAR. ICRAF is ASB's convening center and hosts the global coordination office in Nairobi, Kenya. ASB is governed by a global steering group of 12 representatives from participating institutions, and is chaired by ICRAF's Director of Research.

Sustained collaborative research by ASB partners has established benchmark sites in the western Amazon, the Congo Basin of Cameroon, the island of Sumatra in Indonesia, the northern mountains of Thailand, and the island of Mindanao in the Philippines. This network of sites, spanning the humid tropics, ensures that emerging views of local and national perspectives are grounded in reality.

Instead of the simple dichotomy, 'sustainable' versus 'unsustainable', ASB results indicate that a remarkably wide range of smallholder land use options are agronomically sustainable, depending upon the larger environmental and economic context. A key policy insight from this work is that these (locally) sustainable options differ significantly in their environmental impacts and their profitability and adoptability by poor households. While no forest-derived system is a perfect substitute for the global environmental benefits of forest conservation, ASB results suggest that a middle path of development exists – involving smallholder tree-based systems and community-based forest resource management – that could attain an attractive balance between the environment and development. Whether or not this balance can be achieved depends on a range of policy and institutional innovations, including means to effectively protect natural forests and to compensate households for foregone opportunities.

Objectives of the new phase (2000-2005) of ASB are:

1. To develop replicable assessment techniques and policy-relevant databases on local environmental services that underpin the sustainability, resilience and stability of rural production systems at various scales.
2. To help meet the needs of various stakeholders for methods they can use to monitor and understand the impacts of ongoing change and to develop workable responses under dynamic and uncertain conditions.
3. To identify means and build capacities to manage inevitable conflicts among stakeholders at various scales, including mechanisms to compensate local people for foregone opportunities.

II. Applying New Agroforestry Concept and Approach in Mainland Southeast Asia

Agroforestry systems in mountain watershed areas are a major focus of ICRAF research in Asia (Lai & Garrity 1999). The following sections describe how the evolving agroforestry concepts and approaches discussed above are being applied in the context of ICRAF and ASB activities in mainland Southeast Asia, with a focus on research activities being conducted in a mountainous watershed of northern Thailand. Major initial components of this approach include: 1) characterizing the eco-regional context; 2) establishing a partnership framework and benchmark research site; 3) identifying key driving forces, patterns of change, and policy-related issues; and 4) building an action-oriented agroforestry systems research program. A summary of initial ASB-Thailand research findings is expected to be published during late 2001, and posted on a web site that will be accessible through the main ICRAF web site.

A. Characterizing the Eco-Regional Context

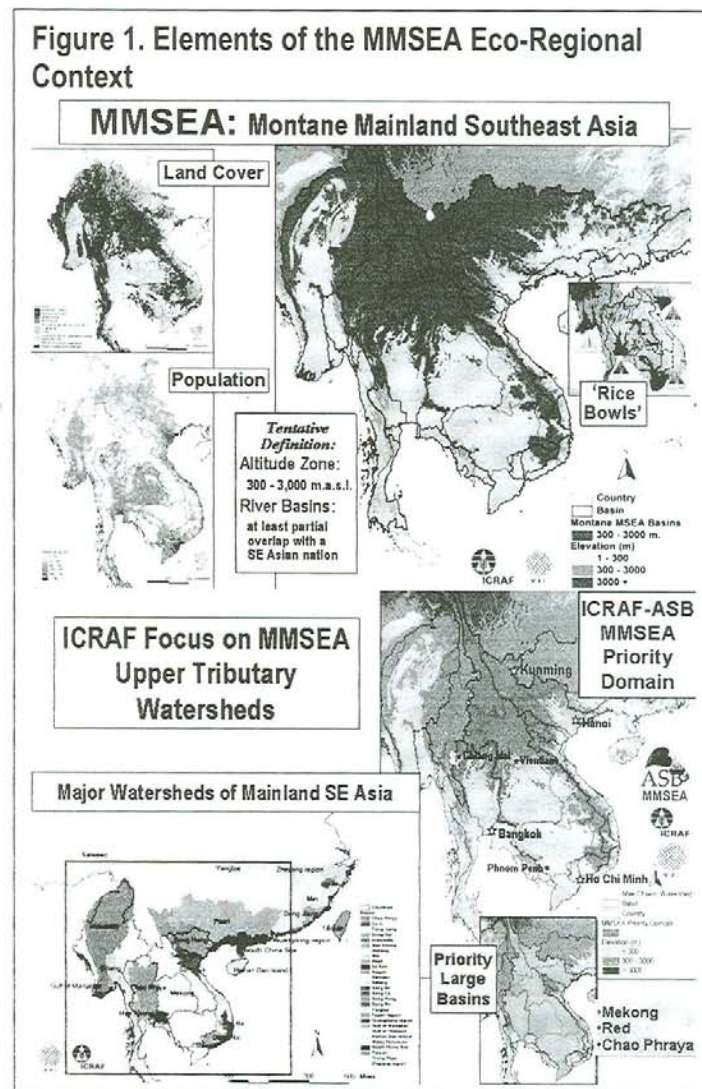
Both ICRAF and the ASB Initiative have framed their approaches here in terms of the Montane Mainland Southeast Asia (MMSEA) eco-region. As the maps in Figure 1 indicate:

