9. Protected areas and water resource development

Section 1

Introduction

Protected areas (PAs) safeguard the hydrological and biophysical functions provided by the natural environment. These functions protect water volume, quality and regularity of flow. In this way, PAs help to maintain the economic benefits that local and national communities derive from sustainable water use. Hydrological and biophysical functions, and the ability of PAs to safeguard them, are highly vulnerable to development pressures. Poor planning, inadequate protection and ineffective management of PAs can compromise the ability of the natural environment to support these functions.

To avoid this situation, water resource managers and economic planners must better understand the contribution of PAs to water resource development, and should incorporate PA establishment and management into an integrated approach to river basin management and national economic development.

Water resources are fundamental to human livelihood and well-being, and to regional and national economic development. Each year billions of dollars are spent in trying to manage water resources to meet human needs: to prevent flooding, to provide a source of clean energy; and to provide water supplies for domestic and industrial consumption and sanitation.

Protected areas are a key component in protecting and enhancing the availability, quality and quantity of water resources, and thus in providing economic benefits to local, provincial, and national economies. This is achieved through a wide range of ecological and hydrological functions.

Many factors affect the relationship between PAs, water, and economic development. Perhaps the most fundamental of these is the status of water as a “free good” in economic terms. This influences the way water is seen in institutional planning and national economic development.

1.1 The cost of water

In economic terms, water resources are like other natural resources, such as soil and air, in that they have typically been treated as free goods by the market. There is no clear relationship, which can be regulated by the price mechanism, between the supply of the resource and the levels consumed. This means that those who obtain the direct benefit of the use of the resource do not pay the full costs — including the social costs — of resource use. The indirect costs (and benefits) arising from the consumption of the resource are borne by third parties. Therefore, there is no financial pressure on users to consume water resources efficiently, or to ensure the long-term availability or quality of the resource for themselves or for others. For example, the economic costs of environmental degradation associated with construction of large-scale dams for irrigation water are typically not acknowledged in the tariffs charged to irrigation water users. In many cases, these fees do not cover the full cost of providing the infrastructure. In the Red River Delta in Vietnam, current revenues from water charges fall far short of the current cost of US$11/hectare/year needed to ensure proper maintenance and replacement of assets (ACIAR 1999).

Situations like these can lead to the misuse of irrigation water, which is being provided at less than the cost of supply. This is inefficient; alternative resource allocations might generate greater benefits. There are many other ways in which inappropriate pricing of natural resources (including logging in watersheds and wastewater discharges) leads to inefficient resource allocations.

1.2 Water resource planning and protected areas

Water resource planners, engineers and development economists have been slow to realise the unsustainable nature of conventional technological/engineering approaches to water resource management, and to consider water resources in the broader perspective of catchments or river basins. This perspective would take into account the upstream and downstream impacts of water management initiatives, and incorporate protection of natural areas providing hydrological services in an integrated planning framework.

Protected area managers have also been slow to recognise the economic and social benefits that PAs can contribute to water-based sectors of regional and national economies. Instead they have focused on the value of protected areas for species protection, biodiversity conservation and landscape protection.

1.3 Hydrological and biophysical functions

A key aim of this chapter is to contribute to a better understanding of PAs’ contribution to water resource management, through a discussion of how PAs protect hydrological and biophysical functions (and the resulting downstream economic benefits) provided by the natural environment. These functions include the following:

- water storage and natural flood regulation functions;
- water supply functions (e.g. irrigation, drinking water supply and hydropower);
- instream and estuarine fishing;
- flushing of pollutants;
- transportation and navigation;
- recreational use of water (including tourism); and
- microclimate impacts on surroundings.

1.4 Definition of protected areas

A "protected area" is taken to mean "an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means." This is the definition developed by IUCN (IUCN, WCPA and WCMC 1994). There is a wide range of categories of protected areas, allowing varying intensities of human use and development. Many sectors, such as fisheries and forestry, are moving to adopt regimes of protection as a critical component of their development strategies.

Section 2

Water storage and natural flood regulation

Natural resource managers acknowledge that undisturbed, naturally vegetated watersheds make a major contribution to regulating flows of stormwater and groundwater to downstream areas. Declaring and managing such areas as national parks or other protected areas can limit deforestation and other development pressures. Undisturbed watersheds can also help reduce the potential for heavy water flows interspersed with drought, which has been associated with deforestation of watersheds in many countries. The hydrological function of protected catchment areas has also been vitally important in the development of agricultural systems based on rice cultivation in eastern Asia, which depend on regular, predictable, seasonal floods.

Achievement: The introduction and implementation of legislation to protect watersheds and water catchments in many countries has ensured the continuation of the hydrological functions associated with natural vegetation cover.

