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Agricultural Transformation and the Politics of Hydrology in Northern Thailand: A Case Study of Water Supply and Demand

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Agricultural Transformation and the Politics of Hydrology in Northern Thailand: A Case Study of Water Supply and Demand

Abstract

Water resource tensions in upland areas of northern Thailand are often attributed to reductions in water supply caused by forest clearing. This paper argues that the hydrological evidence for such reductions in *supply* is very weak and that, rather, the key hydrological issue in upland catchments is a significant increase in water *demand*, especially during the dry season. The arguments are illustrated with a detailed examination of the Mae Uam catchment, located in Chiang Mai province, where the development of dry-season soybean cultivation appears to have approached the hydrological limit of the catchment, and even exceeded this limit in drier years. The paper argues that a shift in focus from water supply to water demand has fundamentally important political implications. As long as the focus of public debate is on water supply, the regulatory focus will be on those resident in the forested upland areas that are seen as being crucial in securing downstream flows. But if the water management focus is shifted to water demand, then regulatory attention must shift to the diverse sources of that demand that exist *throughout* the hydrological system.

Introduction: the politics of water supply and demand

The recent history of development in the mountainous upland areas of mainland Southeast Asia has been one of increasing resource tension. Population growth, migration, commercialization and infrastructure construction have generated unprecedented pressure on upland resources at the same time as official systems of land regulation have sought to meet both development and conservation objectives. Agricultural transformation and the intensification of linkages between rural and urban sectors have posed new challenges that existing institutional structures are often poorly equipped to meet. In many mountainous upland areas, resource tensions are compounded as they find local and national expression in various forms of ethnic maneuver, which seek to define some groups as less legitimate users of highly valued natural resources. Responses to these denials of legitimacy are often framed in similarly ethnic terms as they promote traditions of indigenous resource management as a basis for local identification and political mobilization.

In the mountainous uplands of northern Thailand water resources have emerged as an important point of tension. In the upland catchments of the Ping River basin, there have been increasing reports of conflict over agricultural water supplies between upstream and downstream communities. Underlying many of these conflicts is the persistent claim that the shortages experienced by lowland farmers are caused by watershed degradation—forest clearing in particular—by upstream farmers in sensitive watershed areas. It is regularly asserted that forest cover in mountainous areas is crucial for securing downstream water supplies and that population growth and agricultural expansion in these forested zones has resulted in downstream desiccation. As Pinkaew (1999) has cogently argued, state agencies have played an important role in the construction of this selective watershed orthodoxy, with a system of conservation-based watershed classification that declares vast areas of sloping upland as inappropriate for agricultural activity. However, the state is not the only culprit and there is little doubt that activist academics and NGOs in Thailand have contributed to the watershed orthodoxy with their regular claims that water shortages have followed the disruption of traditional arrangements for forest protection (Walker 2002: 1-2). The overall effect of official and unofficial positions is that forest cover and water *supply* are inextricably linked in local and national environmental debates.

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But what about water *demand*? In fact, with relatively few exceptions, the water demand implications of several decades of agricultural transformation in upland catchments have received little attention. A predominant regulatory and research focus on upland catchment *degradation*—and ongoing debate about the best strategies for the *preservation* of resources—appears to have diverted attention away from the patterns of resource *use* arising out of transformed production systems. This has fundamentally important political implications—as long as the focus of public debate is on maintaining and protecting water *supply*, the regulatory focus will be on those resident in the forested upland areas that are seen as being crucial in securing downstream flows. But if the water management focus is shifted to water *demand*, then regulatory attention must shift to the diverse sources of that demand that exist throughout the hydrological system—not just upland farmers but lowland farmers as well, along with industrialists and urban water consumers (Walker, 2002).

This paper draws insights from anthropology, economics, agronomy and environmental science to examine this contemporary politics of hydrology in northern Thailand. My primary aim is to critically assess the impact of recent agricultural development on *both sides* of the water management equation—water supply *and* water demand. The paper is based on a detailed case study of the Mae Uam catchment in Mae Chaem district of Chiang Mai province, a catchment were some water resource tensions appear to be emerging. In the first section I provide an overview of the Mae Uam catchment and of the recent agricultural transformation that has occurred there. I then turn to this issue of water *supply*, examining the widely held claim that local and regional forest clearing has disrupted the hydrological cycle resulting, in particular, in reduced rainfall and dry-season water shortage. I argue that there is very little evidence to support such claims, despite their widespread currency. In the second half of the paper I turn to water *demand*, and examine the hydrological and sociological dimensions of the very substantial increase in dry-season irrigated agriculture in the Mae Uam catchment. My conclusion is that the most likely cause of increased water resource tension in Mae Uam, and elsewhere, is a *dramatic and unprecedented increase in the level of demand for water in the dry season in both upstream and downstream areas*.

The arguments I present in this paper have important implications for the defenders of the upstream farmers who are typically accused of catchment degradation and destruction of downstream water supplies. In northern Thailand, as in many other parts of the world, NGOs and sympathetic academics argue that minority communities have longstanding traditions of forest management and sustainable land use that provide a basis for sustainable community presence in forested watershed areas. In particular, attention is drawn to traditional practices of forest protection aimed at maintaining downstream water quality *and* quantity. The promotion and revival of these forest-friendly traditions is seen as a key strategy in securing a legitimate place for upland communities in contested northern Thai landscapes. However, this is a strategy that has very considerable risks. In particular, there is a real danger that in presenting these upstream farmers as guardians of catchment resources and as protectors of water *supply*, the legitimacy of their position as consumers of resources—as water *users*—is undermined.

The Mae Uam: a mountainous catchment in northern Thailand

The Mae Uam has its sources in the western slops of Doi Inthanon, the highest mountain in Thailand. From this high montane source, it runs in a southwesterly direction to its junction with the Mae Chaem, dropping about two thousand meters in the process (Figures 1 and 2). The total area of the Mae Uam catchment is forty-three square kilometers with elevation ranging from a low point of 480 meters (near the district center of Mae Chaem) to a high point of almost 2,400 meters (near the peak of Doi Inthanon). The average slope is eighteen degrees and flat land suitable for intensive irrigated agriculture is confined to narrow strips along the valley floor. The population of the Mae Uam catchment is approximately 3,500, distributed between seven villages. In the two most upstream villages, almost eighty-five per cent of household heads surveyed identify themselves as Karen. The Karen are the largest 'hill-tribe' group in northern Thailand who, in response to official charges of hill-tribe natural resource degradation, have developed a reputation in academic and activist literature for their conservationist, forest friendly and non-commercial orientation (Walker 2001). In the other five villages of the Mae Uam catchment almost all households identify as northern Thai, the majority lowland population in Chiang Mai province.

