1. Land Cover: Forest Cover Map of Insular Southeast Asia at 1 : 5,500,000, derived from SPOT-Vegetation satellite images. Tropical Ecosystem Environment Observation by Satellites (TREES).
2. Elevation: The GTOPO30 Global 30 Arc Second Elevation Data Set. http://edcwww.cr.usgs.gov/landdaac/gtopo30/gtopo30.html
3. Population: GIS data sets reflecting population counts and administrative unit boundaries have been integrated from a variety of national sources and harmonized by Uwe Deichmann and the Center for International Earth Science Information Network (CIESIN), Columbia University and World Resources Institute, "Gridded Population of the World: CD-ROM provisional release of updated database of 1990 and 1995 estimates," Palisades, NY and Washington, DC: November 22, 1999.
4. Annual Rainfall ArcAtlas : Our Earth Environmental Systems Research Institute (ESRI)

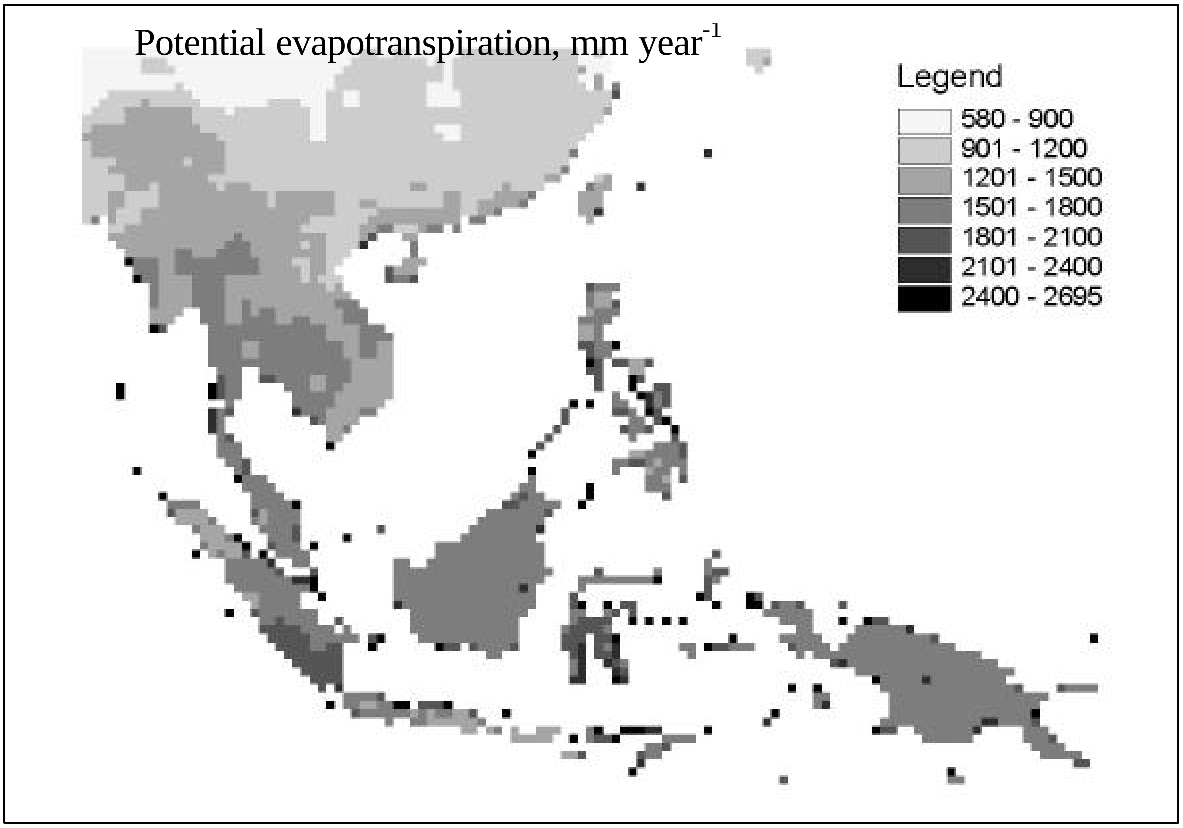


Figure 2.3 E Potential evapotranspiration[5] for southeast Asia

5. UNEP/GRID Dataset GNV183. Monthly Potential and Actual Evapotranspiration and Water Balance. The data set covers the whole world at a resolution of 30 min (approximately 55 km) and is representative of a time period extending from, approximately, 1920 to 1980. This compilation was published in 1994 by C.H. Ahn and R. Tateishi. Monthly Potential Evapotranspiration was estimated applying the Priestley-Taylor formula to the following global datasets provided by US EPA (Global Ecosystems Database) and UNEP/GRID Geneva:
   - Edwards Global Gridded Elevation and Bathymetry (ETOPO5)
   - IIASA Mean Monthly Cloudiness: LCCLD01 - LCCLD12.
   - Matthews Seasonal Albedo: MALBFA - MALBWN, from which monthly values were interpolated.
   - Legates and Willmott Monthly Average Surface Air Temperature and Precipitation (re-gridded): LCWPR01-LCWPR12, LWTMP01- LWTMP12.

Mean E_{pot} in mm day^{-1} per month	Jan	Feb	Mar	Apr	May	Jun	Jul	Agt	Sep	Oct	Nov	Dec
Sumber Jaya (Lampung, Sumatra, Indonesia)	5.0	5.3	5.5	5.4	4.8	4.5	4.6	5.2	5.7	5.8	5.5	5.2
Mae Chaem (northern Thailand)	3.4	4.3	5.3	5.9	5.7	4.9	4.6	4.4	4.4	4.3	3.7	3.1

Most of mainland Southeast Asia has annual rainfall less than 1.7 m year^{-1} and a potential evapotranspiration of 1.2-1.8 m year^{-1} (4 – 5 mm day^{-1}) that approximately matches rainfall. Since river discharge is directly linked to the degree that actual evapotranspiration falls short of potential evapotranspiration, in these situations relatively small changes in water use between different types of vegetation or land use can have relatively large impacts on total river discharge. In order for vegetation to approach meeting the potential evapotranspiration, considerable storage of water from the rainy into the dry season is needed; substantial areas of deciduous and mixed deciduous natural forest reflect adaptation to areas where such storage is inadequate.

Thus, man-made reservoirs of impounded river water, built to provide irrigation water for the dry season, as well as year-round hydro-electricity, are a major feature of the hydrological landscape. Indeed, a resulting distinction between areas above and areas below a reservoir may be more informative than the more common ‘upland’ – ‘lowland’ split.

In most of insular Southeast Asia, both potential evapotranspiration and rainfall are higher than on the mainland, but rainfall (with large areas between 1.7 and 3.4 m year^{-1}) generally exceeds potential evapotranspiration (1.5 - 2.1 m year^{-1} or 5 – 6 mm day^{-1}). This, together with a larger number of wet months, results in conditions where vegetation can more easily meet the potential evapotranspiration based on storage of water between rain events. Under these conditions, changes in vegetation and land cover are likely to have a relatively small impact on total water yield of the rivers, but may affect the timing of river flow during the year.