- Major societies in mainland Southeast Asia are centered on major river valleys and lowland areas, where land has largely been cleared of forest and converted to agriculture.
- Agriculture in lowland zones was the primary target and beneficiary of Green Revolution technology.
- Agricultural production in these zones includes major 'rice bowl' production areas in the lower reaches of the Red, Mekong, Chao Phraya and Irawaddy Rivers. In addition to feeding more than 200 million people, these include main areas of production for the world's two largest rice exporting nations (Thailand and Vietnam).
- Lowland zones are also where centers of political power are located, and where rapid economic growth is focused, particularly in growing urban-industrial mega-cities.

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

While both are clearly important, neither river basin nor nation state boundaries have been found adequate by efforts to identify and articulate MMSEA as an eco-region. At the recent (July 2000) second international symposium on MMSEA hosted by Chiang Mai University, we proposed the simple tentative definition indicated and mapped in Figure 1 to define a domain that encompasses most all of the areas under discussion (Thomas & Saiphothong 2000). We are currently soliciting discussion

and debate on the adequacy of this definition, as well as suggestions about how it can be further improved and refined. We have also further defined our ICRAF-ASB priority domain for work at this stage, which focuses on montane portions of the Mekong, Chao Phraya, and Red river basins, as also indicated in Figure 1.



Key characteristics of central importance that are commonly found across this domain include:

- Watershed headlands that include most remaining forest cover, but high rates of deforestation
- Diverse ethnic populations with relatively high growth rates, poverty, and poor access
- Subsistence agriculture, often based on shifting cultivation systems under stress, and sometimes including narcotics production
- Growing development gap with lowland populations, and priority targets areas for both development and environmental policy

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

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

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

B. Establishing a Partnership Framework and a Benchmark Research Site

ICRAF and ASB operations in Thailand operate under a Memorandum of Agreement approved by the Ministerial Cabinet of the Royal Thai Government, which is a full member of the CGIAR system. Implementation responsibility was delegated to the Ministry of Agriculture and Cooperatives, and the Royal Forest Department (RFD) was assigned to serve as the responsible counterpart agency. In order to provide an official framework for an ASB-Thailand consortium, the RFD established the Northern Mountain Region Agroforestry Systems Research and Development Project, which includes both a national steering committee and a working level administration committee. The Director-General of RFD serves as chairman of the ASB-Thailand Consortium. In addition to the RFD and ICRAF, key participants come from Thai universities, development projects in the benchmark research area, and other partnerships in the global ASB consortium.

Research conducted under ASB-Thailand gives preference to interdisciplinary, multi-institutional efforts to fill knowledge gaps and solve policy-relevant problems associated with land use issues in mountain watersheds of the northern region. Initial research activities have emphasized efforts to build a knowledge base of the five

aspects of land use alternatives indicated in Figure 2. An additional spatial analysis and modeling component seeks to integrate this knowledge and provide the six types of outputs also indicated in Figure 2. A further component links these efforts with additional research and information exchange at several international levels, through our South-east Asia policy research program (Tomich, Thomas & van Noordwijk 1998), through the global ASB working groups, and through partnerships with organizations such as the World Resources Institute (WRI)⁶ and the SE Asia Network for Agroforestry Education (SENAFE)⁷.

The Mae Chaem watershed in Chiang Mai Province was selected as the benchmark research site to serve as the main focus for these efforts, conducted in association with the multi-institutional ASB-Thailand consortium. As can be seen in the nested maps in Figure 3, the Mae Chaem sub-basin is an upper tributary in the Chao Phraya river system. It covers about 4,000 square kilometres and contributes about 40 percent of the flow of the Ping River, and about 16 percent of the flow of the Chao Phraya River.

Figure 2. ASB-Thailand Partnerships

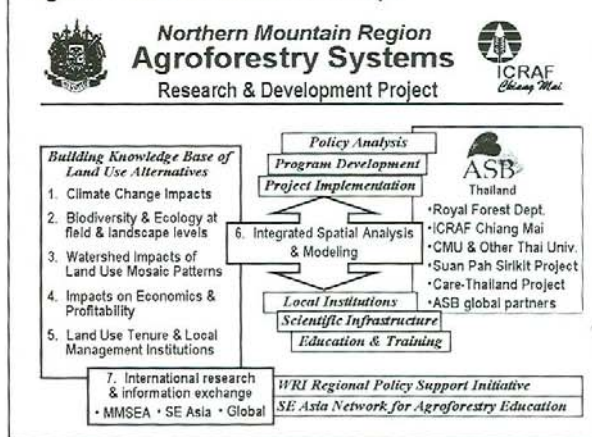
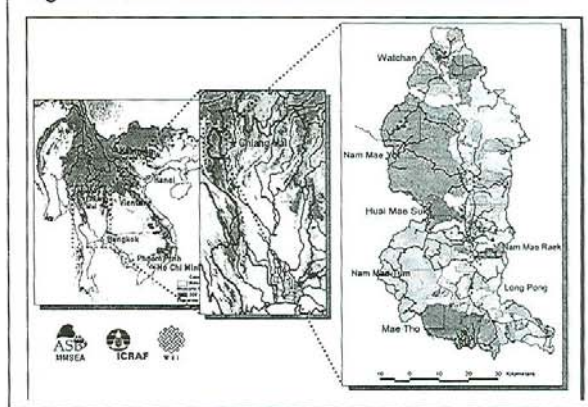


