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Policy Brief

THE ECONOMICS OF WATERSHED PROTECTION: A CASE STUDY OF THE MAE TAENG RIVER

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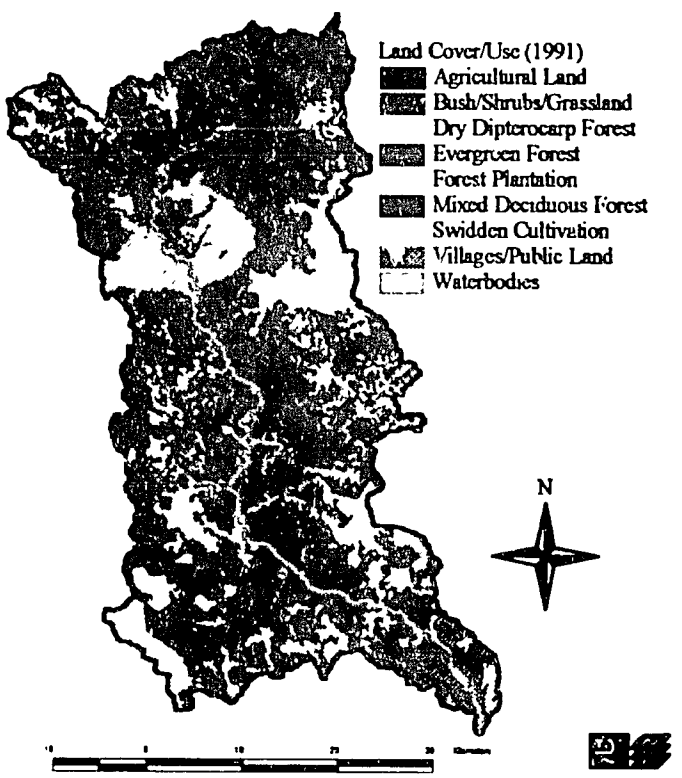
Economic development raises demand for freshwater. In the agricultural sector, irrigation replaces less water-intensive rainfed systems. The manufacturing sector becomes more important, and for most manufacturing processes water is an essential input. The consumption of water for personal use rises due to population growth and higher incomes.

Rising water demand typically exists in a situation in which use rights for water are not well-defined. Water is available on a first-come, first-served basis, with users facing low or no cost for the water they use. But this free-good situation is artificial. Although rain falls freely from the skies, water is most certainly a scarce commodity. Capital investment is required to capture, store, treat, and distribute freshwater to users, whether they are farmers, factories, or families. In addition to the direct financial costs of provision, there are opportunity costs, as use of water by one party usually makes it unavailable to others. Water removed from rivers for irrigation evaporates and transpires from farm fields and cannot be used by other users downstream. Industrial extraction of water from underground aquifers takes away water that otherwise could be used by households.



Failure to compel users to pay the full costs of the water they consume inevitably results in overconsumption and misallocation. Water provided at low or no cost is water that no one has a financial incentive to conserve. It flows not to those who value it the most — those who are willing to pay the highest price — but rather to those who, by geological or topographical good fortune, happen to be first in line. In the end, too much capital is invested to provide too much water to users who do not value water the most. Scarce capital resources are wasted, and economically important uses of water are unmet.

Inefficient water use is a problem world-wide. It knows no geographic or climatic boundaries. It is just as likely to occur in rich regions with abundant rainfall as in poor regions that are arid, though its consequences may take longer to become obvious in the former. Thailand provides an example of a country that, despite a tropical climate that provides relatively abundant precipitation, nevertheless has faced water shortages in recent years. While the shortages have undoubtedly been exacerbated by cyclical droughts, they are also the consequence of water policies that inadvertently divert water from its economically most valuable uses.