Both rainfall and potential evapotranspiration show considerable short-range variation within the broad patterns depicted in Figure 2.3, which are mostly linked to elevation and orographic effects for rainfall, and coastal zone wind for the potential evapotranspiration.

In view of this contrast between the general climatic conditions found in mainland and insular Southeast Asia, we decided to compare the impacts of land use change on watershed functions in both of these domains, as both have a wide range of population densities.

2.1.2 Mainland Southeast Asia – Mekong

In most of mainland Southeast Asia rivers have played a less dominant role in transport that is typical in the more humid part of the tropics, at least beyond important rice producing areas in major lowland zones and large valleys. And, since historically most major empires centered on lowland areas rather than larger river basins as a whole, political boundaries of national states established during the colonial era only partially coincide with the natural boundaries of watersheds (Fig. 2.4).

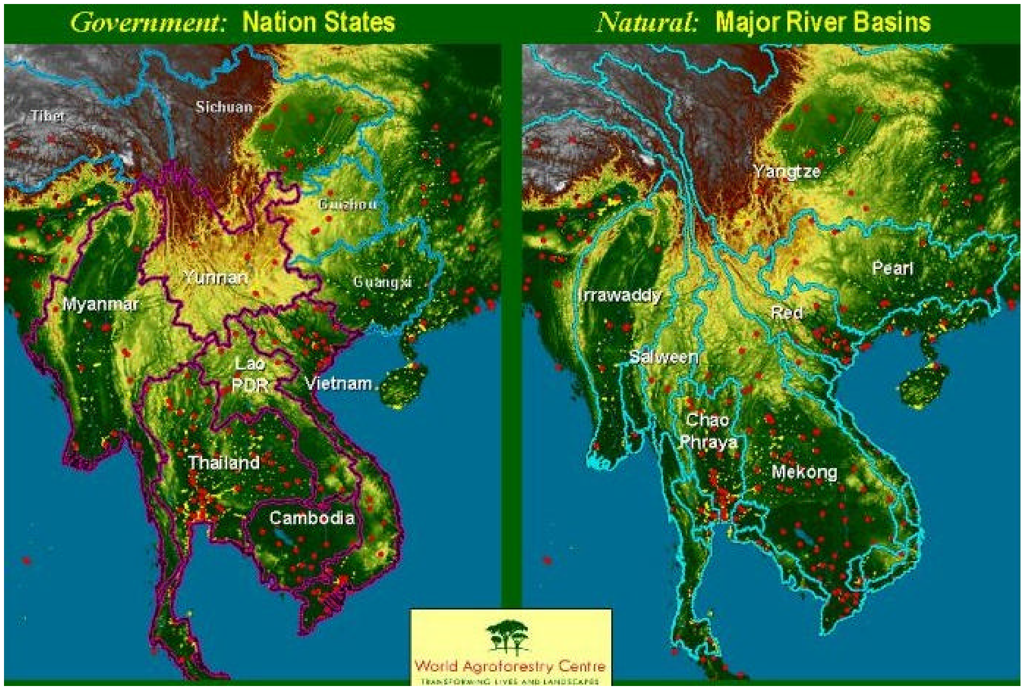


Figure 2.4. National boundaries in mainland southeast Asia do not generally coincide with the natural boundaries of watersheds

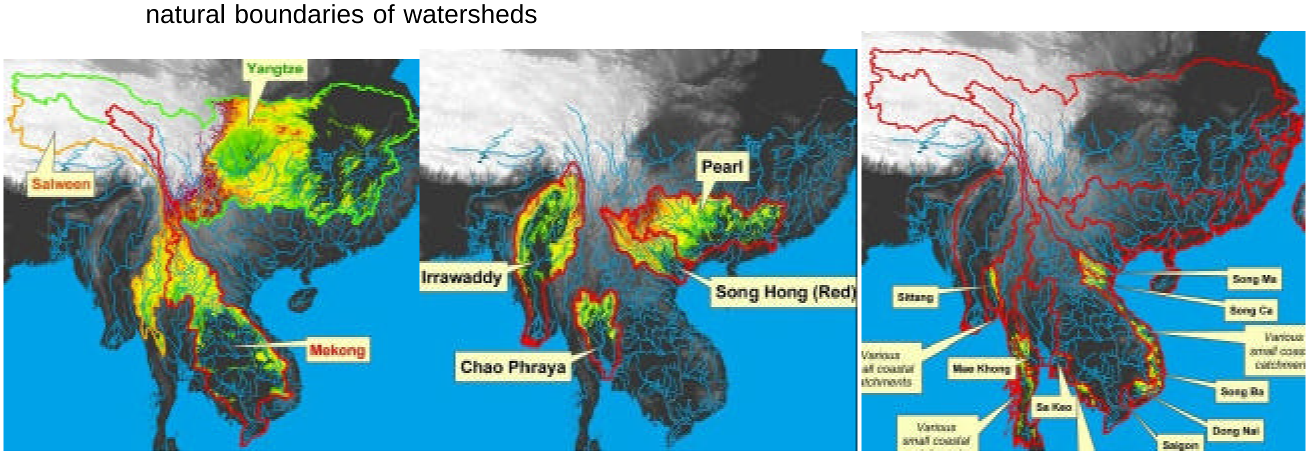


Figure 2.5. Mainland Southeast Asia contains (***left***) three large trans-national rivers (Salween, Mekong and Yangtze) that start with icepack in the Himalaya, (***middle***) four medium-sized river systems (Irrawaddy, Chao Phraya, Song Hong (Red River) and Pearl river) and (***right***) a large number of small, mostly coastal zone rivers that stay within national and often provincial borders

The river basins of mainland Southeast Asia have been grouped into three size categories (Thomas, 2003), as depicted in Fig. 2.5:

- large cross-national rivers, that originate in the snow pack of the Himalayas,
- medium-sized basins that originate in 'montane mainland Southeast Asia' above 300 m a.s.l. (some are contained within a single nation, such as the Chao Phraya in Thailand, others such as the Red River cross national boundaries)
- small basins that may be contained within a single (coastal) province.