Figure 3. Mae Chaem Sub-Basin Benchmark Site



C. Identifying Key Driving Forces, Patterns of Change, and Policy-Related Issues

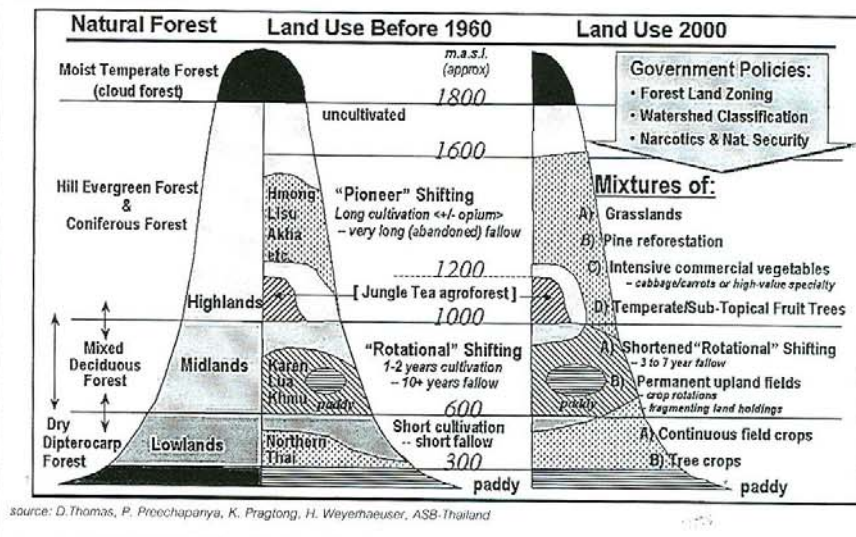
Underlying many of the land use issues in upper tributary watersheds of northern Thailand is the convergence of various pressures and incentives that are helping drive land use change (Thomas 1996):

- Rapid population growth in mountain communities has combined with immigration from neighboring countries (as a safe haven or an economic magnet) to increase land pressure.
- Expansion and commercialization of agriculture has followed from both highland opium crop replacement programs, and expansion of lowland agro-industry into upper tributary valleys.
- Roads have brought market access to many remote areas, while registration of minority communities and media & education services are increasing opportunities for their integration into national society
- Expansion of tourism and urban-industrial society are displacing agriculture and bringing new pressures and competing claims to mountain areas, including land speculation.
- Changes in forest policy have increased emphasis on conservation and brought expansion of national parks and wildlife sanctuaries, as well as protected watershed forests, which preclude formal recognition of land use claims in most mountain areas. Additional policies also target illegal logging, narcotics production and transport, and national security issues.
- Rapid growth of environmental awareness in the general public has also been associated both with a populist element calling for more local control over natural resource management, as well as with a more 'deep green' element that believes local communities should be excluded from protected areas for the longer term benefit of larger society. Tension between these elements is substantial and growing, and occasionally breaks out into open conflict.

The generalized diagram in Figure 4 depicts how various major land use practices vary by altitude and over time under conditions found in North Thailand. Somewhat similar altitude zonation based on lowland, midland and highland zones, and general trends of change are observed across the MMSEA eco-region. You will note that:

- Forest types, ethnic composition, and land use practices vary by altitude zones.
- In the past, altitude zones and land use domains of ethnic groups were more distinct.
- Opium production and the 'most destructive' traditional forms of shifting cultivation have generally been associated with the highland zones.
- Midland traditional systems are associated with rather complex forest fallow systems that require sophisticated knowledge of ecological relationships.
- Incentives and pressures for change during recent decades have brought increased competition over land resources, 'degradation' or conversion of traditional systems, increased agricultural commercialization based on 'lowland' technologies, and larger areas cleared of forest at any one time.
- Very little R&D has aimed at understanding or transforming traditional systems

Figure 4. Generalized Patterns of Mountain Area Land Use Change in North Thailand

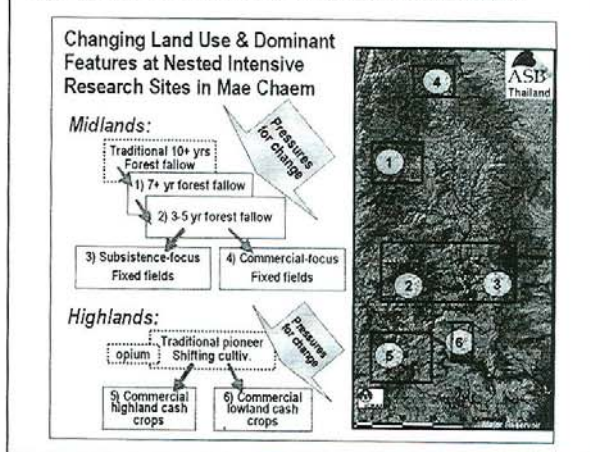


This generalized pattern of change is well represented in the Mae Chaem benchmark site. Figure 5 indicates major stages in these transformations and nested sites within the sub-basin where they are currently present. It should be noted that full traditional systems in either the midlands or the highlands can no longer be observed in this sub-basin.