Figure 1: Northern Thailand with Mae Uam catchment.

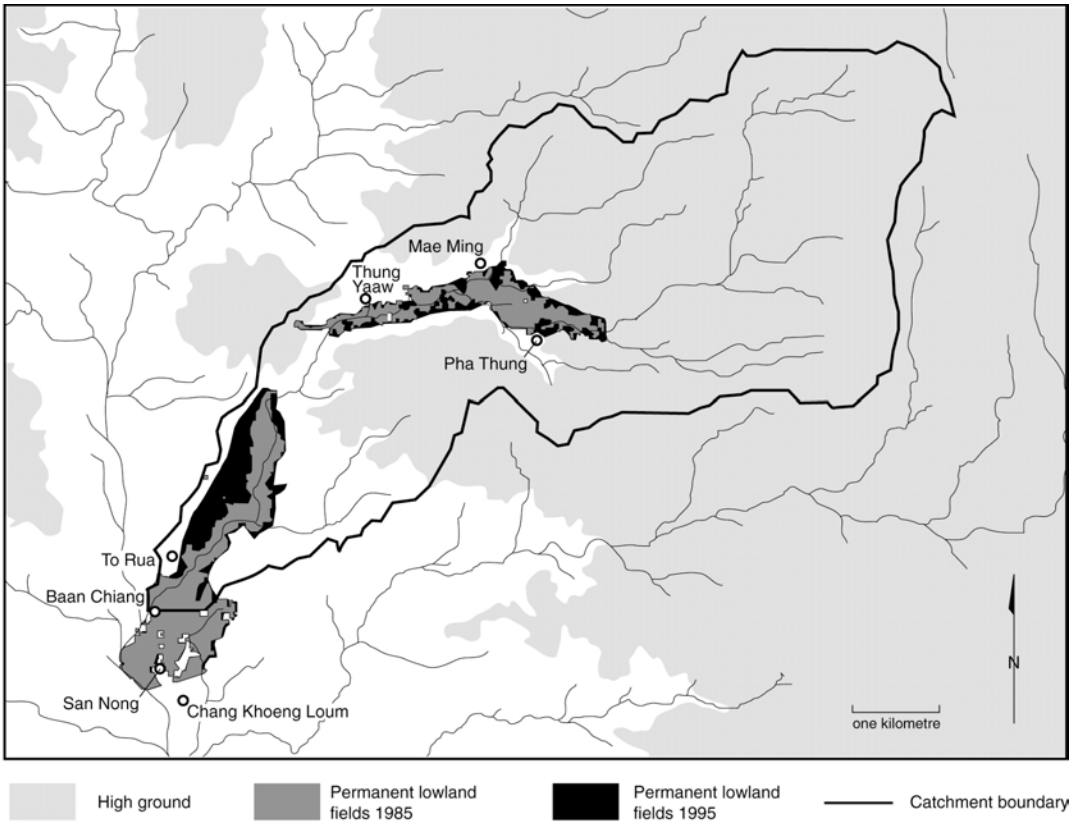

Figure 2: Mae Uam Catchment. Note that paddy fields lying outside the catchment boundary are irrigated by water from the Mae Uam catchment.

Even though the downstream villages form part of the district township of Mae Chaem, the Mae Uam catchment is overwhelmingly agricultural, with ninety-three per cent of household heads surveyed indicating that their main occupation is agriculture.[1] Up until the last two decades, the agricultural focus of these households was the production of rice for subsistence purposes. Rice was grown both in irrigated paddy fields and in rain-fed hill-slope fields. Rice production was, and still is, supplemented by vegetables grown on the edges of rice fields and in home gardens and by the collection of bamboo shoots, mushrooms and wild vegetables from surrounding forests. Prior to the mid-twentieth century it appears that Mae Uam formed part of a relatively open land frontier, with 'satellite' communities experiencing little difficulty in opening up new areas of agricultural land. In some cases villages were established in degraded forest areas that had been opened up by logging operations. Based on experience in other districts of northern Thailand it seems likely that population growth in the past was accompanied by the gradual expansion of paddy land and the shortening of fallow cycles on upland fields (Walker, 2001). With the incorporation of the upper reaches of the catchment in Doi Inthanon National Park in the late 1970s fallow periods, especially in the upstream Karen villages, are likely to have come under increasing pressure.

Over the past twenty years there has been substantial agricultural change in the Mae Uam catchment, in part as a result of the activities of agricultural development agencies. During the 1980s, Mae Chaem district was a priority area for development given its relative isolation and poverty and reputation for opium production and communist insurgency. Government and non-government development activities in the villages along the Mae Uam included infrastructure support (roads, irrigation systems and fish ponds); promotion of new crops and farming techniques; construction of terraced paddy fields; marketing initiatives; and distribution of fruit-tree seedlings (Hufschmidt, 1991; Ministry of Agriculture and Cooperatives, 1984). Irrigation development was a priority activity and, in the upper reaches of the catchment, a series of concrete weirs were constructed from the late 1970s onward while in the lower reaches two major irrigation weirs were built in the late 1980s. An aqueduct which draws supplementary—but expensive, given the need for pumping—irrigation water from the main stream of the Mae Chaem was also constructed to service farmers in the lower reaches of the catchment in the mid-1980s. Agricultural development was greatly facilitated by the construction of a road linking Mae Chaem with the major northern Thai marketing centers during the 1970s and by the gradual improvement of the road along the Mae Uam catchment itself in the 1980s and 1990s. These development initiatives appear to have contributed to a significant increase in the production of cash crops, especially soybeans.

Land-cover data for the Mae Uam catchment from the period 1985 to 1995 provides some interesting perspectives on this recent period of agricultural transformation.[2] First, these data suggest that there has been a modest decline in rain-fed hill-slope cultivation over this period—from 425 hectares in 1985 to 393 hectares in 1995—contrary to popular images of rampant hill-

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[1] A detailed resource, production and marketing household survey was conducted in Mae Uam during December 1998. The survey covered 6 of the 7 villages in the catchment, and a total of 138 samples were collected, representing approximately 20 per cent of the population in each village. Detailed information was obtained on all sources of subsistence and income including cropping, livestock production, non-timber forest harvesting and off-farm employment.