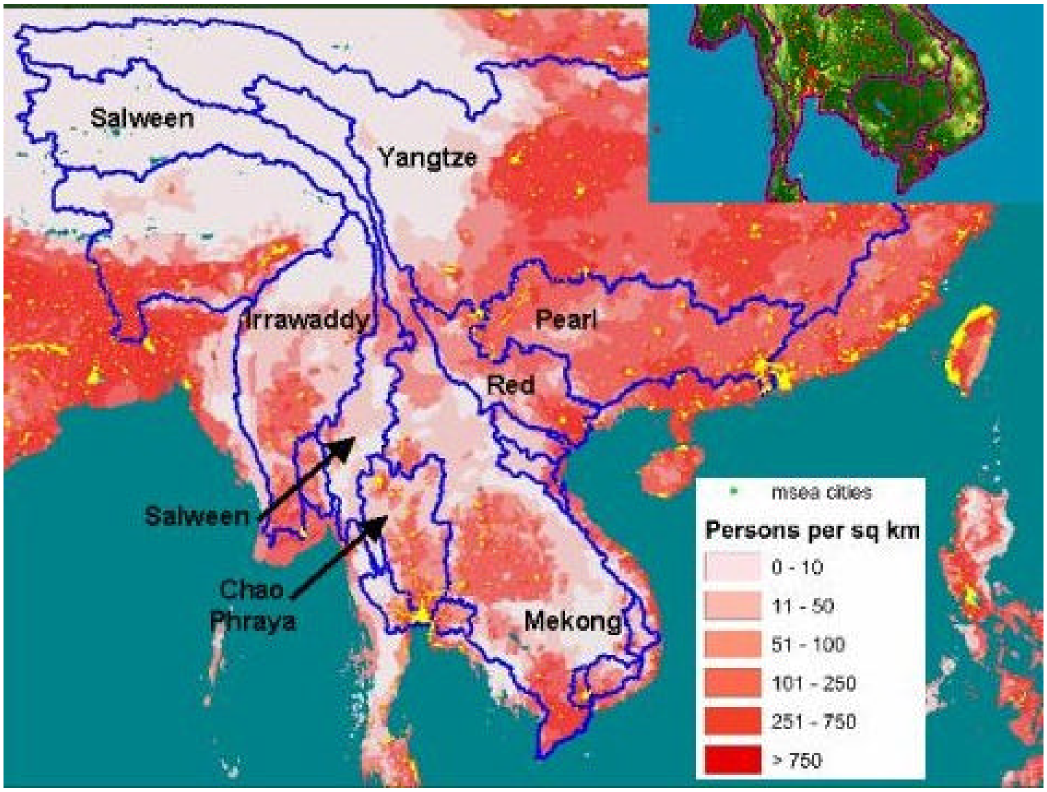


Figure 2.6. Population density in mainland southeast Asia

For this study we focus on one of the large basins (the Mekong) and one of the middle-sized basins (the Chao Phraya of Thailand), which have roughly similar population densities in their lowland zones.

As explored by Thomas (2003), an elevation of 300 m a.s.l. allows for a simple definition of 'upland and montane' versus 'lowland' zones. The dominant land cover and population density differs markedly between these two zones (Fig. 2.7). The upland and montane zone typically has either dense forest or mixed agroforestry landscapes, with major cropland areas at this elevation only in the Red and Pearl river basins of China where population pressures are relatively higher. The lowlands are characterized by paddy rice fields upland crop land, and mixed agroforestry landscapes, but have very little closed forest left.

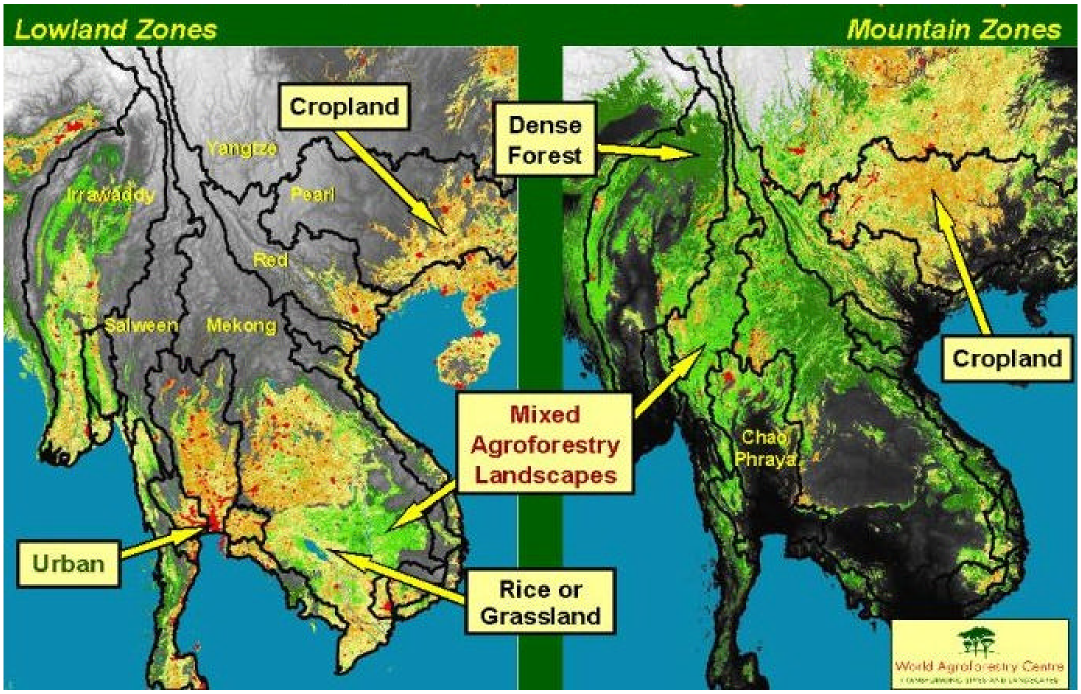


Figure 2.7. Coarse classification of land use in the lowland zones (below 300 m a.s.l.) (left) and the upland and montane zones (right), based on reclassification of University of Maryland land cover data.

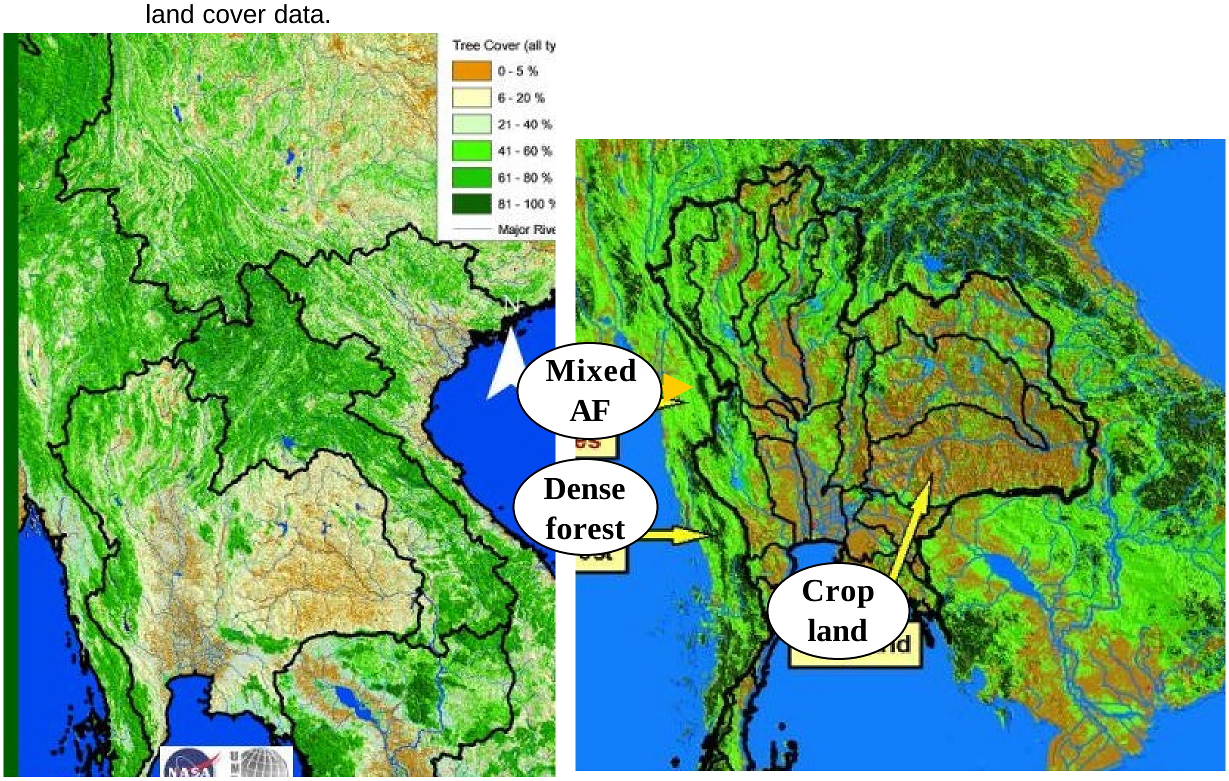


Figure 2.8. Various remote-sensing based classification systems of land cover (left Modis 2000; right reclassified data of the University of Maryland study) distinguish the degree of overall tree cover or dissect the landscape into ‘cropland’, ‘forest’ and intermediate (‘agroforestry’) categories.