The allocation of the water resources of the Mae Taeng River provides an important example of the economic impacts, often unintended, of water and watershed management policies. The Mae Taeng watershed is a 1,900 km^2 catchment basin situated in the far north of Thailand, bordering Myanmar. The Mae Taeng provides a significant portion of the water consumed by the rapidly growing city of Chiang Mai. It also provides virtually all of the irrigation water consumed by farmers in the Mae Taeng Irrigation Project, a 30-year old, 100,000-plus *rai* (6.25 *rai* = 1 hectare) area stretching north and south of Chiang Mai along the west bank of the Mae Ping River. During the dry season (December-April), virtually all of the streamflow in the Mae Taeng is diverted to the Irrigation Project.

Main findings: land-use changes and reduced streamflow

Although land-use information is sketchy, some amount of swidden agriculture (shifting cultivation) has occurred in

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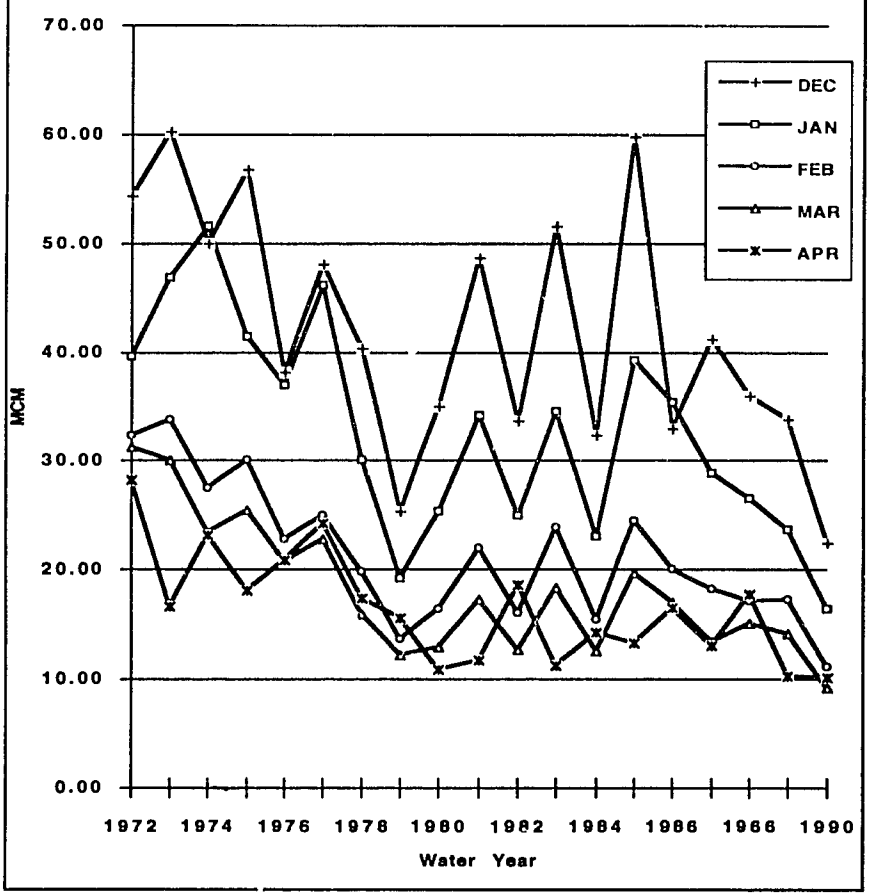
the Mae Taeng watershed throughout this century. This has resulted in the conversion of natural forests to grassland and scrubland. According to a survey conducted by the Department of Land Development (DLD), swidden agriculture, grassland, and scrubland covered 10 percent of the watershed in 1991 The Royal Forestry Department (RFD) has conducted reforestation programs since the early 1960s to reestablish forest cover in such areas. According to the DLD survey, forest plantations covered 10,443 ha, or 6 percent, of the watershed in 1991 There is some doubt about the accuracy of this estimate, however, as the survey was mainly for the purpose of determining the extent of active swidden cultivation, particularly of opium. The RFD's records indicate instead that 16,734 ha were planted during 1967-91. This represents 9 percent of the watershed

