Questioning Perceived Links between Forests and Floods

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Introduction

The driving force behind many environmental and conservation policies are powerful assumptions about the links between forests and water, particularly the effects a healthy upland forest can have on lowland flooding. Each year, devastating floods affect the fortunes of millions of people; and each year the powerful assumptions help determining – frequently ineffective – responses to the events.

The 1980s and 1990s will be particularly remembered for the profound effects of floods on people, property and economies, particularly in many Asian countries. In 1998, the Yangtze River devastated large areas of central China. Damage was estimated in excess of US$30 billion. Between January and August 2004, 46 million people were affected by floods in China. Floods in 2000 affected one-third of Cambodia's population and 5 million people in Vietnam, with associated costs of US$145 million and US$285 million, respectively. In the same year, floods in Bangladesh displaced more than 5 million people and in India 30 million. Many countries – industrial and developing alike – have suffered the effects of catastrophic floods at one time or another. Globally, floods affect the personal and economic fortunes of more than 60 million people each year.

Each catastrophic flood is accompanied by heart-wrenching images of shocked individuals sitting on rooftops, awaiting rescue or the receding of rampaging flood waters. Sympathetic people from all walks of life are moved by the stark scenes of desperation. Conscientious policy makers and politicians move to identify and remedy the perceived causes of the devastation, and mitigate the damage of future events.

In many people's minds, the use and abuse of upland watersheds represents the main cause of massive lowland floods. Upland farmers and loggers – especially in developing countries – are typically blamed for clearing and degrading forests, which are widely believed to protect against such calamities. This causal link between deforestation or forest degradation in the uplands and floods in the lowlands seems intuitive to many. Unfortunately, the reality of hydrological systems is far from simple.

Hydrological systems are extremely complex and it is difficult to disentangle the impacts of land use from natural phenomena. Although several scientific studies have been conducted on the relationship between forests and floods, the limited – sometimes also contradictory – results have often been used to make sweeping generalizations that are inappropriate, misleading, or patently wrong.

In the case of upland and lowland as well as forest and flood relationships, existing 'knowledge' is often based more on myth than on science. In the rush to identify the culprits for the most recent disasters, assumptions are made about processes in one region based on observations from other regions, or by extrapolating from small to large scales. Some people may also find it more convenient or advantageous to perpetuate certain myths, rather than to address the issues in a sound, scientific framework. Hamilton (1985) has characterised this situation as 'The 4 Ms: myth, misunderstanding, misinterpretation, and misinformation.'

All floods cannot and should not be completely prevented – normal flooding is important for maintaining biodiversity, fish stocks and fertility of floodplain soils. However, steps can be taken to limit the adverse impacts of floods and to ensure effective responses to flooding events. This requires a far better understanding of the interactions between human activities and floods, the limitations of watershed management and the role of floodplain or river-basin management in reducing flood-related impacts.

As a first step, decision-making needs to be supported by an objective perspective of the relationships between forests and water, in order to distinguish myths and conventional wisdom from facts and sound science. Building on better understanding of physical processes and the relationships between land use and hydrology, more effective responses can be designed to reduce the magnitude of disasters without repeating past mistakes.

Distinguishing Fact from Fiction

Little distinction is made between what we know and what we think we know, which greatly contributes to a general confusion on the issue. Much of this confusion has a long history and relates to the so-called ‘sponge theory’. Although the exact origin of the theory is unclear, it appears to have been developed by European foresters during the 19th century. It rapidly spread to other continents. For example, in the U.S.A., the sponge theory and similar concepts were promoted by early conservationists like George Perkins Marsh in the late 19th century.

While the theory has never been confirmed, many people have found that it agrees with their own professional understanding and intuition. According to the theory, the complex of forest soil, roots and litter acts as a giant sponge, soaking up water during rainy spells and releasing it evenly during dry periods, when the water is most needed. Although the theory came under criticism as early as the 1920s, it continues to appeal to many people (foresters and non-foresters alike). In many countries, it is firmly embedded in national forest policies and programs. Unfortunately, the popular theory fails the test of close scientific scrutiny. The question is how much of the sponge theory is fact and how much is fiction?

Forests, Regulation of Stream Flow and Flood Prevention

It is commonly believed that forests are necessary to regulate stream flow and reduce runoff, and to some extent this is true. But, in reality, forests tend to be rather extravagant users of water, which is contradictory to earlier thinking (FAO 2003). Considerable quantities of rainfall (up to 35 percent) are intercepted by the canopies of tropical forests and evaporated back into the atmosphere without contributing to soil water reserves (Bruijnzeel 1990). Much of the water that does soak into the soil is used by the trees themselves. Therefore, replacing forest cover with other land uses almost always results in increased runoff and stream flow. Runoff and stream-flow patterns will gradually return to original levels if an area is left to revert back to forest. Converting forest to grasslands, however, will normally result in a permanent increase in total water runoff, which may contribute to the magnitude of some floods.