Major policy-related issues in Mae Chaem and similar upper tributary areas include:

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

Figure 5. Major Land Use Patterns in Mae Chaem



- 2) needs of poor mountain communities to have secure access to resources and services that will allow them to improve their food security and livelihoods
- 3) associated growing upstream-downstream tension and conflict.

D. Building an Action-Oriented Agroforestry Systems Research Strategy

Clearly, agroforestry systems research in North Thailand does not begin from scratch or take place in a vacuum. In addition to numerous traditional forms of agroforestry, various projects and programs have been seeking to promote various forms of agroforestry fields and components of agroforestry landscapes. Thus, one logical initial activity has been to put together a classification of generic forms of agroforestry fields and landscapes in northern Thailand (Thomas 1996), as summarized in Figure 6.

Field-based systems are those where the management unit focuses only on a single field, whereas landscape-based systems are also managed at a level that includes many fields and often common land areas in a broader landscape unit. Field-based and landscape-based systems are both divided into sequential and simultaneous types of systems, depending on their basic approach to dealing with plant competition (Sanchez 1995, Thomas 1996, Nair & Latt 1998, Lai & Garrity 1999). It can be noted that:

Figure 6. Generic Types of Agroforestry Systems in North Thailand

Field-Based Systems (unit = single field)		Source in Thailand	Status in Thailand
Sequential Systems (<i>maximum growth rates at different times</i>)			
Pioneer Shifting Cultivation			
mature forest	repeated cropping 'abandon'	indigenous	very rare
Relay & Transitional Intercrops			
(young trees + crops)	forest or orchard	old (taungya)	establish plantations & orchards
Rotational Systems			
-- <i>Annual - Perennial Crop Rotations</i> [annual short perennial crop]		unknown	unknown
Simultaneous Systems (<i>grow at same time competition / trade-off effects</i>)			
Regular Pattern Systems			
-- <i>Row Pattern:</i> e.g. orchards, alley cropping, contour hedgerows		induced	promoted
-- <i>Linear Pattern:</i> e.g. boundaries, live fences, windbreaks		local	promotion
Mixed/Irregular Pattern Systems			
-- <i>Home Gardens:</i> mixed species, age; multi-storey		indigenous	promoted
-- <i>Complex Agroforests:</i> very diverse, forest-like; e.g. miang tea		local	little study
-- <i>Silvo-Pastoral Systems:</i> trees, palatable shrubs, pasture		little study	little study

Landscape-Based Systems (unit = many fields + common land)	Source in Thailand	Status in Thailand
Sequential Systems (<i>maximum growth rates at different times</i>)		
Forest Fallow Swidden [1-2 crops (long) natural fallow] + protected areas	indigenous	degrading
Composite Forest Fallow Swidden permanent paddy + [1-2 crops (long) natural fallow] + protected areas	indigenous	degrading
Intensified Rotational Systems		
-- Improved Fallow Management		
[1-2 crops short improved fallow] + protected areas (+/- paddy)	local	little study
-- Annual - Perennial Crop Rotations		
[annual short perennial crop] + protected areas (+/- paddy)	unknown	unknown
Simultaneous Systems (<i>grow at same time competition / trade-off effects</i>)		
Community Mosaic Systems		
multi-level management [household + community + local govt]		
-- Watershed Mosaic: sited / managed to preserve watershed functions		
permanent fields (annual + perennial) + perm. watershed forest	induced	emerging promoted
-- Protected Forest Mosaic: sited / managed to preserve forest services		
permanent fields (annual + perennial) + protected forest	local & induced	emerging

- Most sequential systems are degrading, extinct or little studied, with the exception of the taungya system that is still sometimes used as a transitional phase in the establishment of orchards or forest plantations. Sequential annual-perennial crop rotations are possible, but actual examples have not yet come to our attention in northern Thailand.
- Although improved fallow management is at least an interim alternative being investigated in some areas of MMSEA (Cairns & Garrity 1999), emphasis of most projects and promotion campaigns in northern Thailand has been on the transformation of sequential systems into simultaneous ones.
- While most field-based simultaneous systems are among the most familiar forms of agroforestry, such as alley cropping, contour hedgerows, boundary plantings, silvo-pastoral systems, and home gardens, the category of complex agroforests is relatively new. Although the most popular examples of this quite newly-recognized form are traditional systems in Sumatra – such as ‘jungle rubber’ and the damar agroforests (Michon & de Foresta 1997, 1999; Tomich et.al. 1998) – the ‘miang’ tea gardens of northern

Thailand and their recent variants are also in this category (Preechapanya 1996).