2.1.3 Thailand – Chao Phraya – Ping – Mae Chaem - Mae Raek

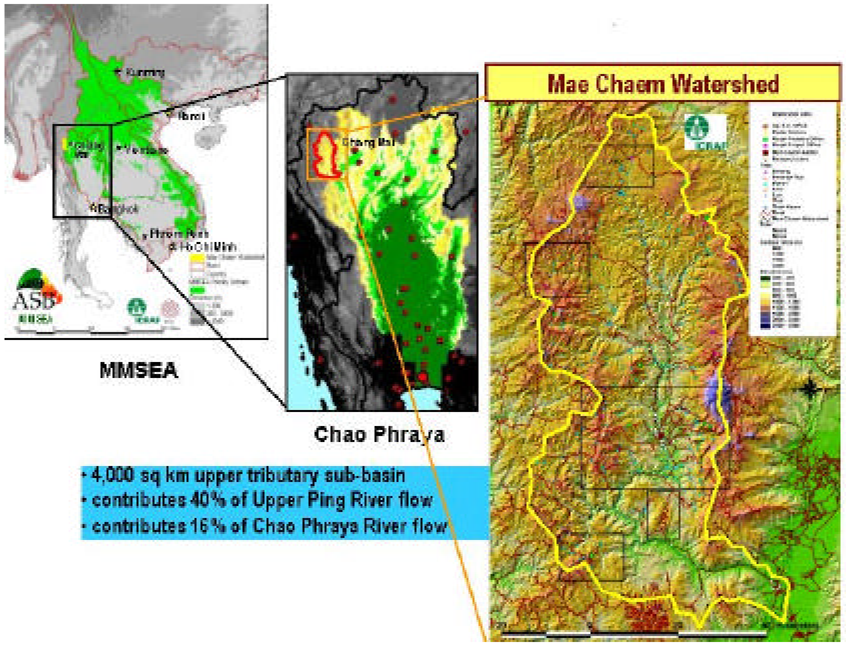


Figure 2.9. Nesting of study watersheds in mainland Southeast Asia

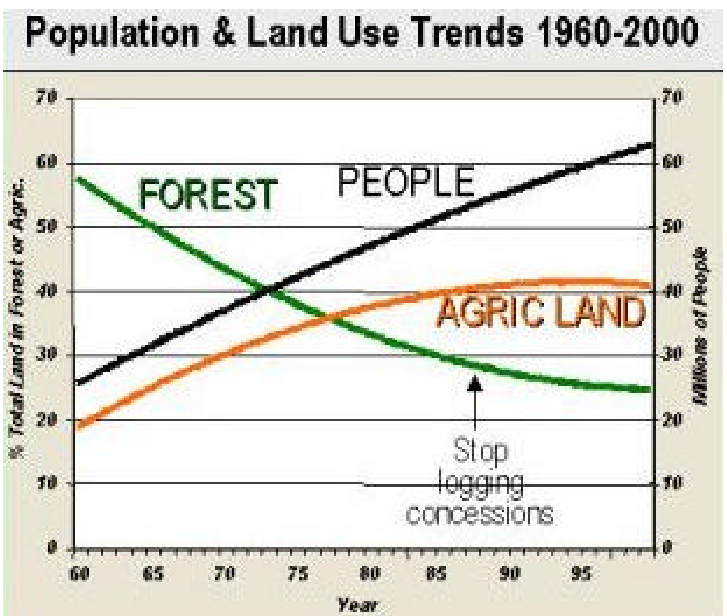


Figure 2.10 In the last 40 years of the 20'th century forest cover in Thailand halved from close to 60% in 1960 to 25% in 2000, while the human population steadily increased. The end of logging concessions did not stop loss of forest cover, but is associated with a break in the trend

Most of the remaining closed forest in Thailand is inside 'protected areas'. While in northern Thailand there is still considerable forest cover outside of these areas, most is still under reserved forest status, many of such areas are targeted to be brought into protected area status on the basis of their high (perceived) biodiversity value. Since most remaining forest is located on mountain ridges, arguments to bring them into protected area status are augmented by their perceived contribution to maintenance of watershed services.

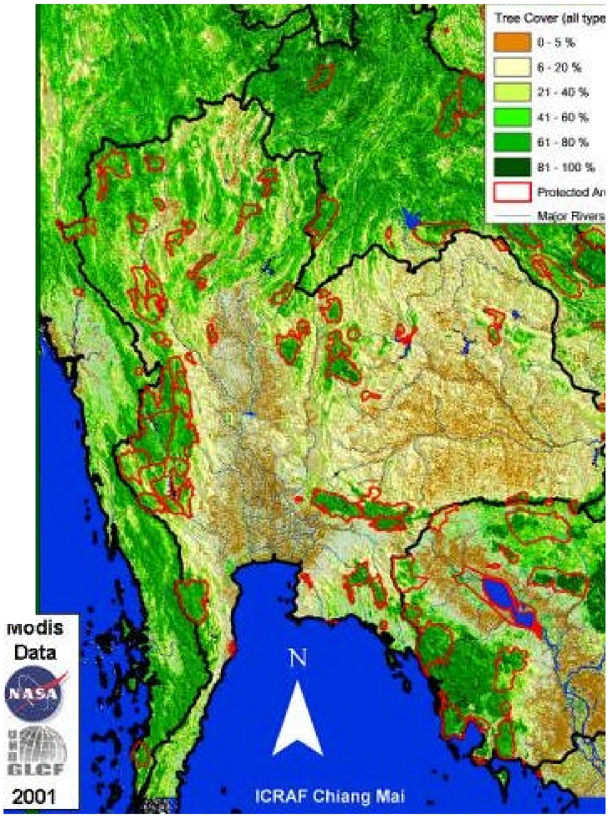


Figure 2.11. Remaining forest cover in Thailand and protected areas

Since most remaining forest areas are in mountain zones of mainland Southeast Asia, it should not be surprising that protected area conservation programs also have their greatest impact in the montane zones. Fig. 2.11 overlays protected areas (red) currently registered at the international level with land use in lowland and mountain zones of river basins in the region. The total number and extent of protected areas is greater than this and still expanding. In the past, these areas have frequently been declared and demarcated by central governments with little or no consultation or concern about local communities living within the areas targeted, many of which have subsequently either been relocated or placed in a highly restricted "enclave" status. While there are indications that such processes are now including more consideration of and consultation with local communities, protected area expansion is clearly a major element of land use issues. Thus, one major set of issues in the region relates to how much expansion at what locations is necessary for what types of biodiversity protection, and what forms of resource use are allowable for what components of the population.