[2] The land-cover data was derived from Landsat satellite imagery acquired in 1985 (August), 1990 (February) and 1995 (February)(NRCT 1997: 43). The National Research Council of Thailand study (NRCT 1997: 45-46) classified land-cover into six categories: forest, agriculture, urban, bareland/openland and grass/regrowth. The forest category includes permanent natural forest and reforestation. The agricultural category is said to include 'permanent or temporary agricultural area that are mostly occurred [sic] in flat plain or lowland' however from analysis of the spatial distribution of this category, and limited ground truthing, it is clear that, in the majority of cases this refers to paddy fields and some permanently cultivated fields on the fringes of paddy. Bareland/openland is defined in the study as 'the area of new cleared area or prepared highland agricultural area.' I refer to this category as 'rain-fed hill-slope fields.'

slope expansion, and associated deforestation, in northern Thailand. Importantly, these data suggest that most rain-fed hill-slope fields are now permanently cropped, rather than being left fallow or abandoned. Of the 393 hectares cultivated in 1995, over 336 hectares had been also been cultivated in 1990 and almost 240 hectares had been cultivated in both 1985 and 1990. Discussions with village leaders and household surveys have indicated that all upland fields are now permanently cropped, even in Karen villages where, from recent literature (see, for example, Waraalak, 1998), one may expect significant levels of rotational shifting cultivation (*rai mun wian*). There is an ongoing debate in northern Thailand about the impacts of shifting cultivation on the environment of upland catchments, however in the Mae Uam catchment this now appears to be a non-issue.

The second, and most important, trend in land-use in the Mae Uam catchment is the expansion in permanent agricultural fields in the relatively low slope and low elevation areas along the valley floor. This expansion has taken the form both of irrigated paddy fields (assisted by improvements in irrigation infrastructure) and the establishment of orchards and permanent gardens on the sloping land immediately adjacent to paddy fields. As can be seen in Figure 2 this expansion has been most significant in the downstream zone of the catchment, though there is also evidence of paddy field consolidation in the upstream agricultural zone. Land cover data indicates that in 1985 these areas of permanent valley bottom cultivation covered 203 hectares (4.4 per cent of the catchment area). By 1990 this had increased to 256 hectares (5.6 per cent) and by 1995 had reached 350 hectares (7.6 per cent). This expansion has been facilitated by the construction of irrigation infrastructure and the construction of paddy fields as part of local development initiatives.

Water resources

The climatic pattern in Mae Chaem district is typical of that in northern Thailand, with a distinct wet season from about May to September. Outside the wet season rainfall is limited and in some years no rain falls for three months or more. According to data collected by the Royal Irrigation Department for the town of Mae Chaem, average annual rainfall during the 1980s was 910 millimeters. During this period the driest month was January (average of zero) and the wettest month was September (average of 155 millimeters). Rainfall is much higher in the more elevated parts of the catchment as illustrated by the fact that the peak of Doi Inthanon has an average annual rainfall of about 2,200 millimeters.[3]

As can be expected from the seasonal pattern of rainfall, stream flow in the Mae Uam peaks during July-August and declines steadily from October to April. Total stream flow during the dry season months is only about twenty per cent of annual stream flow (Walker 2002: 7) though this low flow is a crucial source of irrigation water for dry-season cropping. Dry-season stream flow is 'harvested' by an extensive network of irrigation weirs and canals. There are approximately forty wooden and ten concrete weirs distributed between the five settlements and numerous village-based institutions exist to maintain the irrigation infrastructure and to manage the distribution of water to farmers' fields.

During field surveys undertaken by the author and collaborators in December 1998, farmers in the downstream northern Thai villages expressed concerns about dry-season water shortages and the high cost of pumping supplementary water supplies from the main stream of the Mae Chaem River. These concerns are typical of these expressed by downstream farmers in mountain catchments in many areas of northern Thailand. In the Mae Uam catchment, concerns about dry-season water supply have even prompted locally contentious proposals for dams in the middle and upper reaches of the Mae Uam to store 'surplus' wet season flow. In the early 1990s, activists in the upstream Karen villages campaigned vigorously, and successfully, against a proposed reservoir that would have inundated some of their valuable paddy fields. By the late 1990s more modest plans were being developed with army engineering teams reportedly planning the construction of a number of small 'check-dams' on minor sub-tributaries within the catchment. In nearby areas of Mae Chaem

[3] Rainfall data were obtained from the website of the Royal Irrigation Department at www.rid.go.th.

district upstream Karen farmers are said to fear relocation due to complaints of lowland farmers about the impact of water shortages on agricultural production (Ukrit 2001: 18).

Has forest loss altered water supply?[4]

In popular and academic discussions of agricultural development in northern Thailand it is widely held that water shortages experienced by downstream farmers are caused by forest clearing in upper-catchment areas. A reduction in forest area is said to have caused both a reduction in rainfall and a reduction in stream flow, particularly in the dry season.

> Northern farmers who depend on the downstream flow of water for their livelihoods claim the rivers are drying up and they point the finger of blame at the hilltribe farmers… Dr Suchira Prayoonpitack, a Chiang Mai University sociologist, said the watershed forests of the North can no longer absorb and hold water. 'Several decades ago, fertile forests served as natural water catchments and reservoirs,' Dr Suchira explained. These catchments prevent floods during the rainy season, and are a source of water during the dry season. But the rapid diminishing of the forest has caused floods in the rainy season and drought in the dry season. (Supradit, 1997b)5

In a similar vein, the publicity brochure of one Royal Forest Department-supported development project that is active in the Mae Uam catchment argues that 'forest is the course of water for all people who live on Thai soil' and that forest 'provides for underground water storage, making the ground moist as a benefit for all people' (Suan Pa Sirikit, nd; my translation). In order to restore and maintain hydrological balance the project is promoting a range of forest replenishment and protection initiatives: replanting watershed forests, distributing seedlings and constructing firebreaks.

There is no doubt that there has been a reduction in forest cover in Mae Uam and in many other mountainous catchments of northern Thailand. Land-cover data indicate that in 1985 approximately seventy-eight per cent of the Mae Uam catchment was covered with forest but by 1995 this had declined to seventy-two per cent, a loss of over 250 hectares. There is also some evidence of considerable forest degradation, especially in the lower reaches of the catchment outside the national park area. This local reduction in forest cover is one small part of a much more significant regional trend that has seen the level of forest cover in northern Thailand decline from, presumably, close to 100 per cent in the early 1900s to about forty-four per cent in the mid-1990s (Walker 2002: 11). But is it too simplistic to attribute emerging water resource tensions to this reduction in forest cover? What is the evidence about the relationship between forest cover and water supply?