This vegetation slows the percolation of precipitation into topsoil and underground water tables, regulates flows to downstream river courses, and reduces the potential for flash floods and droughts and for the erosion of topsoil and vegetation. (For an alternative view of the forest cover/flooding relationship under certain conditions see chapter 4.)

The importance of natural forests was recognised in Thailand in 1989, when the Ministry of Agriculture and Cooperatives placed a nationwide ban on commercial logging. This followed the collapse of hillsides in Nakhon Sri Thammrat Province in Thailand during an intense rainstorm in 1988. The resulting floods killed hundreds of people and caused widespread damage to land and property (PAD Review 2002a).

Vietnam also has legislation to protect, and, where applicable, reforest highly critical watersheds, with the aim of reducing downstream flooding (the 5 Million Hectares Reforestation Program).

Legislation to protect catchments against logging, swidden agriculture, mining and other development pressures has helped to protect the hydrological and biophysical functions of these areas.

Challenge: Many countries have yet to appreciate the economic value that protecting watersheds and other natural water systems provides in regulating and providing water flows for downstream uses.

Recognition of this value needs to be followed by implementation of appropriate protection mechanisms. In addition, the benefits of rehabilitation are unlikely to be maintained unless the natural areas that provide these services are effectively managed.

Where countries have failed to protect catchments, downstream flooding associated with rapid runoff has caused considerable loss of life as well as damage to infrastructure, agriculture and aquaculture (Table 1).

Table 1. Flood damage in Central Vietnam in 1999

	December floods	October/November floods
No. people killed	115	592
No. people injured	164	412
No. people missing	12	30
No. households evacuated	11,475	15,000
Damage to houses	423,653 flooded and damaged 9,053 destroyed	650,000 damaged/collapsed
Paddy crops destroyed (ha)	28,779 ha	n/a
Total damage (VND)	736 billion (US$53 million)	3,300 billion (US$237 million)

Source: UNOCHA 1999

Wetlands are also a valuable part of flood management. In the United States, Minnesota's Department of Natural Resources calculated an average cost of US$300 to replace each acre-foot of wetland water storage: "...In other words, if development eliminates a one-acre wetland that naturally holds 12 inches of water during a storm, the replacement cost would be $300. The cost to replace the 5,000 acres of wetlands lost annually in Minnesota would be $1.5 million (in 1991 dollars)" (US EPA 2001).

Challenge: Another major challenge is for water resource planners to consider the impacts of structural flood remediation measures on natural ecosystems and biophysical processes.

They must also examine the socio-economic benefits that protected areas bring by maintaining and controlling flooding regimes through the hydrological functions of naturally vegetated areas.

Engineering structures such as retention dams may have extreme and unintended consequences for downstream and upstream ecosystems and human activities that have developed in response to periodic flooding, particularly subsistence livelihoods based on freshwater biodiversity (World Commission on Dams 2000, Chapter 4).

The World Commission on Dams' report on the Pak Mun Dam in Thailand discusses a range of upstream and downstream impacts on aquatic ecosystems and harvesting (Amornsakchai et al. 2000). Such impacts can seriously disrupt the ability of the natural environment to provide hydrological and biophysical functions. These functions, especially where safeguarded within PAs, can help to regulate water volume and flow dynamics or can supplement structural engineering approaches. To take advantage of the contribution of the natural environment, water resource planners need to consider rehabilitation of watersheds, protection of wetlands or modification of agricultural activities (e.g. cultivation of flood-tolerant varieties of rice), as alternatives to engineering solutions.

In many cases this will involve the rehabilitation of degraded watersheds through appropriate reforestation with native species (as opposed to fast-growing commercially valuable exotic species), and measures to prevent encroachment and development of wetlands. In Cape Town's watershed, it was found that "...removing thirsty alien tree species and restoring native vegetation produces water at a fraction of the cost of water delivered through diversion or reservoir projects..." (Johnson et al. 2001, p.1).

Section 3

Water supply functions and protected areas

The protection of natural catchments and water bodies is a fundamental part of ensuring the supply of high-quality, regulated water for downstream irrigated agriculture, hydro-electric power for industrial development and domestic consumption, water supplies for urban populations, and aquifer recharge.

Precipitation and runoff in the headwaters of river systems arising in, and flowing through, protected areas are commonly collected in dams and reservoirs for storage. This water is used for downstream water supplies and hydro-electric power, providing enormous economic and social benefits to rural and urban communities.

Hydro-electric power

Achievement: In many countries, assigning PA status to upland watersheds and catchments has yielded significant economic benefits for local and national economies by ensuring a regular supply of water for hydro-electric schemes. The resulting power can stimulate industrial development and be exported to provide foreign exchange earnings.