Furthermore, there is a range of additional state forest and conservation policies that have their greatest impact in MMSEA zones. Large additional areas in some countries have been assigned other types of reserved status for various purposes, such as for timber production. Most countries also have or are establishing watershed classification systems that seek to place further restrictions on land use in upper river basins, with the objective of maintaining watershed services for downstream populations. All of these efforts are indicative of a trend across the region toward increased delineation of zones for different types of land use, established by governmental systems of decision-making that are politically dominated by majority lowland societies. Perhaps not surprisingly, one of the overarching issues associated with conservation programs follows from the fact that it has been very difficult for lowland societies to recognize traditional practices that use forest regeneration to restore fertility (swidden cultivation) as a legitimate form of agriculture. Lowland views have also been reinforced by "experts" from international organizations and "development" agencies. Thus, land tenure, land allocation, and competing demands for land for timber production and protected conservation area expansion continue to be major issues across the region.

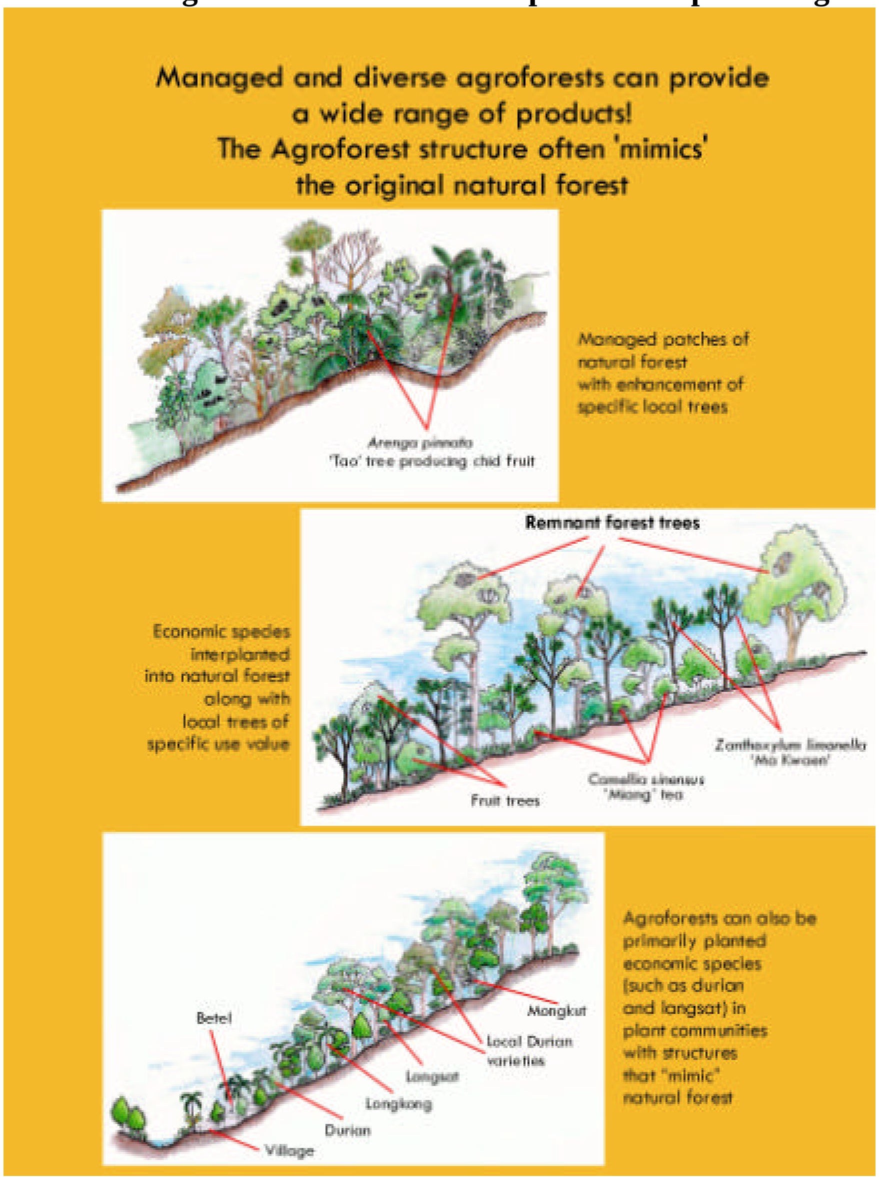
2.1.4 Agrobiodiversity in MMSEA landscapes

Many local communities of various ethnic groups have centuries of experience in utilizing a wide range of flora and fauna in mixed local agroforestry landscapes. Thus, for the managers of many of the region's agroforestry landscapes, biodiversity is viewed more from the point of view of how it interacts directly with local human populations rather than as a separated zone from which human populations are "fenced out". While this type of view is now frequently associated with the term "agrobiodiversity", it often involves much more than concern about genetic variation within plant populations of a single "crop" species. As an example of this, we can look at three types of local approaches for integrating "agriculture" and "forest" components of agroforestry landscapes in MMSEA:

- In forest fallow swidden systems, forest is temporarily cleared for "agricultural crop" production, and then returned to natural forest regeneration processes. Within the cropping component of this "sequential" agroforestry system, upland rice is often mixed with quite a large number of other "crop" species, including "domesticated" native plants. Forest fallow components allow for areas of early forest regeneration stages to be available each year, so that useful native plants from early-succession plant communities are also plentiful there.
- Other types of "agroforest" practices include "enrichment planting" of perennial "agricultural" species into forest areas, such as the "miang" *(Camellia sinensis*) tea gardens found in the upper Chao Phraya river basin and neighboring areas. While these may be associated with some thinning of forest species, the basic forest communities and structure are maintained. In some areas, such systems are being gradually transformed to include greater numbers of a range of "agricultural" species, with a consequent reduction in native ones. And in still other areas, highly diverse mixed orchards with uneven-aged "agricultural" trees (some of which may be native to the area), are planted in a manner that mimics the structure of native forest.

While the number of natural species may be lower in various such types of "agroforests", their "forest-like" structure may provide habitat and environmental service functions similar to natural forest. But "scientific" study of these systems is still very scarce. In addition to various types of "agricultural" or "agroforest" patches in MMSEA agroforestry landscapes, remnant patches of natural forest are also usually present, and frequently found in association with stream headwaters, steep drainage gullies, and other strategic locations in the landscape. In many cases they are associated with use rules or taboos, and they may play a role in spiritual beliefs or local rituals. In any event, these forest patches—which are sometimes near or connected to larger forest areas—also play a role in overall biodiversity properties of agroforestry landscapes in MMSEA.