Has forest clearing reduced rainfall?

Fortunately, long-term rainfall data is available for the district center of Mae Chaem, which is located very close to the lower reaches of the Mae Uam catchment. The data must, however, be interpreted with considerable caution given that there are numerous years for which the data are clearly incomplete or erroneous. When the most obviously incorrect years are excluded from the analysis the data suggest a very modest long-term decline in rainfall combined with significant short-term variation (Figure 3). Analysis from some other locations in northern Thailand where the data set is somewhat more complete suggests a similar pattern of long-term decline but there are other locations again where there have been long-term increases. Taken as a whole, the regional rainfall data suggests that there has been no long-term reduction in levels of precipitation despite substantial reductions in forest cover (Walker 2002). It is interesting to note that that data from

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[4] This section is a brief summary of relevant sections of Walker (2002).

[5] For other examples of these views see Walker (2002).

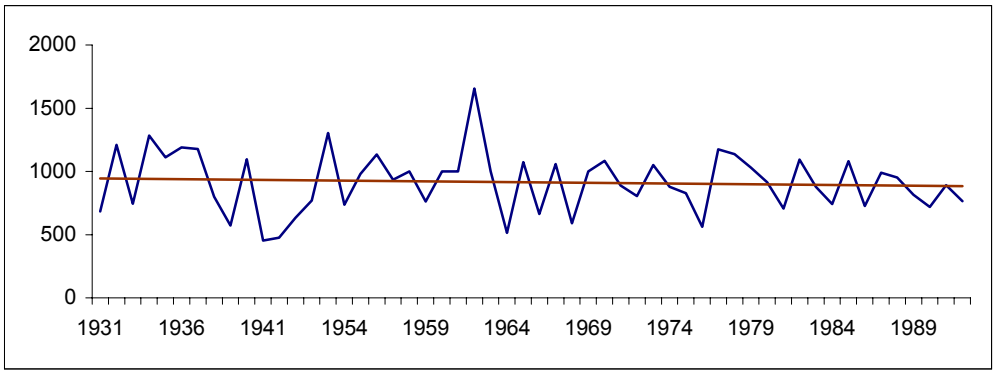

Figure 3: Annual precipitation (millimetres) with long-term trend in Mae Chaem. Source: Royal Irrigation Department.

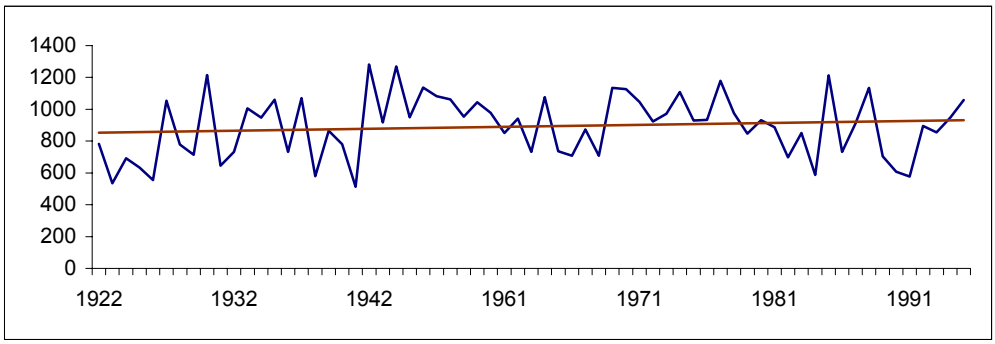

Figure 4: Annual precipitation (millimetres) with long-term trend in Chomtong. Source: Royal Irrigation Department.

Mae Chaem (where forest loss has been relatively modest) suggests a slight decline while data from the neighboring district of Chom Thong (where forest loss has been much more significant and water resource conflicts are much more intense) suggest a long-term increase (Figure 4). Only a very selective reading of the regional data could support the claim that deforestation has lead to reductions in levels of rainfall.

It appears likely that the long-term stability in regional rainfall is largely a result of the strong maritime influence in Southeast Asia. The rain that falls in northern Thailand is predominantly monsoonal and derives not from evapo-transpiration in northern Thailand itself but marine sources to the west (Donner, 1978: 675). For this reason local forest cover has very little impact on rainfall. Nevertheless, there are temporal and spatial factors that may account for widespread beliefs linking forest cover and rainfall. In temporal terms there does appear to be some evidence that a relatively drier period occurred during the 1980s and early 1990s and that this followed a relatively wetter period during the 1970s. Importantly, the dryer period during the 1980s and 1990s coincided with a dramatic increase in interest on forest policy in Thailand and it is not surprising that these two key environmental issues—water supply and forest loss—have become linked in public debate and policy discourse. But it must be emphasized that the recent dryer period is by no means unprecedented, with the longer-term data showing a long-standing oscillation between relatively wetter and relatively dryer periods, seemingly independent of the progressive decline in forest cover (Walker 2002: Figure 8). Spatial factors are also significant. Forested areas in northern Thailand tend to be located at higher altitudes and these are also the areas that receive the highest rainfall as warm moist air masses rise to higher and cooler altitudes. The popular belief in Thailand that 'where there is forest there is rain' has a strong basis in common-sense experience and observation but the higher levels of rainfall in highland areas are a function of altitude rather than forest cover.

Are forests catchment sponges?

In Thai public discussion of environmental issues it is regularly argued that forests serve as catchment 'sponges'—storing wet season rainfall and releasing it during the dry season. However, despite the level of public certainty, the role of forests in modifying stream flow in catchments is one of the more complex issues confronting hydrologists. In order to examine the issue two separate hydrological processes need to be examined: the ability of forested areas to absorb rainfall and the level of water use of the forest itself.

In relation to the first process, there does appear to be some evidence that during rainfall events forests are relatively effective 'sponges' in that they absorb more water than other land-surfaces, largely as a result of the layer of forest humus and relatively good soil condition. A fascinating study undertaken in northeast Thailand by Takahashi et al. (1983) found that rates of infiltration on forested land were *significantly higher* than they were on nearby cultivated plots. Rates of infiltration on cultivated plots were particularly low—with runoff sometimes exceeding sixty per cent—early in the cultivation cycle before crops and weeds provided groundcover. By contrast they found that run-off from the high infiltration forest plots rarely exceeded 10 per cent. This finding is backed by Vincent et al. (1995: 8-9) who, based on a review of relevant research, argue that infiltration rates are higher in natural forest areas due to 'thick layer of natural debris' that protects the soil and slows runoff.