The RFD's reforestation efforts have provided important economic benefits in the form of reduced soil erosion, increased production of wood fiber and some nontimber products (e g , turpentine), and expanded wildlife habitat, but they have probably also reduced streamflow in the Mae Taeng. Evidence from forest hydrology studies indicates that the replacement of grass or scrub cover by forests reduces average annual streamflow Forests transpire more water than ecosystems with less vegetative biomass, and they evaporate more water due to their higher leaf area A review of 94 catchment experiments conducted in various countries around the world found that in every case the replacement of low cover (bareland, grassland, weeds, brush) by trees reducedannual water yield. Reductions were greatest when the trees were evergreen, which transpire year-round. on average, every 10-percent increase in coniferous cover reduced annual water yield by 40 mm. Of significance, pines have been the priority species in the RFD's reforestation program in the uplands. In some instances, pine plantations have been established in areas that, before swidden cultivation, were covered with deciduous forests, which transpire very little during the dry season, when they lose their leaves

Reforestation aims at mitigating the effects of deforestation that has already taken place. To prevent further deforestation, and to discourage the cultivation of opium poppies, the Government has promoted projects that encourage swidden agriculturists to take up sedentary agriculture and cultivate rice and cash crops like cut flowers, fruits, vegetables, and barley In many cases, these projects have involved the introduction of irrigation systems Irrigated agriculture consumes more water than swidden or rainfed agriculture, particularly when it permits the cultivation of a dry-season crop. Estimates of the area of irrigated agriculture in the watershed are limited and of dubious accuracy According to the DLD survey, this area was only 2 percent in 1991, but this estimate only includes irrigated rice. It leaves out small-scale irrigation systems associated with other crops In any event, one would expect the expansion of irrigated agriculture to have raised water consumption in the watershed and reduced streamflow.

Figure 1. Dry Season Monthly Stream Flow - Ban Sop Kai



Despite these efforts, deforestation has continued in the watershed If we accept the RFD's forest plantation estimates and the DLD's estimates for other land uses as the most accurate, natural forest cover (excluding swidden agriculture) was down to 70 percent of the watershed area in 1991. The percentage in earlier decades is not clear, due to the lack of reliable estimates of the area affected by swidden agriculture, but it was certainly higher. The loss of forest cover would be expected to raise average annual streamflow and thereby offset, to an unknown degree, the expected reductions due to reforestation and irrigation. Soil erosion and soil compaction can, however, weaken this effect during the dry season: when the infiltration capacity of the soil is reduced, precipitation during the wet season is less likely to be stored for gradual release over succeeding months

In sum, the net impact of land-use changes in the Mae Taeng watershed on streamflow depends on the extent to which the streamflow-decreasing effects of reforestation and irrigation have outweighed the streamflow-increasing effects of deforestation. A statistical analysis of monthly streamflow data for the Mae Taeng determined that there was no statistically significant trend in streamflow during WY52-WY72 (WY = water year; WY52 = April, 1952 to March, 1953). During WY72-WY91, however, which is the period when watershed protection efforts

(i e , reforestation and promotion of sedentary agriculture) were stepped-up, streamflow declined by statistically significant amounts during the dry-season months of December-April (see Figure 1) In the aggregate, the decrease was 3 2 million cubic meters (MCM) on average, streamflow was lower by 3 2 MCM each year during the dry season compared with the preceding year

Of course, this result could perhaps simply reflect reductions in precipitation during the period If there is less water entering the system, there is less to flow out. But statistical analysis of monthly streamflow during December-April, allowing for the effects of rainfall during the previous 7 months of the year (rainfall during even earlier months was found to have no significant impact), yielded virtually identical results streamflow declined by statistically significant amounts in each month, and the aggregate decrease was 3 2 MCM Adding a temperature variable (to represent, very crudely, evapotranspiration potential) or changing the period of analysis (to account for possible shifts in the rating curves at gauging stations) did not affect the results appreciably The most conservative estimate of the residual decline in streamflow was 2 9 MCM