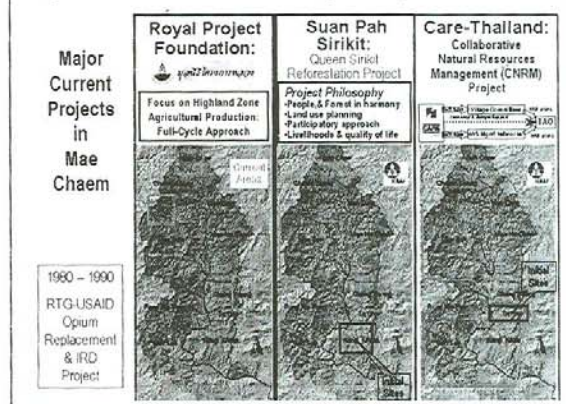
- One of the most interesting contributions of agroforestry in northern Thailand is the emergence of simultaneous landscape-based forms of agroforestry that have been tentatively classified as community mosaic systems. These systems are basically derived from traditional sequential composite forest fallow swidden systems that have been transformed as a result of land use pressures and opportunities found in northern Thailand. The major thrust of this transformation has been the conversion of the forest fallow shifting cultivation component into permanent fields (which sometimes become agroforestry fields), coupled with conversion of remaining fallow areas into community managed and/or protected permanent forest compartments in the landscape mosaic.

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

The next step toward building an action-oriented agroforestry systems research program in northern Thailand has been to learn from the previous and current pilot projects that have been and are being conducted in these areas. Figure 7 indicates projects that are serving as major sources of pilot project experience in the Mae Chaem watershed. These are all efforts that build on 20 to 30 years of experience in working with communities on issues related to agriculture and/or natural resource management in the area. This work has evolved substantially from its early forms, in parallel with changing conditions and environmental awareness in the broader Thai society. It is our goal to help accelerate this process through the application of new scientific approaches and tools.

Additional knowledge was gained from reviewing existing literature and experience of our research partners at the RFD and other government agencies, academic institutions and independent research organizations. Building on the experience and insights of our research and pilot project partners, we developed an overall action research strategy with the components indicated in Figure 8. The following sections briefly summarize the orientation of work being conducted in conjunction with each of the analytical overlays at various R&D levels.

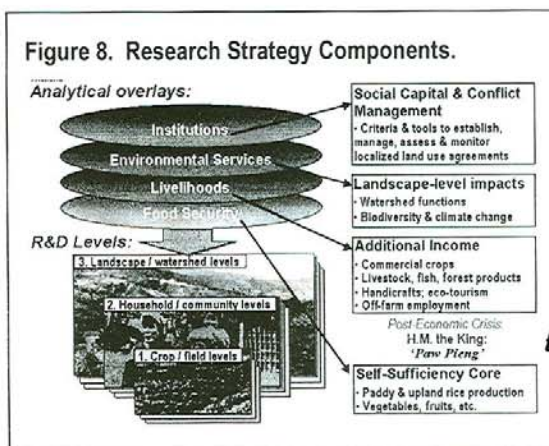
Figure 7. Sources of Pilot Project Experience



1) Food Security and Livelihoods Overlays

Production and Livelihood Strategies. Research in this area centers on understanding and assessing household production and livelihood strategies, as well as the benefits, costs, constraints and land use patterns associated with them. Field-level production practices need to be assessed within a household and community context, and compared across the larger range of prevailing conditions.

Households in the region do not focus only on production of a single crop. Indeed, they engage in what may be called a 'portfolio' of production components, which are chosen from the opportunities available to them based on their objectives, constraints and perceptions of expected returns. Household resources are allocated among portfolio components, and household welfare is tied to their overall output. Major general categories of components related to the performance and impact of alternative land use systems under investigation by ASB-Thailand would include:



- **Rice.** Since local development projects indicate most villages are experiencing deficits in subsistence rice production, and since upland rice is the largest agricultural component of shifting cultivation systems, rice and food security are important policy concerns. Expansion of paddy area, where topography and water resource access allow, has been supported by various development programs. Compared to upland rice production under short-fallow or permanent field conditions, paddy appears to offer substantially higher productivity per unit of both land and labor, even when the area required for regenerating forest fallow fields is ignored. Very preliminary evidence indicates this difference in relative returns may increase as upland fallow cycles become shorter, possibly reflecting decreased soil fertility and increased weed competition, and efforts to offset decreases through increased labor and/or chemical inputs. We hope that collaboration with current and perhaps additional research partners can help us understand more clearly the scope for improving subsistence rice production under the conditions encountered in upper tributary areas like Mae Chaem.
- **Cash Crops.** Cash crops are being promoted through various project and private sector channels, usually on permanent fields where intensification is intended to reduce narcotics production and pressure on remaining forest lands. Although a substantial range of crops appear suitable for various of the ecological niches found in complex mountain landscapes, a number of other factors also affect the viability and profitability of their production. We plan to expand economic assessments of various major examples, and hope to cooperate with newly launched efforts by the

Royal Project Foundation and Chiang Mai University researchers to apply spatial information systems technology to assist in assessing site qualities and helping reduce risks, hazards and negative externalities that can be associated with these systems. There is also scope for cooperating with efforts to promote simple agroforestry through the integration of fruit trees, shade trees and/or contour or boundary plantings in agricultural fields.