Box 2.1 Agroforests in MMSEA as prime examples of ‘agrobiodiversity’



Thus, the degree to which agroforestry landscapes in MMSEA either “destroy” or “maintain” environmental services, such as biodiversity, watershed functions or carbon stocks, is not necessarily a simple issue resulting in a binary choice. But in order to assess the environmental service objectives and the criteria and indicators by which they can be assessed—including ones that incorporate insights from local knowledge based on generations of experience—need to be articulated and clearly understood. And the “other side of the coin” is that environmental services provided by agroforestry landscapes should be recognized by “stakeholders” near and far who share in the benefits from them, and who should also have an equitable share in any additional costs associated with their maintenance. The political economy of how environmental services are produced and who benefits from them is likely to be an issue of increasing importance in MMSEA and its relationships with downstream lowland populations in the years to come.

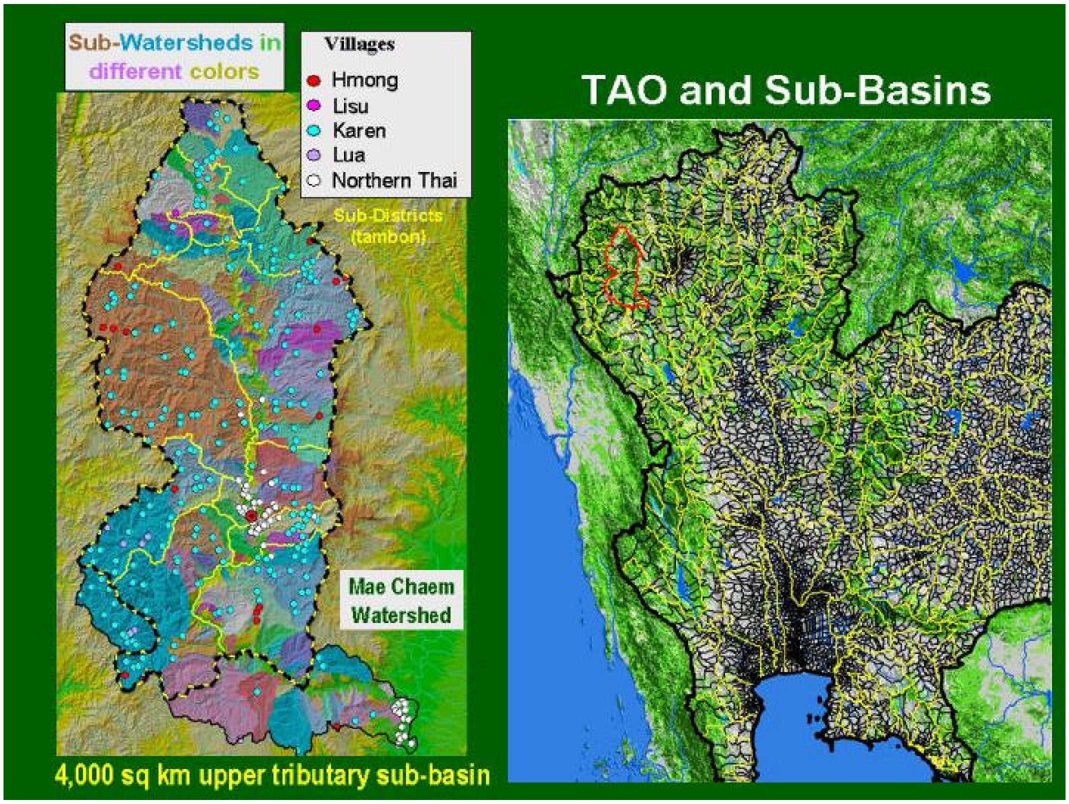


Figure 2.12. Administrative structure at the level of the Mae Chaem valley and the Chao Phraya basin

2.1.5 Natural resource governance in MMSEA

Social and institutional change is yet another trend with potential for substantial impact in MMSEA and its relationship with downstream lowland areas during coming years. While there is growing consensus across mainland Southeast Asia that local institutions are best placed to manage resources to meet local needs and build on local knowledge, stakeholders from local to downstream to global levels also want assurance their needs will be met. Levels of government administrative units have been the initial focus for decentralization, but there are indications that other forms of social organization may also be necessary. Thus, one of the major challenges for the region relates to how it can establish, operate and maintain a system of units of social organization that can effectively manage the natural resource base to meet this nested hierarchy of needs, including negotiation of acceptable distributions of costs and benefits. In order to help us visualize some of the nature and scope of these issues, the left side of figure 2.12 takes us back to the Mae Chaem watershed in the upper Chao Phraya river basin. Even within this one 4,000 square kilometer basin one can see:

- A substantial range in the size and configuration of individual sub-watersheds, each with its set of local village communities and ethnic mix. Pilot local sub-watershed management committees are trying to bridge village and ethnic boundaries in some areas, in order to manage common resources and reduce local upstream-downstream tensions related to water supplies and fears of flash floods and landslides.

- The "mismatch" between jurisdictions of elected sub-district (tambon) governments and the sub-watersheds within which its constituency lives. While local governments have the legal mandates and administrative and budgetary mechanisms to support local natural resource management, the natural units of forest, watersheds and other resources in their domain seldom correspond to their own administrative boundaries. Moreover, how will these various local organizational units respond, for example, to downstream concerns about water flow or quality from the Mae Chaem watershed as a whole?

A sense of the sheer number of sub-district governments that would need to be involved in this level of localized natural resource management in Thailand is indicated by comparison of the map in Fig. 2.11 that depicts reserved forest (light green) and protected areas, relative to the map on the right in Fig. 2.12 that depicts boundaries of sub-district governments in all regions of the country. If the diversity and complexity of local conditions elsewhere is comparable to those faced by sub-district governments in Mae Chaem, it becomes clear that coordination within and among this number of local organizational units presents a major challenge. Thus, if management at larger forest areas and river basin and sub-basin levels is to be effective, it becomes obvious that there is a role for higher levels of social organization. And, since major government processes are conducted through existing administrative structures, such efforts must have working relationships at district, provincial and national levels.

While some advocate alteration of administrative boundaries to match more closely with watersheds, the process of doing so would be exceedingly difficult and would still result in mismatches with units of forest or other natural resources, as well as with organizational patterns related to social, economic or other characteristics of "macro-landscapes" around the region. Similar issues also extend to the international level in most of the large river basins, as well as in some of the most important large protected forest areas.

A more likely path might lead toward less formal organization of networks of local communities directly involved in managing natural resource units, combined with clear channels for their linkage with governmental administrative units. Both types of organization could have nested hierarchies that are linked at appropriate levels. One important element of how such hierarchies could function effectively at their various levels would be a clearer understanding of types of natural resource management decisions— and the roles of different stakeholders—that would be most appropriate at each of the nested spatial and organizational levels. This could help lead to efforts to more fully develop management and support system capacities at each level, as well as methods for inter-level interaction and negotiation. A second element is a need to focus on process elements of how social units function within and among levels, in order to assure that these processes are inclusive and transparent enough to establish and maintain credibility and their own longer-term viability.