Contrary to popular belief, forests have only a limited influence on major downstream flooding, especially large-scale events. It is correct that on a local scale forests and forest soils are capable of reducing runoff, generally as the result of enhanced infiltration and storage capacities. But this holds true only for small-scale rainfall events, which are not responsible for severe flooding in downstream areas. During a major rainfall event (like those that result in massive flooding), especially after prolonged periods of preceding rainfall, the forest soil becomes saturated and water no longer filters into the soil but instead runs off along the soil surface.

Studies in America (Hewlett and Helvey 1970) and South Africa (Hewlett and Bosch, 1984) were amongst some of the first to question the importance of the link between forest conversion and flooding. Studies in the Himalayas indicate that the increase in infiltration capacity of forested lands over non-forested lands is insufficient to influence major downstream flooding events (Gilmour *et al.* 1987, Hamilton 1987). Instead, the main factors influencing major flooding, given a large rainfall event, are: (i) the geomorphology of the area; and (ii) preceding rainfall (Bruijnzeel 1990, 2004; Calder 2000; Hamilton with King 1983; Kattelmann 1987).

Even at the local level, the regulating effect depends mostly on soil depth, structure and degree of previous saturation. Thin soils produce ‘flashy’ flows (quick responses). Massive programmes of forestation that have often been proclaimed as 'the answer' to preventing floods, simply will not do the job, although there may be many other benefits from reforestation (Hamilton and Pearce 1987).

Size Matters, especially that of River Basins

This is not to say that forests are not beneficial in hydrological terms. As early as 1905, Gifford Pinchot, the "father of forestry" in America, described the "good influence" of forests in reducing the severity of floods. On a small scale – up to 500 km^2 – the presence of forests can indeed affect peak riverflows and thus floods (Table 1). However, even in smaller basins, the extent to which forests can absorb excess water during heavy rainfall depends greatly on forest type and management, and even more importantly, on the underlying geological and antecedent rainfall conditions. In Pinchot's own words rain water "which falls after the forest floor is saturated runs into the streams almost as fast as it would over bare ground." In large river basins, the positive effects of forests in reducing catastrophic floods are negligible.

Table 1. The spatial dimension of land-use effects

Impact	Basin size [km^2]						
	0.1	1	10	100	1,000	10,000	100,000
Average flow	x	x	x	x	-	-	-
Peak flow	x	x	x	x	-	-	-
Base flow	x	x	x	x	-	-	-
Groundwater recharge	x	x	x	x	-	-	-
Sediment load	x	x	x	x	-	-	-
Nutrients	x	x	x	x	x	-	-

Legend: x = Observable impact; - = no observable impact
Adapted from Kiersch (2001).

Major floods frequently occur towards the end of the rainy season, when heavy rain falls in a number of sub-basins (simultaneously) and usually on soils that are already saturated and therefore incapable of soaking up additional water. The extent and severity of wide-scale flooding can be further intensified by the occurrence of torrential rains in the floodplains during vulnerable periods. This can be further exacerbated by high tides, which frequently happen in Bangkok, Dhaka and other low-lying cities.

Increasing Flood Frequencies – A Case of Misinformation?

How about the notion that flood frequencies have increased? Floods have occurred throughout the world long before deforestation was a problem. For example, Hofer and Messerli (1997) unearthed records of eight major floods in Bangladesh between 1870 and 1922, and concluded that "there is absolutely no statistical evidence that the frequency of major flooding has increased over the last 120 years." In China, the Yangtze and Yellow Rivers have broken their banks, causing huge loss of life and changing the face of the landscape for centuries. Large-scale floods in the Chiang Mai valley in northern Thailand are well documented for events in 1918-1920 and again in 1953. And in Bangkok, the floods of 1983, which inundated parts of the city for four months, were comparable to events in 1795 and 1831 (Terwiel, 1989), when most of Thailand was still covered by forests.

Are today's floods more damaging than yesterday's?

Settlements have always been established on floodplains, despite the risk of periodic flooding. The numerous social, economic and environmental benefits of living near water have historically outweighed the risks of floods.

Most early settlements were located on the higher areas of floodplains, which helped to minimise risks and potential damage from floods. As towns and cities grew, new housing areas and commercial estates expanded into the more flood-prone areas that had traditionally been avoided. In many Asian countries, this urban sprawl is taking place with alarming speed and little concern for any consequences.

The development of urban areas also transformed formerly vegetated land to impermeable surfaces, with little or no water storage capacity. Extensive areas of wetlands that once acted as natural retention and storage areas for floodwaters were drained, filled and built upon. The large increase in non-absorbing surfaces that goes with urban growth exacerbates the problem, speeding surface runoff, and allowing less infiltration. In addition, natural stream channels were straightened and deepened. With 'flood control' as their explicit objective, engineers around the world spent decades (and billions of dollars) building dams, embankments and levees to prevent floodwaters from inundating floodplains.