- **Forest Products.** Although research and development activities in this area are a relatively recent development, quite a number of ideas are now emerging for further work. One area of interest relates to the substantial number of natural products said to have been collected from regenerating forest fallow fields. As fallow cycles grow shorter – or are stopped completely by conversion to permanent fields – some say that important products are now becoming scarce. Similar arguments are made about various foods, medicinals and materials traditionally derived from natural forest sources. We hope to collaborate in studies that investigate the nature and role of these products, and potential opportunities – perhaps involving tree domestication⁸ – that may be emerging. Another area that has received very little systematic study is forest grazing of cattle. There are some indications that this is an important livelihood component for various mountain households and communities, and that there may be a stocking level threshold below which livestock may have some beneficial effects in some types of forest, especially in areas where wildlife levels have declined.
- **Home Gardens and Agroforests.** Most current examples in northern Thailand of complex home gardens are in lowland communities, while complex agroforests are primarily limited to ‘miang’ tea plantations embedded in hill evergreen forests (Preechapanya 1996). Several development projects, including some in Mae Chaem have been promoting home garden approaches in mountain communities. We intend to cooperate with these efforts in exploring the potential of these efforts. Moreover, some exceptionally innovative farmers in one area outside of Mae Chaem are transforming their miang plantations in a way that may indicate an additional agroforestry alternative. These efforts are directed at gradually replacing many or most of the natural forest trees with a very diverse population of trees yielding fruits or other economic products, while maintaining a very complex structure that mimics the natural forest (Tanpanich 1997). We plan to cooperate in study of these efforts to see if they may be appropriate in other areas.
- **Non-farm and off-farm income.** Particularly in poor areas where there are heavy constraints on expanding or intensifying agricultural production or capture of forest products, during the economic boom period off-farm wage labor was becoming an increasingly important component of local livelihood strategies. The economic recession is said to have had a rather serious negative impact on this component, and the consequences for land use systems are not clear. Some projects, particularly the Suan Pah Sirikit project have sought to counter some of this effect by helping facilitate upgrading and expansion of handicraft production for commercial markets. Our main interest in issues such as these are to collaborate in investigations that can help clarify their impact on local livelihoods and land use decision making.⁹

One tool very useful in assessing both component practices and the portfolio of components making up a household or village strategy, is the Policy Analysis Matrix

(PAM) approach (Monke & Pearson 1989). Several initial studies have been conducted by our partners at CMU, Mae Jo University and the Royal Forest Department¹⁰ using the PAM approach, and we plan further expansion of this line of investigation. The PAM technique has several attractive features, such as a simple but well-structured format for cataloging input-output and price data, that lends itself to easy calculation of private operator profitability, as well as social profitability – divergences between the two help identify economic policy distortions that serve as subsidies or taxes on these operations.

A second line of analysis is expected to begin next year, which will center on application of multi-agent system modeling (MAS) of local land use decision-making. This work will be led by Dr. Benchaphun Ekasingh and her colleagues at Chiang Mai University, working in collaboration with a CIRAD-IRRI team led by Dr. Guy Trebil (see paper in this volume).

2) Environmental Services Overlay

Environmental services associated with various types of agroforestry systems are an increasingly important area of research, especially as they affect biodiversity, climate change, and watershed functions (Tomich et.al. 1999). The dominant policy concern related to environmental services in northern Thailand centers on watershed services. Objectives are to maintain the highest possible year round supply of clean water for downstream populations, and the lowest possible levels of siltation in downstream water resources and distribution infrastructure. Protection of biodiversity and forest resources are important secondary concerns, particularly in areas in or near protected parks and wildlife sanctuaries. The importance of protected watershed zones in upper tributary watersheds such as Mae Chaem is reflected in the data in Figure 9. While at the national level 50 percent of the land is classified as suitable for general agriculture and 26 percent is protected watershed, proportions at the northern regional level shift to about one-third of the land for general agriculture and one-half for protected watersheds. In an upper tributary like the Mae Chaem sub-basin, however, about 90 percent of the area is protected watershed, while only 1 percent is for general agriculture; while 12 percent of the area is 'usable', 92 percent of that area is restricted to production employing trees and conservation farming.