However, the ability of forests to absorb water during rainfall events is only part of the story. While forests are *sponges* they are also very effective *pumps*. As pumps, forests in northern Thailand are so effective that fully forested landscapes can return up to eighty per cent of rainfall to the atmosphere leaving only twenty per cent as stream flow (the source of water supply for irrigators). Forest water usage starts when rainfall is intercepted by the forest canopy and evaporated back into the atmosphere and continues when the extensive and deep root systems of forests enable year-round extraction of soil moisture. In the *fully forested* catchment of Huay Kok Ma it was found that forests 'pumped out' over 1,200 millimeters of the 2,000 millimeters of rain that fell (Walker 2002: 13-14). It is this 'pump' effect that leads Alford (1992: 267) to conclude that 'the mountain catchments of northern Thailand are among the most 'arid' on earth.'

The fact that forests are very effective catchment pumps means that clearing forests typically increases annual stream flow and this increase can be very significant. However, with some loss of the 'sponge effect' there may be an increase in the proportion of annual flow that takes place in the wet season shortly after rainfall events. Will this mean that there is less water for the dry season? A careful and detailed answer to this question has been provided by Bruijnzeel (1989) who, after reviewing numerous international catchment studies, argues that if *a reasonable amount of care* is taken to maintain the infiltration capacities of cleared land, the effect of reduced forest water use will outweigh the effect of reduced infiltration, *resulting in an increase in dry-season base flow*. An illustration of this is provided by the study of Takahashi et al. (1983) referred to above. Recall that they found that rates of infiltration on forested land were significantly higher than rates of infiltration on cultivated land. However, when the soil itself was examined it was found that soil moisture was significantly higher in cultivated areas, despite the lower levels of infiltration. The reason for this was that plants on cultivated land extracted much less water from the soil than the forest. *In other words there was some loss of sponge effect on cultivated land but this was more than compensated for by the reduction in the pump effect that followed forest clearing.*

So, what conclusions can we draw from the hydrological evidence in relation to Mae Uam? Overall, it seems clear that a modest reduction in forest cover is unlikely to have had a substantial impact on stream flow and, if anything, the impact on dry season stream flow may have been marginally positive. It is relevant to note that almost half of the forest loss in the Mae Uam catchment between 1985 and 1995 has resulted in the development of permanent agricultural fields in the lower-lying and lower slope areas of the catchment. The substantial presence of terraced paddy in these areas—which slows and filters the passage of water through the landscape—means that opportunities for soil infiltration are relatively abundant (Hamilton, 1987: 257). In other words, the negative impact of forest loss on the so-called 'sponge' effect in these areas is likely to be very modest. It is also

important to remember that any minor (positive or negative) effects of human-induced land cover change on water supply are likely to be relatively insignificant when compared to the *naturally occurring* short-term variation in rainfall.

Has agricultural intensification increased water demand?

Dry-season water resource constraints are emerging in the Mae Uam catchment in an environment of modest reductions in forest cover, relatively stable hill-slope cultivation but significant increase in the area of paddy and paddy-fringe cultivation in the low-slope areas of the catchment. The trend away from land-extensive shifting cultivation to land-intensive paddy production has been documented in a number of studies of agricultural systems in northern Thailand (Cooper, 1984; Kanok and Benjavan, 1994; Michaud, 1997) but has not been given much serious consideration in recent discussions of water resource management in mountainous upland catchments. In the following sections I will examine the key components of this process of intensification and its impact on demand for irrigation water. While my focus is on dry-season agricultural activity, it is informative to compare this with trends in wet-season cultivation.

Wet-season agricultural change

Agricultural modernization has had a relatively limited impact on wet-season agricultural activity in the Mae Uam catchment. The predominant agricultural activity during the wet season is the production of rice in irrigated rice fields for subsistence purposes. During the wet season in 1997 rice was grown on eighty-three per cent of the cultivated paddy area. The balance was made up of soybeans and maize (about five per cent each) and small plots of shallots and turnips. Over eighty per cent of these non-rice crops were grown on rain-fed paddy fields with irrigated paddy devoted almost exclusively to rice production. It is clear that subsistence-oriented production is by far the highest priority on the relatively high-yielding irrigated fields (over 3,000 kilograms of rice per hectare). During the wet season there is also some cultivation of hill-slope rain-fed fields, which in 1997 amounted to about forty-five per cent of the area of paddy cultivation. During 1997 these fields were cropped with upland rice (seventy-three per cent), soybeans (twenty per cent) and maize (eleven per cent). Upland rice features prominently—despite relatively low productivity (around 1,200 kilograms per hectare)—largely because there is a significant group (about seventeen per cent of farmers) who are entirely dependent on hill-slope rain-fed fields for their agricultural livelihoods.

Dry-season agricultural change

By contrast, there have been very important changes in the patterns of dry-season cultivation. While further ethno-historical research is needed it appears that until about twenty years ago dry-season cropping in the small upland catchments surrounding Mae Chaem was limited to small areas of vegetable gardens on the banks of streams. The absence of dry-season cropping does not appear to have been a reflection of rice-based self-sufficiency—given local reports of regular rice deficiency—but reflected the dry-season economic focus on off-farm labour and trading activities as a supplement to under-producing rice production systems. Local accounts suggest that cattle trading was an important feature of these economic systems, with dry season paddy fields used as a staging point for cattle in the trade between upland villagers—and perhaps even villages across the border in Burma—and the larger trading centers close to Chiang Mai. Given the rudimentary state of transport connections, farmers working as dry-season ox-traders also played an important part in the basic commodity trade (Congmu, 1997: 152; cf. Chusit, 1989 and Moerman, 1975).