These 'solutions' may have served to help reduce flood impacts locally but have often had the effect of shifting the problem further downstream, a result that can be observed worldwide. This pattern has been exacerbated by the removal of the natural storage functions of the floodplain. Today's floodplains bear little resemblance to yesterday's floodplains, and it should not be a surprise therefore that even minor floods can nowadays cause major damage.

The severity of floods is often measured and described in terms of economic losses rather than physical parameters. This approach can easily give the impression that flooding has become much more severe in recent times. In reality, the huge economic losses attributed to flooding in recent years are mainly a reflection of expanding economic growth, increased investment in infrastructure, rapidly growing floodplain populations and poorly planned urban and regional development. Although the escalating economic costs of floods underscore the urgent need for improved floodplain management and disaster mitigation, it is incorrect to conclude that floods are any more frequent and intense (in physical terms) now than in the past.

Although humans do not directly cause floods, we have sometimes greatly exacerbated the problems caused by floods. Not only do many cities have inefficient water-drainage systems, local land subsidence makes recent floods appear worse than past events. For example, due to excessive and long-term groundwater withdrawal, Bangkok is sinking into the ground at an average rate of 2 cm every year. Since the city's elevation is between 0 and 1.5 m above sea level, it is not surprising that high tides can inundate major parts of the city, especially when they coincide with heavy rains (Pramote Maiklad 1999). Other cities suffer similar problems. Moreover, the large increase in non-absorbing surfaces that goes with urban growth exacerbates the problem, speeding surface runoff, and allowing less infiltration.

The Latest News – The Role of the Media

The media also plays a significant role in shaping perceptions of the intensity, frequency and severity of flooding. Modern television news networks, in particular, can record and broadcast news of catastrophes far more quickly and comprehensively than anytime in history. While major flooding events of the past often went completely unreported, or were described only sketchily, perhaps months after their occurrence, modern media has the capacity to report extensively on disasters occurring anywhere in the world within hours. This capacity of the media, coupled with journalists' penchant for sensationalising news events – particularly disasters – can easily lead people to conclude that floods are occurring more frequently and with greater severity than in the past, when instead they should ponder why many people and institutions have forgotten or discarded traditional approaches for coping with rivers and floods.

More Effective Flood Management – From the Woods to the Plains

An open-minded review of the scientific literature indicates that forests cannot stop catastrophic large-scale floods, although forests can play a certain role in delaying and reducing peak floodwater flows at local levels. This in no way diminishes the need for proper management and conservation of upland forests. But it does point toward the critical need for integrated approaches in river-basin or floodplain management that look beyond simplistic forest-based 'solutions'.

Effective floodplain management, like watershed management, is an iterative process of identifying and assessing alternative ways of reducing the impact of floods (particularly of catastrophic events) in flood-prone areas. Decision-making in floodplain management involves compromises between the costs and benefits of alternative actions. It also requires that upper catchment areas be considered part of the solution and not the 'source' of the problem.

It should be evident that individual flood alleviation schemes cannot be considered in isolation and that a 'solution' in one part of a river basin may be detrimental for other areas further downstream. In recent years, numerous restoration projects have been implemented to reverse the impacts of earlier engineering works such as the Rhine Action Plan on Flood Defence adopted in 1998 after major floods in 1993 and 1995 (Leentvaar 1999). Increasingly, management of flood risks is moving away from structural engineering solutions toward programs that work with natural processes.

The new approach weighs alternative actions in floodplain management in the context of whether overall flood effects are positive or negative. Although attention is usually focused on the negative effects of floods, there are highly important positive effects that warrant recognition and consideration. Flooding in many low-lying areas in Asia is a vital element of the culture and economy of the people. Annual floods along many rivers carry fine sediments and nutrients that renew the fertility of the land and aquatic habitats, and the continuous flow of silt-bearing irrigation water helps control diseases in many areas. In many floodplains, certain crops (e.g. jute or deep water aman rice in Bangladesh) depend on seasonal flooding. In a region where agriculture and fishing remain vitally important, the loss of these beneficial effects could potentially lead to unacceptable economic and social disruption. However, what is beneficial to some may inflict heavy economic costs upon others. The challenge is to balance costs and benefits.

New flood management approaches are steadily expanding the role of non-structural measures within integrated floodplain management programs. Key measures include the identification of natural storage areas, such as swamps and wetlands, where excess water can be directed and temporarily stored during periods of flooding. The World Commission on Dams (WCD 2000) categorises the components of an integrated approach to floodplain management according to those which reduce the scale of floods, those which isolate the threat of floods and those which increase people's capacity to cope with floods (Table 2).