These statistical results provide strong circumstantial evidence that watershed protection efforts in the Mae Taeng watershed have had the unintended effect of reducing streamflow Rough calculations suggest that the magnitude of the streamflow reduction can be plausibly explained by land-use changes in the watershed For example, based on the relationship that a 10 percent increase in area of evergreen forest decreases water yield by 40 mm (if it replaces grassland), the RFD's reforestation efforts during 1972-91 would be expected to cause annual streamflow to decline by 3.2 MCM per year.

Main findings: costs to downstream users

Were there no downstream users, the increase in water consumption within the watershed would not be a concern But, as described earlier, there are indeed important downstream water users, in both the Mae Taeng Irrigation Project and the city of Chiang Mai Faced with less water during the dry season, farmers in the Mae Taeng Irrigation Project have reduced cropped area and switched to less water-demanding crops. Dry-season cropped area declined from about 100,000 *rai* in the late 1960s and early 1970s to around 40,000 *rai* in the late 1980s and early 1990s Soybeans replaced rice as the principal crop. Of course, reduced water availability is not the only reason for these adjustments; the conversion of land to nonfarm uses and escalating agricultural labor costs have also been important. Had streamflow not decreased by 2.9 MCM per year, annual agricultural revenue during 1980-91 would have been higher by 26 to 93 million baht, depending on the year. These are best interpreted as upper-bound estimates, as they do not take into account fully the constraints imposed by available labor resources. These amounts are substantial, being equivalent to 29-93 percent of actual annual revenue during the period.

The number of water accounts serviced by the Chiang Mai Water Works has doubled during the last 10 years. The Water Works has three treatment plants Two, the Wang Sing Kham and Pa Tan plants, draw water from the Mae Ping. The other, the Umong plant (constructed in 1968 and enlarged in 1976), draws water from the main canal of the Chiang Mai Irrigation Project. Although the Umong plant represents 56 percent of the Water Works' total treatment capacity, it is the lowest priority water user in the Irrigation Project, as farmers have first right to water in the system Consequently, as streamflow has declined over the past two decades, the Umong plant has been forced to shut down during most of the dry season, due to an inadequate supply of raw water

The foregone water production due to the Umong plant sitting idle during December-April totals 4 5 MCM. During the same months, the total amount of streamflow diverted into the irrigation project averaged 90 MCM during WY70-WY91. Hence, just a 5-percent reduction in agricultural use would enable the plant to operate at full capacity. Such reallocation of water away from irrigation and toward municipal use appears to be justified on economic grounds, as water in most municipal uses is economically much more valuable than water in irrigation. The marginal agricultural revenue generated by an additional cubic meter of water being used in irrigation was only 0.91-1.66 baht during 1980-91. In contrast, in 1993, the marginal value of raw water ultimately sold to industrial users was 6.99 baht per cubic meter, and the marginal value of raw water ultimately sold to households or government offices was 3 79 baht per cubic meter. Only water sold to industrial estates was less valuable at the margin than irrigation water: its marginal value was only 0.60 baht per cubic meter.

Although these watershed protection efforts may be socially and economically justified, they appear to have unintentionally raised water consumption in the watershed, thereby depriving downstream users . . .

Municipal water shortages are exacerbated by high leakage rates. In 1993, only about 71 percent of treated water was actually sold. Most of the balance was water loss in the distribution system. The leakage rate is about 50 percent higher than what is considered acceptable for a municipality in a developing country. Because the Water Works withdraws raw water from the Mae Ping and the Mae Taeng Irrigation Project (when water is available) for free, it has little incentive to plug the leaks.