While non-agricultural pursuits are still an important component of dry-season activity, the widespread adoption of soybean cultivation represents a very substantial change. Data from the household survey in Mae Uam indicate that soybeans were cultivated on almost seventy per cent of the irrigated paddy area during 1997-1998. Soybeans have been widely promoted in northern Thailand—largely as an import substitution initiative—and they now constitute, by area, one of the main non-rice crops in the region (Abamo, 1992: 15, 26). In the Mae Uam catchment, local varieties have been grown for local consumption over a long period but commercial production of soybeans was only introduced in about 1984 when demonstration plots of improved varieties were established in numerous villages in the district as part of the Mae Chaem Watershed Development

Project (Ministry of Agriculture and Cooperatives, 1984: 21). Good yields were recorded and, despite the fact that limited input support was offered to farmers, adoption was rapid, perhaps due to uncharacteristically high prices in the latter half of the 1980s (TDRI, 1994: 74). Soybeans remain attractive given relatively stable prices, low input costs and relatively modest labour requirements. Of course, adoption has not been completely unproblematic with low yields in some areas—possibly associated with declining soil fertility—prompting adoption of other dry-season crops. Maize, which can be readily sold in Mae Chaem, is a popular alternative though its relatively high water consumption is a major disadvantage in dry years. Other farmers have experimented with higher value vegetable crops such as sweet corn, carrots, potatoes and shallots, but none of these alternatives have proven as popular as soybeans.

The hydrology of dry season cultivation

How hydrologically significant may this increase in dry season agriculture be? Some relatively simple calculations suggest that it may be very significant indeed. First, it is necessary to provide some data on dry-season water *supply*. Given that there is no stream gauge in Mae Uam I have estimated supply by taking eleven years of stream flow data from a nearby catchment with roughly similar aspect, elevation and morphology and scaling the data according to the specific characteristics of the Mae Uam.[6] My intention is merely to provide an indication of the likely magnitude of water supply in Mae Uam. Figure 5 provides one of the key results of these calculations, setting out the total water supply during the month of February, typically a month of high irrigation demand given the stage of development of the soybean crop. The very significant short-term year-to-year variation in dry season water supply—independent of longer-term land-cover trends—is clearly evident.

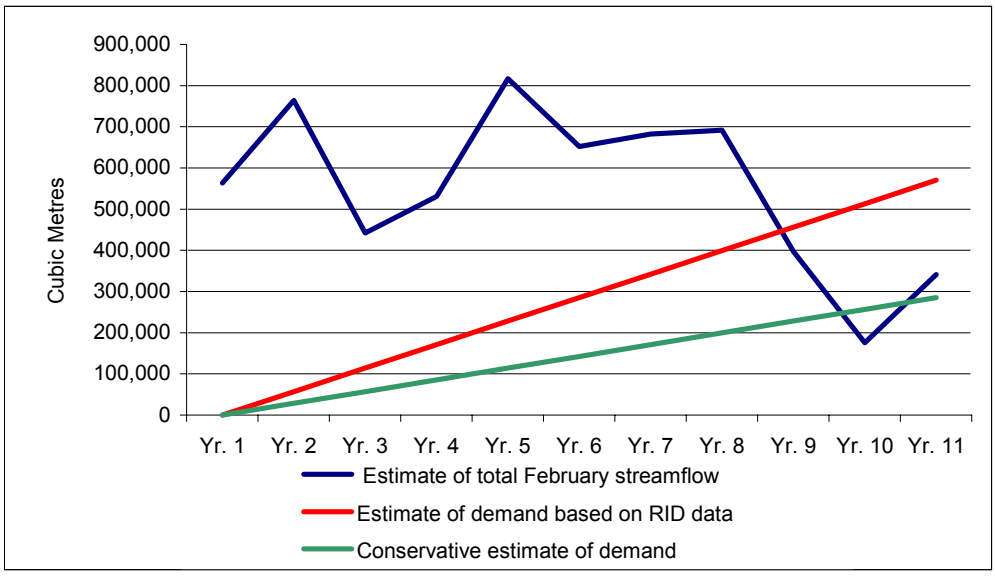

Figure 5: Estimate of water supply and water demand in February, given hypothetical 11-year increase in dry-season soybean cultivation.

My estimate of water *demand* is based on the water consumption (evapo-transpiration) of the soybean crop. My calculation uses the standard method of combining an estimate of evapo-transpiration from a 'reference crop' (for Chiang Mai) with a crop coefficient for soybeans (which varies according to the stage of growth of the crop.) Using the Royal Irrigation Department's (RID) reference crop data and their crop-coefficients for soybeans the total water consumption of one

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[6] These data are then scaled by two factors: catchment size and average elevation. The source catchment has minimal agricultural activity, so the stream flow (supply) data is not affected by irrigation extractions (demand).

hectare of soybeans planted in mid-November is about 4,900 cubic meters (1,340 cubic meters during February). However this represents crop water consumption under ideal and well-fertilized conditions and, if achieved, would result in levels of yield significantly beyond those typically achieved by farmers in Mae Uam. A much more conservative estimate of 2,400 cubic meters (670 cubic meters during February) is provided by Perez et al (2002) based on an estimate of likely agronomic conditions in Mae Uam. Given the significant difference I have used both estimates of water consumption: the "RID" estimate and the "conservative" estimate.

These estimates of water demand, focusing on the month of February, have been added to Figure 5. The demand figures reflect a hypothetical increase in soybean cultivation from zero to eighty per cent of the irrigated paddy area in the catchment.[7] I am not suggesting that this is an accurate reflection of the history of soybean cultivation in Mae Uam. Rather, my intention if to provide a broad indication of the hydrological magnitude of past, and possible future, agricultural intensification within the catchment. At the higher levels of soybean cultivation the potential for water deficit in dry years is clearly evident, even if the more modest levels of crop evapo-transpiration are used. After viewing these data the complaints of soybean cultivators about water shortages in drier years are certainly unsurprising. Furthermore, there are a number of additional factors that highlight just how critical this water constraint may have become. First, given irrigation inefficiencies, significantly more water has to be extracted from the stream to meet crop evapo-transpiration. While much of this additional water can be re-used within the catchment, the relatively inefficiency of conveyance and delivery systems compounds timing and coordination problems. Second, technological constraints place limits on the percentage of water that can be extracted from the stream—some estimates I have heard are as low as fifty per cent—given that pumps are not used to extract water from streams or canals during low flow periods. Moreover, irrigation weirs have no capacity to store water to meet water demand in peak periods. For all these reasons *it is very likely that substantial water resource constraints and tensions are likely to emerge well before the supply and demand lines intersect.*

The sociology of dry-season agriculture

Dry-season cultivation of soybeans is a widespread phenomenon in *both* upstream and downstream areas of the Mae Uam catchment, and in both Karen and northern Thai villages. Among all the households surveyed in the Mae Uam catchment almost sixty per cent cultivated soybeans in the previous dry season devoting, on average, almost eighty per cent of their household paddy fields to this pursuit. Given that it appears that dry-season water demand may be a key factor in emerging water resource tensions in the Mae Uam catchment it is important to develop an understanding of the characteristics of these dry-season soybean cultivators. Two key features stand out: ownership of irrigated paddy land and relatively limited involvement in off-farm wage labour.