Mekong River Commission's (MRC 2001) uses a similar approach in promoting 'Integrated Floodplain Management', which comprises a mix of four types of management measures. These reflect the flooding, flood risk and flood hazard characteristics of a particular floodplain, the specific social and economic needs of flood-prone communities, and the environmental and resource management policies for the floodplain.

Table 2: Complementary approaches of integrated flood management

Reducing the scale of floods	Isolating the threat of floods	Increasing people's coping capacity
Better catchment management Controlling runoff Detention basins Dams Protecting wetlands	Flood embankments Flood proofing Limiting floodplain development	Support traditional strategies Emergency planning Forecasting Warnings Evacuation Compensation Insurance

Source: World Commission on Dams (2000)

Integrated Floodplain Management on the Mekong River

Land-use planning measures are aimed at "keeping people away from the floodwaters." Land-use measures on the floodplain aim to ensure that the vulnerability of a particular land-use activity is consistent with the flood hazard on that area of land.

Structural measures are aimed at "keeping floodwaters away from the people." Typical structural measures include flood mitigation dams, embankments and flood detention basins.

Flood preparedness measures recognize that – no matter how effective the above types of management measures are – an overwhelming flood will eventually occur. These measures embody flood forecasting, flood warning, and raising the general flood awareness of the potentially affected population groups. In a number of cases, flood preparedness and emergency measures may be the only type of management that is feasible or economically justified.

Flood emergency measures deal with the aftermath of major events by "helping affected people to cope with floods." Flood emergency management, like floodplain management, is a process that typically encompasses preparation, response and recovery. The process embodies evacuation planning and training, emergency accommodation planning, flood cleanup, restitution of essential services, and other social and financial recovery measures.

From: Mekong River Commission, 2001.

Making Rational Decisions Based on Sound Scientific Evidence

Flood processes are highly complex. Only integrated approaches take this complexity sufficiently into account and lead to adaptive and effective flood management. An improved approach to watershed and floodplain management integrates land management in the uplands with land-use planning, engineering solutions, flood preparedness and emergency management in the lowlands. This requires good understanding of all the physical processes involved, as well as the social behaviour and culture of local residents. Furthermore, this approach should draw upon the best available scientific knowledge about the environmental, social and economic impacts of floods and the environmental, social and economic effects of interventions.

The myths and misperceptions about the causes of flooding that have misguided decision makers, planners and managers alike need to be replaced by rational understanding based on facts. Too many local, national and international agencies have used 'conventional wisdom' and unsupported claims to advance their own institutional interests and because it has been politically correct to channel aid funds to upland reforestation and conservation projects. The media has unfortunately perpetuated many of the myths regarding forests and floods out of a well-intentioned, but ill-informed, desire to protect the environment, especially the forests of upper watersheds.

It should be clear that large-scale reforestation programmes, the adoption of soil and water conservation technologies in agriculture, logging bans and the resettlement of upland people to lowland areas will not significantly reduce the incidence or severity of catastrophic floods. Positive environmental impacts from these interventions will be of a local nature, while the negative social and economic impacts are likely to be more widespread.

Importantly, the habit of blaming upland inhabitants for catastrophic floods of whole river basins must be abandoned. Instead, practical solutions are needed to redress watershed degradation caused by unsustainable management practices, including poor logging practices and inappropriate infrastructure development. While refraining from exaggerating the negative impacts that mountain people have on the environment, we should also not overstate the positive impacts of their participation in watershed management programs, as is happening with some recent attempts to develop markets for the environmental services that forests may provide. Moreover, policy-makers and development agencies have a moral and ethical responsibility to ensure that regulatory and project approaches are based on the best available scientific knowledge and do not unnecessarily place upland communities at risk of further impoverishment.

While the ability of forests to prevent catastrophic floods is limited, watershed management should definitely not be abandoned. Forests provide a variety of environmental services, which need to be protected and nurtured for the benefit of today's and tomorrow's upland and lowland populations. Watershed management needs to consider the needs and interests of local populations, but should also account for the needs of the wider society.

The scope of forestry in mitigating floods

…the scope for forests to reduce the severity of major floods that are derived from an extended period of very heavy rainfall is rather limited.

From: UK Forestry Commission, 2002.

The most effective approaches to reducing damage caused by catastrophic floods require a strong focus on downstream areas and floodplains. People in these areas need to 'learn to live with rivers'. At the same time, politicians and policy-makers need to abandon their belief in quick fixes for flood-related problems. While the high costs of floods are evident, it is important that the beneficial aspects of floods are also acknowledged. It is only by promoting and supporting comprehensive integrated watershed and floodplain management that the needs and aspirations of all residents – uplanders and lowlanders – can be adequately addressed.

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