Conclusions

Water allocation problems exist between users in the Mae Taeng watershed and users downstream, as well as between different groups of downstream users. The watershed has been the site of some of the country's most

aggressive efforts to combat deforestation and opium cultivation Although these watershed protection efforts may be socially and economically justified, they appear to have unintentionally raised water consumption in the watershed, thereby depriving downstream users in Chiang Mai and the Mae Taeng Irrigation Project. Water shortages in Chiang Mai have been further accentuated by the preferential allocation of water to farmers in the Irrigation Project, who value the water less, and by the lack of a financial incentive for the Chiang Mai Water Works to conserve the water it treats and distributes

These problems are rooted in water users' lack of appreciation for the costs of their use When the RFD selected species for its reforestation programs, it did not consider differences among the species in terms of water consumption. It had no reason to, as it was not accountable for the downstream impacts of reduced streamflow. Moreover, it was probably not aware of these impacts, given the limited number of forest hydrology studies conducted in the country. When agencies designed agricultural development projects for upland areas of the watershed, they did not consider ways to conserve irrigation water, because, like the RFD, they (or rather, farmers included in the projects) did not have to pay the costs that higher water consumption imposed on downstream users When farmers withdraw water from the canals of the Mae Taeng Irrigation Project, they consider ways to conserve it only insofar as conservation increases their profits, they ignore the increased costs that municipal users must incur to obtain water from alternative sources. Finally, when the Water Works produces treated water, its motivation to ensure that the water is actually delivered and sold, instead of leaking away, is reduced due to the fact that it does not pay for raw water

Policy recommendations

The foregoing findings and observations suggest the following policy recommendations:

- HYDROLOGICAL STUDIES — The Government should sponsor more studies of the hydrological impacts of land-use changes. Some important studies have been conducted in Thailand, but much more research is needed Better information will help ensure that the economically most desirable watershed management decisions are made. Financial figures cited above indicate that these decisions can have substantial downstream impacts.

- REFORESTATION — The RFD should take impacts on water balances into account when it selects species for reforestation programs. Where water yield is an important objective of watershed management, the RFD should plant species that are less water-demanding, such as deciduous ones. Where water yield is especially critical, and the rate of soil erosion under existing vegetation is tolerable, refraining from reforestation might be the best choice.

- UPLAND AGRICULTURAL DEVELOPMENT — Agencies involved in upland agricultural development projects should take impacts on water balances into account when they select crops and cropping methods (rainfed or irrigated, and type of irrigation) Ideally, farmers should be charged for the irrigation water they use. Given that most irrigation systems in the uplands are small-scale, dispersed, and often informal, however, this is probably not possible at the current moment. An alternative would be to subsidize the construction of more efficient irrigation systems Although subsidies are in principle to be avoided, they might be justified in this case by the reduction in downstream costs

- MAE TAENG IRRIGATION PROJECT — The Royal Irrigation Department (RID) should consider imposing a charge on farmers for the irrigation water it provides them, to create an incentive for more efficient use and to reflect the opportunity cost of their use Funds raised by such a charge would also enable the RID to enhance maintenance of the system, and perhaps to pay for more efficient irrigation upstream If water charges are socially undesirable due to the burden they place on farmers, an alternative would be to grant transferable water use rights to farmers, and to allow them to decide whether to use the water themselves, to sell it to other farmers, or to sell it to the Chiang Mai Water Works. The great discrepancy in marginal values between irrigation water and municipal water (except for industrial estates) suggests that the introduction of water markets would lead to water flowing out of agriculture and to the Water Works. Farmers would benefit, as they would make more money by selling water than by growing crops The Water Works would benefit as well, as it could avoid costly interbasin transfers as a source of raw water Paying for raw water obtained from farmers would also create a financial incentive for the Water Works to reduce water losses during distribution.

- MUNICIPAL WATER — In the absence of a water market, the RID should consider levying a charge on raw water withdrawn for treatment by the Water Works. As in the case of a price set by a water market, a charge would encourage the Water Works to reduce its leakage rate. The Water Works should also review its schedule of water rates to ensure that the rates reflect the full costs (capital, operating, and environmental) of supplying water to different users.

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