Access to irrigated paddy land

Ownership of irrigated paddy fields is, of course, the key to dry-season soybean cultivation. Expansion of paddy fields has resulted in a relatively high incidence of ownership with about eighty per cent of households in the catchment owning irrigated paddy fields. Among dry season soybean cultivators the level of ownership of irrigated fields is about 0.7 hectare. The fact that all dry season soybean cultivators are irrigated paddy owners may seem obvious, but it is a point worth reinforcing given the ongoing preoccupation with hill-slope farmers as the key agents of catchment transformation. A few simple statistics illustrate the key role of irrigated fields in supporting agricultural intensification. Irrigated fields result in higher and more stable yields during the main rice-growing season. Survey data indicate that those who cultivate soybeans in the dry season are relatively successful wet-season rice cultivators with average production of about 2,200 kilograms of rice per household. This generously covers subsistence requirements and permits the sale of about fifteen per cent of irrigated rice production. Revenue from wet-season rice sales facilitates

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[7] This is an *estimate* of irrigated paddy area derived from land cover data, village mapping and household survey data.

investment in dry season agricultural inputs and, in turn, fertilizer residue and nitrogen benefits[8] from dry-season cultivation have a beneficial effect on wet-season rice yields. For some farmers (about fifteen per cent of dry-season soybean cultivators) cash incomes and investment potential is further supplemented by the ownership of rain-fed hill-slope fields on which they can grow wet-season cash crops (soybeans and maize) given the subsistence security afforded by their irrigated paddy fields.

The contrast with the seventeen per cent of households totally dependant on rain-fed hill-slope fields is striking. Contrary to widely held stereotypes this is not just an upper-catchment "hill-tribe" phenomenon. The Karen village of Mae Ming does have the highest incidence of complete dependence on upland fields (forty-four per cent of households) but the second highest incidence occurs in the downstream northern Thai village of Ban Chiang (twenty-four per cent) and in the highest elevation Karen village of Pha Thung the incidence is relatively low (only fourteen per cent). These households, of course, *have no impact at all on dry-season irrigation demand* and none indicated that they had been able to rent irrigated paddy fields during the dry season (unsurprisingly, given its high level of use). A brief consideration of the relatively precarious position of these households casts important light on their relative inability to benefit from processes of agricultural intensification within the catchment. During the wet season they farm, on average, 0.6 hectares of hill-slope fields on which cultivation of rain-fed rice is the predominant activity (almost ninety per cent of the cultivated area). This is a strongly subsistence-oriented system with all households indicating that they consume (or keep for seed) all the rice they produce. Given that average rice production is only about 650 kilograms per household—and average household size is five—it is not surprising that seventy-five per cent of these households cannot meet their subsistence needs from rice production and an estimated forty per cent have difficulty meeting their subsistence needs even when income from non-agricultural sources is taken into consideration.[9] By a range of other indicators these households emerge as the most disadvantaged: they have by far the lowest level of spending on agricultural inputs; the lowest household labour input; the lowest use of hired labour and the lowest ownership of consumer durables. Given the precarious position of many households in this category their inability to invest in hill-slope irrigation systems (such as sprinklers) is unsurprising and it seem unlikely that many will be in a position to purchase or construct more productive irrigated paddy fields.

Non-agricultural activities and soybean cultivation

Looking at the Mae Uam catchment as a whole around fifty per cent of gross household income is derived from non-agricultural activities. Key sources are non-agricultural labouring (thirty-three per cent of gross household income), agricultural labouring (seven per cent) and trade (six per cent). Interestingly, given the emphasis in academic and activist literature on forest management in mountain areas of northern Thailand, forest products account for a relatively insignificant one per cent of gross household income.

These average figures conceal various dimensions of social and spatial variation. Here, however, I want to focus on comparing soybean and non-soybean cultivators to highlight the very significant differences in their livelihood strategies. On average, dry season soybean cultivators earn about 28,000 *baht* from their household's agricultural activities (crops and livestock). This is substantially higher than the 17,000 *baht* earned by those who cultivate no soybeans in either the dry or wet season. Does this mean that soybean cultivators are economically better off? Not at all! This is because the non-soybean cultivators earn much more from non-agricultural sources (39,000 *baht* versus 17,000 *baht*). About three quarters of this non-agricultural income is derived from wage labour outside the agricultural sector. The net effect is that non-soybean cultivators have gross household incomes on average about twenty per cent higher than their soybean-cultivating

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8 Soybeans are nitrogen fixing.

9 Tanabe (1994: 66) estimates per capita consumption of rice in northern Thailand at 300 kilograms.

neighbours. The dramatic difference in household livelihood strategies between these two groups is highlighted by the fact that soybean cultivators derive sixty-two per cent of their income from crops and livestock while for non-soybean cultivators the percentage is only thirty-one per cent.

This profile of household income highlights some of the subtleties of the process of rural commercialization. While the dry-season soybean cultivators have chosen a path of market engagement they are, in other respects, less involved in market relations than their less *agriculturally* commercial neighbours. The alternative to growing soybeans in the dry season is not, as is sometimes suggested, a subsistence-oriented and community-focused lifestyle of dry-season ritual and leisure but involvement in external labour relations to the extent that agriculture takes on a somewhat minor role in household income. Indeed one of the reasons cited for the popularity of soybean cultivation is that it enables male farmers to maintain closer contact with their villages and households.

Catchment location and soybean cultivation

The data from the Mae Uam catchment do not support any clear distinction between rapidly commercializing lowlanders and subsistence-oriented uplanders. Indeed the lowest rate of soybean cultivation (thirty-eight per cent of households surveyed) was found in the downstream northern Thai village of Chang Khoeng Loum that is, in many other respects, the most commercialized village in the catchment. But, while there is no clear upstream-downstream distinction there do appear to be some noteworthy spatial patterns. Overall, sixty-six per cent of farmers in the downstream villages grow soybeans in the dry season, while the percentage in the upstream villages is only forty-eight per cent. The contrast is most striking between the downstream northern Thai village of To Rua (ninety-four per cent) and the upstream Karen village of Mae Ming (forty-four per cent). The intensity of cropping was also higher among dry-season cultivators in the downstream northern Thai villages. These soybean cultivators allocated almost all their irrigated paddy to dry-season cultivation while in the upstream villages the percentage was somewhat lower, at seventy-four per cent.

