Impact of Innovative Land Management Practices on Annual Runoff and Soil Losses from 27 Catchments in Southeast Asia

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In Southeast Asia, the declining productivity of lowlands is leading to continued expansion of cultivated land on slopes, often involving the clearance of native upland vegetation. Being an open access resource, upland soils have been subjected to misuse and unsustainable farming practices, resulting in degradation. Land degradation is often associated with poverty especially in the mountainous regions inhabited by people who are often politically disempowered and economically marginalized.

Public interest in these communities has emerged mainly from a realization that environmental degradation of uplands affects richer communities: run-off and soil loss resulting from the changes in land use and/or climatic conditions concerns not only the upland farmers but also the users of water resources downstream. Peculiar attention has thus to be paid to upper catchments. It is generally hypothesized that increased exploitation of land resources in small headwater catchment areas, with associated fragmentation of native forest vegetation, results in increased sediment discharge and elevated nutrient loads that reduce water quality and availability for downstream users. As the land resource base becomes less productive, food security is compromised and competition for dwindling resources increases. A downward eco-social spiral is created when uplands are eroded and their nutrients depleted by unsustainable land management practices that result in lost soil stability and permanent damage.

Southeast Asia is the most populated area of the world and has a very fast rate of economic growth. Invariably the entire region will be impacted by the insatiable consumptive footprint of the emerging economies of China and India. As the pace of economic and social change in this region accelerates, the possibilities of discontinuous and accelerated change cannot be ignored. Such change may convert large tracts of current rainforest into agricultural land - with potentially critical environmental implications such as natural disasters (e.g. floods) and crop failure (e.g. due to drought), especially in the context of climatic change. Bruijnzeel, (2004) reported that rainfall in the whole of Thailand shows a remarkable decreasing trend since the 1950s during the month of September, i.e. when the southwest monsoon current is weakening. In July and August, when the monsoon is still strong, no such decrease is noted. In East China, the aridity index tends also to increase as a result of changes in surface roughness, leaf area index and reflection coefficient. Thus, observational evidence concurs with model predictions in suggesting that large-scale land-cover change in East Asia is indeed capable of producing changes in the regional surface climate. Where annual rainfall is known to have decreased significantly over the last decades (Sahel, Western Australia), no

concurrent decrease has been observed in the frequency of extreme events. Under these conditions, no decrease in the frequency of flooding is to be expected from a reduction of mean annual rainfall. IPCC (2001) has predicted increased runoff of 50%-150% in Southeast Asia. Public concern is growing, as illustrated in the growing frequency of newspaper articles on increased flood frequency and the impact of drought. Studies of erosion under climate change have not taken into account farmer choices on crop rotations or planting dates, which will adjust to compensate for climate change. Adaptation of the upper catchments in Southeast Asia to climate and land use changes is dependent on their current and predictable adaptive capacity. The assessment of their vulnerability to these changes and their adaptation should be a priority, especially in developing countries where investments are usually more focused on recovery from a disaster than on the creation of adaptive capacity.

The interactions between climatic and anthropic changes remain much less studied in this region than in areas of mean latitude, although their effects are likely to have impacts at the global level. Integrated and cross-scale knowledge is therefore essential to understanding current processes and predicting future trends. A key element in achieving these goals is the ability to operate at multi-scales within a catchment where the integration of attributes will enable integrated approaches. Also essential is the need to quantify the sensitivity and resilience of fragmented landscapes in upper catchments.

Much research into soil erosion on sloping land has harvested considerable results, but almost all research has been carried out on plots. Only a few studies have been conducted in Asia on catchment scales, mainly in the Himalayan region, and these remain limited in space and time. Only a few tropical watershed studies have lasted long enough to facilitate a credible analysis of the long-term effects of land use change on the environmental services provided by catchments.

In order to provide sound data on the extent of accelerated soil erosion resulting from rapid land use changes, it was decided by the end of the 1990s to launch a regional network, the Management of Soil Erosion Consortium. This association of five countries (Indonesia, Laos, Philippines, Thailand and Vietnam), an international (IWMI) and a French (IRD) institute, is implementing a long term research programme to monitor at the catchment scale changes in farming systems, runoff and sediment yields, and to test various improved practices to reduce soil losses and enhance livelihoods. This paper summarizes the main results obtained by this consortium over the last six years and assesses the impacts of i) rapid land use changes and possible climatic changes on annual run-off ratio and sediment yield, including bed load and suspended sediments loads from 27 catchments and sub-catchments in the five countries; ii) various soil conservation practices tested in these catchments. These objectives meet the two technology transfer needs related to catchment processes recently identified for the tropics of Southeast Asia: i) ‘how to incorporate the appropriate level of ‘good science’ with socio-economic issues and constraints; and ii) develop appropriate management perspectives.

27 catchments and sub-catchments have been selected and monitored since 2000. Their size varies between 0.6 ha and 285 ha., their mean slope steepness between 8% and 48%, and their annual rainfall between 1028 mm and 3840 mm. Contrasting socio-economic conditions favour the intensive use of industrial agricultural inputs in Thailand, and organic inputs in Indonesia. Laos, Vietnam and Philippines. Descriptive statistics for the runoff coefficient and sediments yields were computed from the 116 catchment-years available from the five countries.

The observed current shifts from upland rice to maize in Southeast Asia, as a response to shorter summer monsoons, show that future crop management changes due to climate and economics can affect the magnitude of erosional impacts beyond that which would be predicted from direct climate change alone. Current observations also suggest that the conversion of upland rice to maize is associated with similar changes in weeds, the native forest vegetation tending to be replaced by a savannah-type vegetation. The main drivers of land use changes differ greatly among countries, depending on population density, economic conditions, and so on.

Measured runoff coefficient ranged from 0.1% to 75%, suspended sediments loads from 0 to 26.4 tonnes ha^{-1} yr^{-1} and bed load from 0.01 to 51.6 Mg ha^{-1} yr^{-1}. Conversion of upland rice or fruit tree crops to maize invariably induced dramatic increase in sediment yields. By contrast, conversion of cassava to fodder crops, improved fallows, or planting grass on bench terrace risers and in the lower areas of catchments reduced soil losses to nearly nought within one or two years. The proportion of forest or tree plantations did not appear as a key factor for soil conservation. The advantages of the mostly spontaneously adopted agro-forestry systems are best illustrated in Indonesia - these systems are not well accepted by farmers in other countries. Tree plantations on hill-slopes greatly limit soil erosion, but are thought by farmers in Vietnam to deplete water availability for downstream irrigated rice. Despite their effectiveness in combating erosion, natural vegetative strips introduced in the Philippines were not adopted by tenant farmers, due to cost of establishment.

The negative impact of land use change - and to a lesser extent, climatic change - can be corrected by including innovative conservation measures in the catchment management to control runoff and soil losses. If they are to be adopted by farmers, conservation strategies need to be tailored to the local demographic, economic and cultural conditions. This diversity needs to be more acknowledged by international agencies and donors, some of which are too specialized in a single strategy.