Moreover, concern in downstream communities and national society about negative impacts that changing land use patterns in mountain areas are having on watershed services has already become a major source of tension, that is occasionally erupting into confrontation and conflict between upstream and downstream

Figure 9. Protected Watershed Zones

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

communities. Thus, our research plans to help address these issues through three lines of activity:

- ***Higher-Resolution Watershed Impact Assessments.*** Despite its theoretical underpinnings, the original watershed classification maps were constructed manually using very coarse assessment and large minimum mapping units. One result is that there are numerous areas in complex mountain terrain that are classified as protected watershed areas, but contain relatively small pockets of land that technically meet criteria for classification in a less restricted category. And quite often it is exactly such areas where mountain communities have located their agricultural or agroforestry fields. Thus, we are working with ASB-Thailand partners to conduct more detailed assessment of land use change in pilot areas within areas currently classified as protected watersheds, but using higher resolution GIS and remote sensing techniques. The hypothesis of this work is that this approach can help to substantially reduce land use conflict with a significant number of communities.
- ***Impacts of Agroforestry Landscape Mosaic Patterns.*** While various studies of erosion or hydrological effects of land use practices have been conducted at field plot level or in single use small catchments, relatively little empirical study has been conducted on the processes and importance of lateral flows and filters (van Noordwijk and Ong 1996; van Noordwijk, van Roode, et.al. 1998) in catchments containing the type of complex land use mosaic patterns actually observed in many areas of northern Thailand and MMSEA (Garrity and Agus 2000). Thus, we are collaborating with RFD research partners and Dr. Meine van Noordwijk in conducting studies in several small instrumented sub-catchments with different mosaic patterns of land use. Nested studies within these sub-catchments will be linked with computer modeling to help clarify the role and importance of filter strips and channels in regulating lateral transfers within these mosaic landscape patterns.
- ***Community-Based Monitoring of Watershed Services.*** When one listens to the often very heated debate regarding the negative impacts of changes in upstream land use on downstream water resources, one of its most striking characteristics is the absence of any empirical data. While occasional reference may be made to indicators based on local traditional knowledge (Preechapanya 2000), its utility is often lost since the opposing party is a member of a different ethnic group that does not subscribe to the same body of traditional knowledge. Moreover, outside 'experts' who are called in to assess such impacts are often not trusted by one or both sides. Thus, we are working with our research partners, led by Dr. Pornchai Preechapanya, to test the hypothesis that some relatively simple science-based methods for measuring, monitoring and managing impacts of land use change on watershed services may help efforts to reach common understandings and reduce tension and conflict at local inter-community, sub-catchment and sub-district levels. Emphasis is on participatory tools that can be used by local communities, NGO field workers, and local officials to measure stream flow, key climatic data, erosion and sedimentation, as well as proxy

measures of water quality using biological indicators and turbidity. Additional activities are exploring local knowledge associated with watershed management, including plans to employ the WinAKT expert systems approach (Sinclair & Joshi 2000).

3) Institutions Overlay

Institutional aspects of agroforestry systems are an increasingly important focus of research and development activity (Garrity 1999a, 1999b). The emergence of community mosaic agroforestry systems in Thailand has been closely linked with institutional innovations occurring in the same pilot areas:

- One of the important contribution of pilot research and development efforts in northern Thailand during the last decade has been development of what has become known as the participatory land use planning process. Initially formulated and tested through collaboration between staff of the Royal Forest Department and Chiang Mai University (Tankimyong et.al. 1994), this approach, with its village-centered negotiations, scale mapping and 3D model tools, and locally-formulated agreements and enforcement mechanisms, has now been tested, adapted and further refined by a substantial range of pilot development projects. While it has helped demonstrate the potential of localized land use agreements, however, there is still no legal basis for official recognition of such agreements in most mountain areas of north Thailand.
- A second, closely related line of very promising activity centers on local watershed management networks who have scaled up participatory land use planning to the multi-village, multi-ethnic group sub-catchment level. Again, while variants on this approach are now becoming quite widespread, there is still no legal basis or standing for such organizations or the agreements they reach.

Despite the apparent official dead-end for these institutional innovations, there may still be light at the end of the tunnel. During the last few years, Thailand has embarked on a process of profound change in the legal and institutional context within which innovative efforts such as these have been working:

- Foremost in this process is the 1997 national constitution that is filled with provisions promoting decentralization and participatory democracy, including rights for local communities to participate in management of natural resources in their area.
- The constitution also reinforces additional legislation that is transforming local tambon (sub-district) councils into, much more fully elected and constituted local governance organizations (TAO: tambon administrative organizations) with substantially more authority over what does and does not happen within their local domain.
- Long-delayed community forestry legislation may be taken up next year by the first Parliament elected under the procedures of the new constitution. If passed, it could provide an important additional channel for communities in

upper tributary watersheds to obtain official recognition of negotiated local land use plans in protected watershed zones.

While all this appears very promising, the institutional, planning and management capacity of many TAOs, especially in situations such as those found in upper tributary watersheds, is still often very weak. While projects such as those conducted by our partners Care-Thailand and Suan Pah Sirikit in Mae Chaem, there is also still a shortage of concepts and tools that can allow them to put together the emerging pieces into a coherent system that can meet both their needs and the legitimate concerns of increasingly vocal and aggressive downstream communities and national society (Thomas et.al. 2000).

Thus, ASB-Thailand is collaborating with our development partners in Mae Chaem to build and test a pilot spatial information system that can help provide linkages and tools to bring participatory land use planning, community-based watershed monitoring and work of TAO and watershed management networks into a more coherent system. Basic components and relations in the system are depicted in Figure 10.