Such organizational and management within the context of a range of trans-boundary conditions in larger river basins. The Chao Phraya and Yangtze river basins provide two different scales where "domestic trans-boundary" issues need to be addressed within single national frameworks. Trans-boundary issues in the Red, and small portions of the Pearl and Irrawaddy river basins, require bilateral collaboration, and the Salween extends this to the trilateral level. The Mekong river basin, which includes portions of six countries, provides the most complex context, and after several decades of efforts the Mekong River Commission is still exploring how the two 'upper basin' countries can be included in their programmes.

Even within a single nation state context, governance of major river systems must find ways of negotiating and reconciling interests among a range of stakeholders whose demand for watershed services vary according to their needs and location within the basin. Fig. 2.11 illustrates an example of various strategic locations within the Chao Phraya river system, and Box 2.2 lists some of the major watershed concerns at each of these locations. The official policy response has been to impose land use restrictions on most of the uplands in the North Region (Fig. 2.13)

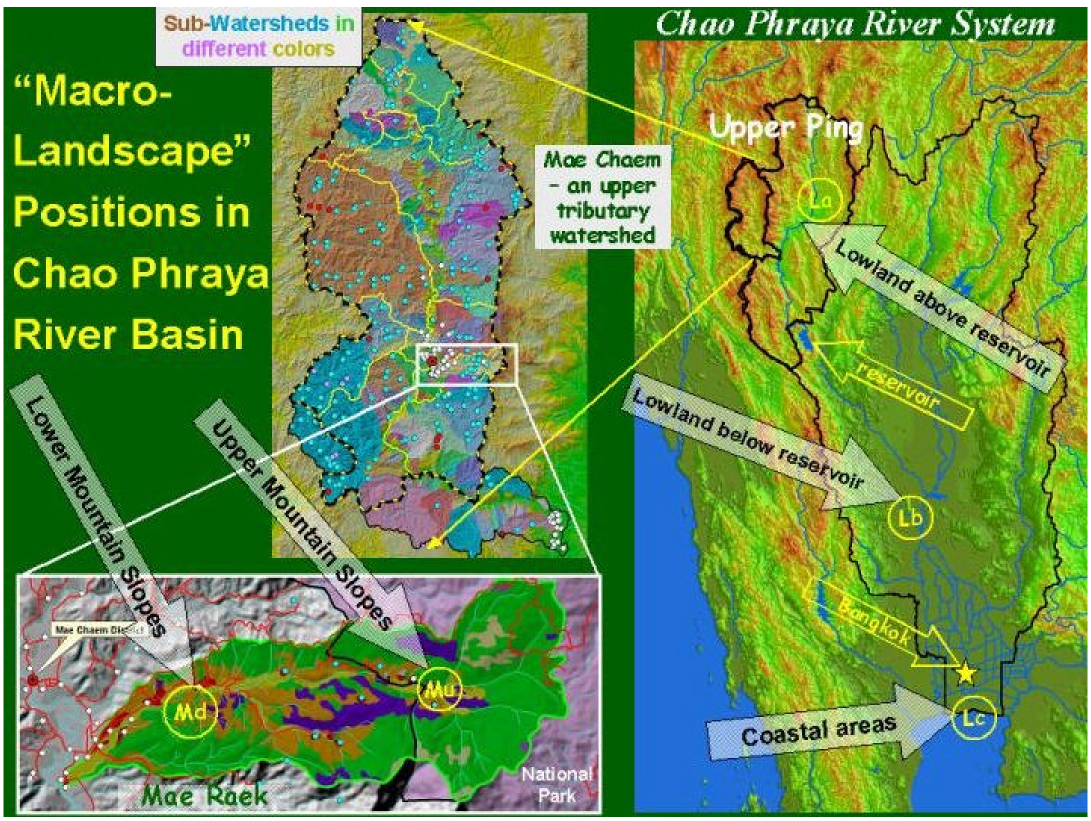


Figure 2.13. Major locations in the "macro-landscape" of the Chao Phraya river system where demand for watershed services differ

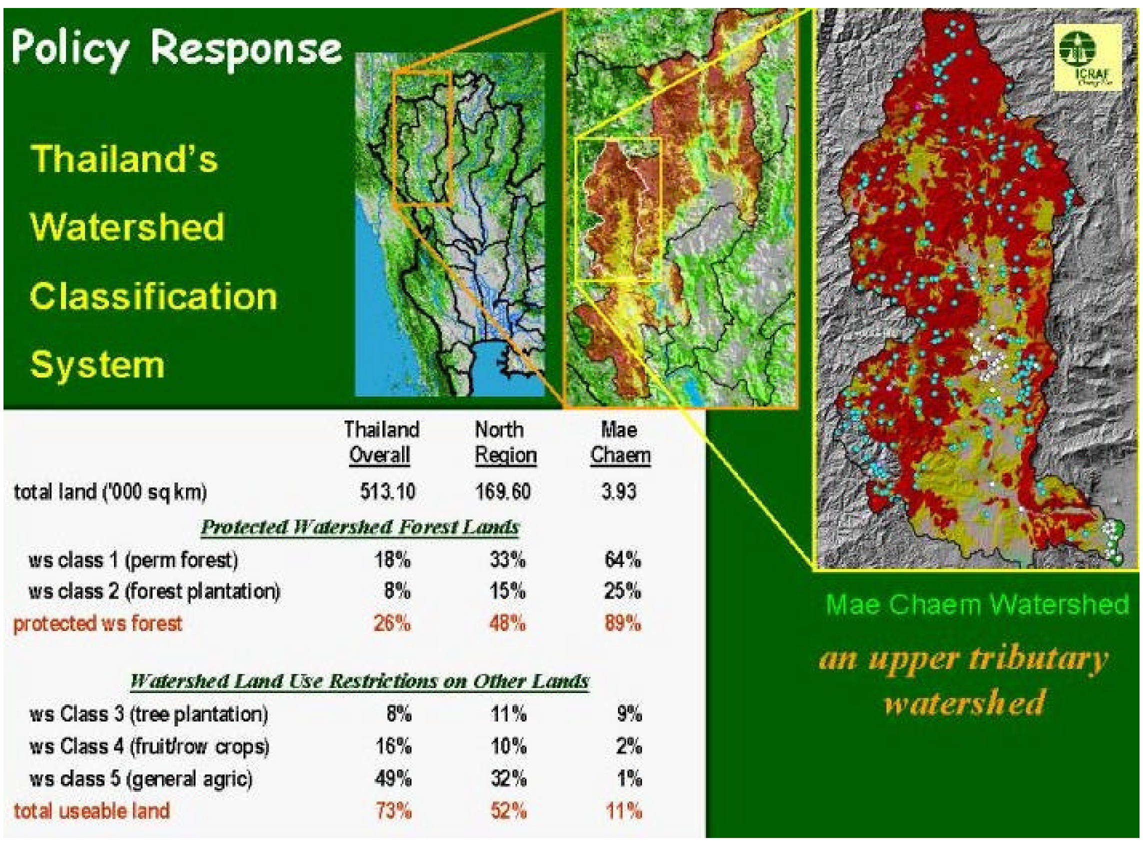
Box 2.2 Who wants what watershed services in MMEA?