What may account for this variation in the level of dry-season cropping? Why does To Rua, in particular, have such a high rate of dry season soybean cultivation? Further research into the micro-processes of farmer decision-making is clearly required to answer these questions, but there are some obvious reasons and some more speculative possibilities. First, To Rua has a particularly high rate of irrigated paddy ownership (ninety-four per cent) significantly higher than the rate of paddy ownership in Mae Ming (fifty-six per cent). Second, the soil in the downstream areas, particularly near the village of To Rua, is said to be particularly suitable for soybean cultivation, requiring minimal fertilizer input. Third, it appears that as a result of good planning or topological good fortune, the two weirs built in the lower reaches of the catchment in the 1980s appear to have provided the opportunity for intensification of permanent cultivation around To Rua. Analysis of the land-cover data indicates that the largest area of expansion or permanent lowland cultivation in the catchment occurred on the northern fringes of To Rua's paddy fields. It may also be significant that To Rua farmers have first call on the water flowing from these new irrigation weirs (and those in Chang Khoeng Loum have last call). Fourth, the downstream villages have very good access to marketing infrastructure in the town of Mae Chaem. Of course, the upstream villages are not particularly inaccessible but less regular visits by traders and higher transport costs mean that "farm-gate" soybean prices in these villages are about ten per cent lower. Finally, downstream farmers appear to have more secure tenure than their upstream counterparts. In To Rua, for example, only twenty per cent of agricultural plots have no formal title while in Pha Thung seventy-two per cent of plots fall into this category. Though there is no unambiguous relationship between tenure security and agricultural strategy it is likely that more secure tenure gives the downstream farmers access to cheaper, formal, sources of agricultural credit.

Conclusion: the politics of water resource management

The case study of the Mae Uam catchment provides some important insights into the current context of water resource tension in the mountain catchments of northern Thailand. This local

study illustrates the potential for the hydrological limits of catchments to be reached—and exceeded in drier years—as a result of relatively unremarkable processes of agricultural intensification and where the irrigated land comprises a modest percentage of the total catchment area. The situation in Mae Uam also highlights the potential for dry-season intensification to take place in *both* upstream and downstream areas though poorer resource endowments may place some constraints on upstream cultivation. Soybean cultivation has been widely adopted in Mae Uam even though it seems somewhat less lucrative than off-farm alternatives. Given the important implications for water resource management, the specific local reasons for this on-farm rather than off-farm preference warrant further attention.

Analysis of secondary literature suggests that the dry-season trends in Mae Uam are broadly typical of those occurring in other mountain catchments especially in some of the areas where the most intense water resource conflicts have emerged (Pinkaew, 2000; Renard, 1994: 663; Ukrit, 2001; Ukrit and Isager, 2001). This unprecedented increase in *demand* for water should prompt some reassessment of the widespread preoccupation with water *supply* and its relationship with forest cover. Too often, it seems, catchment conflicts have been reduced to unproductive debates about the appropriate strategies for protecting the forest cover that is said to ensure adequate water supplies. Lowland farmers, uniting under the environmental banners of 'watershed protection,' advocate relocation of upstream forest destroyers while the defenders of these upstream farmers point to longstanding traditions of sustainable forest management in sensitive water supply areas. Despite the vigor of the debate[10] there is little questioning of the role of forest cover in maintaining water supply. What is ignored in this debate is the growing body of hydrological evidence that forest clearing has *had no significant impact on long-term rainfall trends and a very modest impact, if any, on stream flow in the dry season*. What is also ignored in this debate is that there is *very substantial natural short-term variation in water supply* and that this variation is unrelated to medium or long term changes in forest cover.

The ongoing focus on water supply and forest protection frames catchment management debates in partial and highly selective terms. In particular it contributes to the maintenance of a regulatory focus on farmers located in areas where the level of forest cover is still significant, precisely the farmers who by various measures are often the most socio-economically disadvantaged. The inequity of this regulatory focus on forest is evident at various spatial scales. At a local level—within villages—the impacts of forest protection measures fall most heavily on farmers who are completely dependant on the cultivation of rain-fed hill-slope fields. The material from Mae Uam demonstrates that these farmers are the most disadvantaged and vulnerable and—underlining the injustice—these are the farmers whose agricultural activities have the least hydrological impact. There is increasing anecdotal evidence from other areas suggesting that these farmers are particularly vulnerable when local forestry initiatives aimed at demonstrating conservationist credentials are put in place. At a broader scale the material from Mae Uam demonstrates that hydrological pressures in terms of water demand are emerging from agricultural activities *throughout* the catchment area and that there is no reason at all for regulatory mechanisms targeting hydrological issues to be focused on relatively forested upstream areas. This selective application of the principles of catchment management—a point highlighted by Pinkaew (1999)—clearly serves the interests of the relatively more developed and socio-politically more influential communities in downstream areas.

Socially and environmentally sustainable initiatives in catchment management must surely involve attention to the water demands of upstream *and* downstream farmers. In some recent cases of water resource conflict, defenders of upstream communities have drawn attention to the increasing demands for water by lowland farmers. This is important *but not sufficient*. The material from Mae Uam shows that sharp dichotomies between high-water-using downstream farmers and subsistence-oriented upstream farmers are simply not tenable and they are even less tenable in some other areas where highland intensification has been more marked. Some may consider it politically

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[10] For one of the most recent contributions to this ongoing debate see Deland (2002).

risky to draw attention to increasing water use by upstream farmers, especially when these farmers are members of minority ethnic groups who tend to be denied a legitimate presence in northern Thai landscapes. But my view is that it is important to assert the rights of these relatively marginal framers as legitimate *users* of catchment resources not just as *guardians* of resources for those in downstream areas. In future processes of water resource negotiation it would be unfortunate indeed if upstream irrigators found their resource claims constrained or even undermined by normative images of catchment guardianship, forest protection and subsistence orientation. It is surely relevant to note that those most virulently targeted in recent catchment disputes are upland farmers whose intensively commercial practices are inconsistent with official and alternative images of appropriate upland livelihoods. A defense of their rights may best be framed in terms of their legitimate claim to a fair share of scarce and valuable resources, a claim that needs to be liberated from the normative imagery of the hydrological importance of upland forest guardianship.

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