Operationally, it will include a basic node located in Mae Chaem that will allow local development workers to interact with local leaders and officials, produce custom maps to meet their needs, and input and manage data on local plans and agreements. Local agreement data, such as that shown in Figure 11 from preliminary testing in the Mae Raek sub-watershed, will be transmitted to a node in Chiang Mai where it will be merged into a larger GIS for monitoring of actual land use by remote sensing. 'Hot spots' will be identified for attention and remedial action where actual land use does not correspond with plans. We also hope to georeference watershed monitoring locations and consolidate data

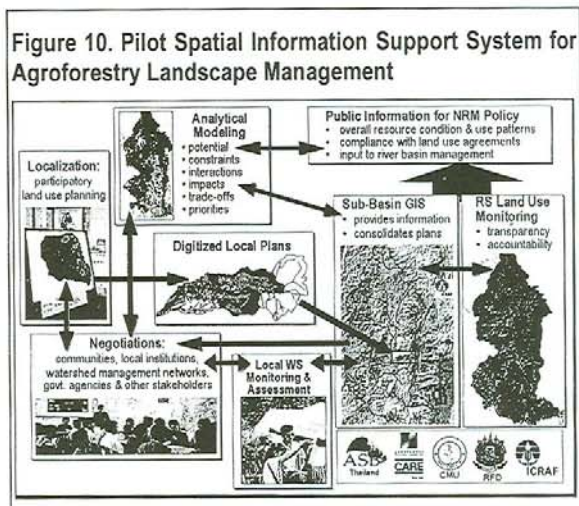
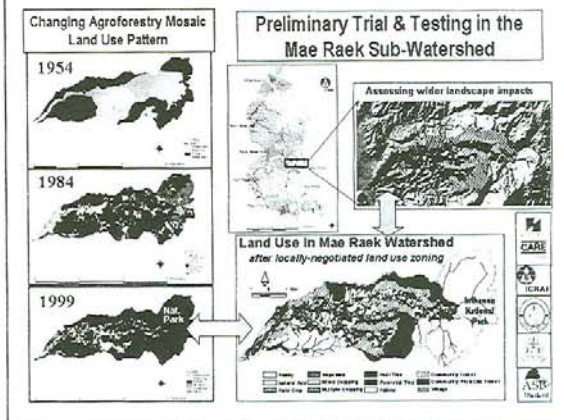


Figure 11. Pilot Spatial Land Use Assessments



collected by local communities to improve overall environmental monitoring. This system will build on other pioneering work in Thailand (e.g., Ekasingh et.al. 1996), and it should be able to interface with various other levels of planning, management, monitoring and analysis, and provide sufficient transparency and accountability to meet the concerns of critics.

In summary, agroforestry is emerging from its early field-based focus on alley cropping to take up the complex challenges associated with understanding, assessing and influencing the broad array of forces and processes that affect trees and their roles in producing goods and services provided by agroforestry fields and landscapes. We would greatly welcome your contributions to this process.

Notes:

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- ¹ This currently used definition (ICRAF 1998, 2000) is a more recent refinement of the initial reconstruction proposed by Leaky (1996).
 - ² A few recent ICRAF-associated examples in this area are Cannell et.al. (1996), Ong & Huxley (1996), Murdiyarso & van Noordwijk (1997), Vandemeer et.al. (1998), van Noordwijk et.al. (1998a), and Palm et.al. (2000).
 - ³ A few published examples of efforts in this direction involving ICRAF SE Asia staff include van Noordwijk & Tomich (1995), van Noordwijk et.al. (1997), Garrity (1999a), Tomich et.al. (1998, 2000).
 - ⁴ A few published examples of associated work involving ICRAF SE Asia staff include van Noordwijk et.al. (1998b), Tomich et.al. (1998) van Noordwijk (1999), Thomas et.al. (2000).
 - ⁵ Tentative new title agreed upon during the September 2000 ICRAF program review held in Nairobi, Kenya.
 - ⁶ Primarily through our partnership with WRI's Regional Environmental Policy Support Initiative (REPSI), whose regional base is located within the ICRAF Chiang Mai office.
 - ⁷ For an indication of the directions of SEANAFE activities, see Rudebjer & del Castillo (1999).
 - ⁸ Some of the recent efforts to develop an approach for plant domestication research in SE Asia are discussed in Roshetko & Evans (1999).
 - ⁹ For example, ICRAF staff are providing collaborative support for a doctoral study on the role that social capital played in helping villagers to cope with the impact of the Asian economic crisis in a sample of 12 ethnic Thai and Karen villages in Mae Chaem. This work is part of a broader project jointly led by Dr. Ian Coxhead of the University of Wisconsin and Dr. Mingsarn Kaosa-ard of TDRI and the CMU Faculty of Economics. Findings are expected to be published during early 2001 as: Geran JM. Coping with Crisis: Social capital and the resilience of rural livelihoods in northern Thailand. Ph.D. dissertation. University of Wisconsin, Madison. Further information is also available on a website [<http://www.aae.wisc.edu/coxhead/projects/>]
 - ¹⁰ Research findings are contained in unpublished reports to ICRAF Chiang Mai that are expected to be available on a new ICRAF Thailand web site during 2001.

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