Upper mountain slopes: even rainfall within rainy season, tanks for supplemental sprinkler irrigation of high-value crops

Lower mountain slopes: reliable stream flow for weir-based irrigation, no flashfloods, landslides, heavy sediment or chemical pollution

Lowlands above large reservoirs: reliable flow for weir-based irrigation plus year-round water for horticultural crops and urban populations; no floods on flood plains during heavy rainfall years

Lowlands below large reservoirs: total water retained by the reservoir plus regulation and allocation of release for irrigation, electricity, flood control, domestic water supply and urban & industrial uses



	Thailand Overall	North Region	Mae Chaem
total land ('000 sq km)	513.10	169.60	3.93
Protected Watershed Forest Lands			
ws class 1 (perm forest)	18%	33%	64%
ws class 2 (forest plantation)	8%	15%	25%
protected ws forest	26%	48%	89%
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%

Figure 2.14. Official watershed classification with 5 classes that restrict land use to different degrees and the area fractions of protected watershed forest lands for Thailand as a whole, the North Region and the Mae Chaem watershed

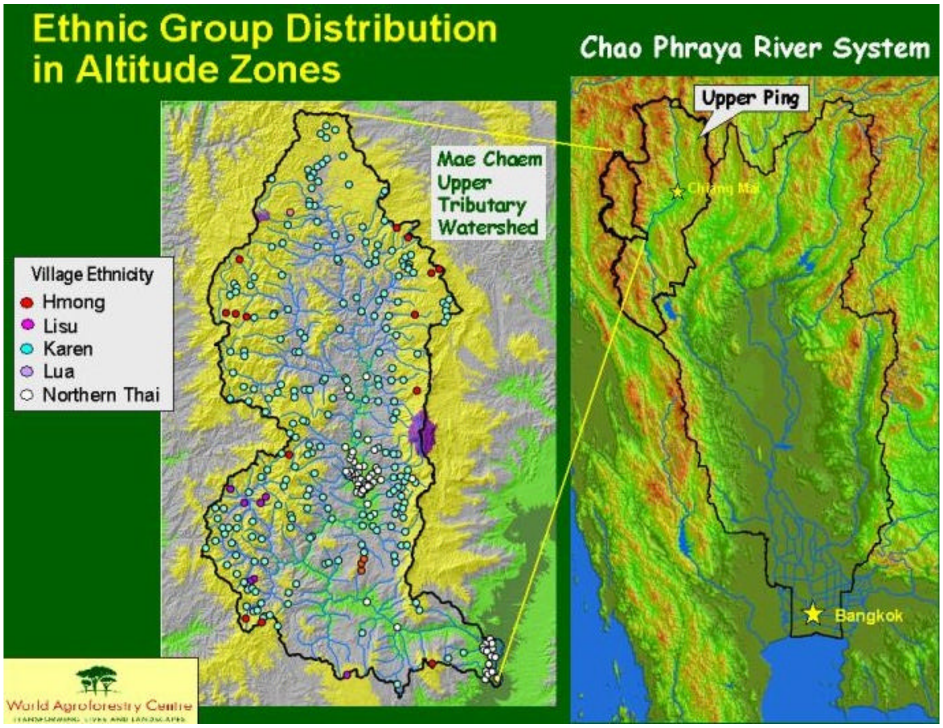


Figure 2.15. The Mae Chaem watershed has a substantial ethnic diversity, associated with diversity on livelihood strategies and land use patterns

2.1.6 Actual land use patterns in Mae Chaem: is there a problem?

A simple diagrammatic representation of some of the major elements of this variation is presented in Fig. 2.16. Although it is overly simplified, we have found it to be quite useful, and we are encouraging colleagues to make similar ones for other parts of mainland SEA. There are three major components to this diagram that should be emphasized here, without dwelling too much on details, each of which could be associated with quite extensive discussions.

- Natural vegetation and ecosystem gradients are indicated by the column of forest type labels on the left of the diagram.
- Variation in ethnic groups according to altitudinal zones and the agroecosystems traditionally associated with each group are indicated by columns of labels in the center of the diagram.

Current land use is indicated by the column of labels to the right of the diagram, as well as some of the major government policies that seek to directly affect land-use practices.

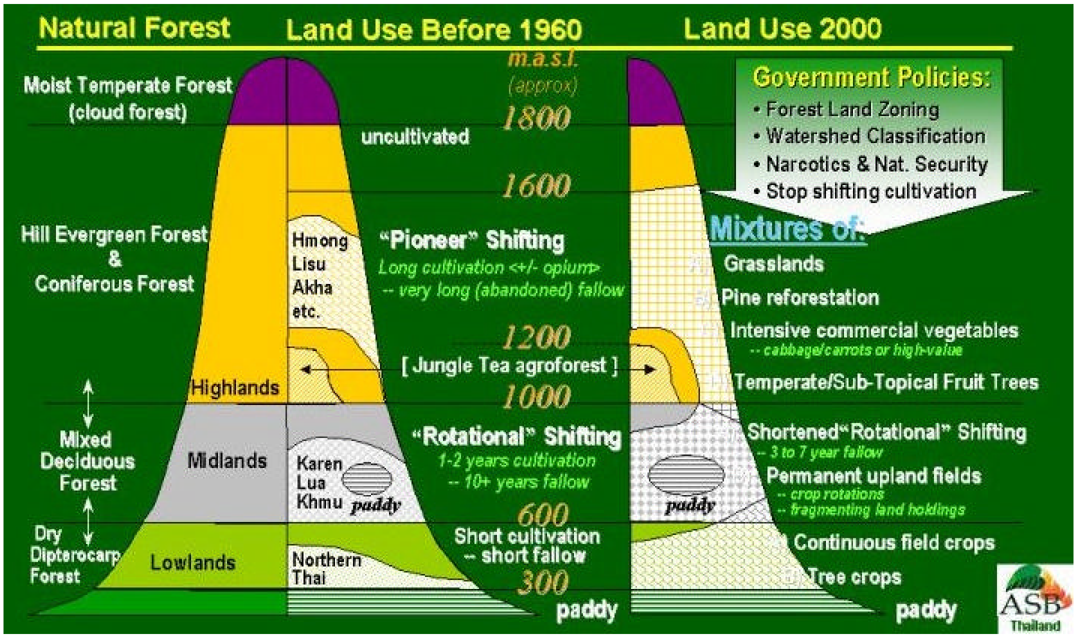


Figure 2.16. Diagrammatic representation of the main changes in land cover and land use for different elevational zones, comparing the natural forest vegetation, land use patterns before 1960 and the situation around 2000

Clearly, traditional livelihoods result in an overall mosaic of land-use practices that indicate mixed agroforestry landscapes have long existed in this area. But a range of forces driving change have been sweeping through this area since about 1960, including those associated with population growth, agricultural commercialization, opium crop substitution, infrastructure development, government administration and health, education, and other services, and more recently economic restructuring and globalization. In addition, various government policies such as those depicted in Fig. 2.14 have sought to specify or constrain how responses to these forces should affect land-use practices and patterns. The net result of these factors has often remained a mosaic agroforestry land-use pattern, but component practices, relative proportions and spatial configurations of these patterns have often changed very substantially, along with associated change in local livelihoods and impacts on environmental services.

The local landscape typology of the Karen ethnic group distinguishes a number of different forest types associated with different functions (Table 2.1)