The Lesotho Highlands water project (which depends on the resources of the Maloti-Drakensberg Transfrontier Conservation Area) provides power for Johannesburg and the surrounding Gauteng region. It represents a potential source of foreign exchange earnings for a nation with few other natural resources.

Lao PDR sells most of the electricity from the Nan Leuk hydro-electric scheme (in the Phou Khao Khonay National Biodiversity Conservation Area) to Thailand. There are similar plans to export power to Thailand from the Nam Theun 2 scheme to be constructed within the Nakai-Nam Theun NBCA.

The availability of micro-hydro-electric schemes in relatively remote regions has helped improve the well-being of people who would not be served by larger-scale networks. In addition, hydro-electric schemes do not consume fossil fuels, and do not contributing greenhouse gasses associated with the combustion of fossil fuels.

Challenge: Water resource managers must ensure that hydro developments yield benefits for local and national economies without causing significant environmental impacts for protected areas, or reducing the economic value of the ecological and hydrological services they protect.

Dam systems with large environmental impacts include the Snowy Mountains Scheme in South-East Australia. It led to the development of irrigated rice- and fruit-growing industries in downstream areas of New South Wales and Victoria, and to the expansion of Canberra, but also reduced water in the natural river system to less than five percent of normal flows. Similarly, impoundment of river systems in Tasmania to provide subsidised industrial power for mining and smelting industries has led to the loss of World Heritage-quality wet rainforest wilderness.

In its study of the Pak Mun hydro-electric dam in Thailand, the World Commission on Dams found that this run-of-river scheme has flooded 50 sets of natural rapids, and has been directly or indirectly associated with the disappearance of a number of fish species (Amornsakchai et al. 2000).

Social impacts are also associated with these projects, especially in the case of rural populations that depend on the natural resources of protected catchments and watersheds. In the case of the Lesotho Highlands Scheme, the Trade and Environment Database claims: “More than 20,000 people are likely to lose their homes or part of their property when the dams are built. Farmers cannot be compensated with new fields because of the intense land pressure there” (Trade and Environment Database 1997).

Other impacts include changes to social structures built around water rights, and to the livelihoods of downstream fishing communities. The Asian Development Bank (2000c) notes that hydro-electric development in Lao PDR and flood mitigation works in Vietnam have caused changes in river flow, which in turn has had negative impacts on rice and fish resources downstream in the Tonle Sap wetlands in Cambodia.

Failure to carry out an integrated approach to water resource planning in such areas, and to adequately ensure the integrity of PAs in upland catchments, can compromise the biophysical and hydrological values of natural areas and lead to significant social and economic impacts.

Drinking water

Achievement: The ability of protected natural watersheds to safeguard and improve water quality is recognised by water utilities in major cities such as New York and Sydney, where drinking water supplies depend on strictly protected catchments.

This enables water supply utilities to avoid alternative, more costly, forms of chemical and biological water treatment processes.

The economic value of this contribution to the supply of drinking water was recognised by the City of New York. Instead of spending $8-10 billion on a new filtration plant, the city is investing some $1.8 billion to protect the Catskills watershed, which supplies the city with drinking water (Postel 2002). Investing in catchment rehabilitation also saves the city $300 million per year in operating costs which would have been incurred if the water filtration plant had been constructed (Stroud Water Research Center 2000).

Another example of a water supply utility contributing to catchment protection is found in Costa Rica, where the La Esperanza Hydro-electric Project in Costa Rica, is paying the Monteverde Conservation Area approximately US$30,000 per year to conserve the 3,000 hectares of forest above the La Esperanza turbines. Other hydro-electric companies in Costa Rica are also funding the management of upper watershed areas (PAD Review 2002b).

Considerable investment in watershed protection has been made through international development assistance and Asian Development Bank loans to improve water quality for urban drinking supplies, sanitation and river basin management (Asian Development Bank 1997a, 1997b, 1999).

Water supply

Challenge: The environmental and socio-economic impacts of large water storages on protected and unprotected catchment areas have generally been poorly understood, or ignored, by construction and financing agencies.

Despite the growing awareness of the interdependence of natural hydrological functions, protected areas and downstream economic benefits, reducing the environmental and social impacts of large water supply infrastructure is still a major challenge.

Environmental impacts include destruction of fish migration routes, loss of ecosystems in inundated areas and loss of species that depend on fluctuations in river levels (which are reduced by regulated discharges). There are also reductions in the normal sediment load from water courses; sediment becomes trapped behind dam walls, with consequent loss downstream in deltas and estuarine areas.

Other activities in catchments that affect water resources include increased surface runoff as a result of logging. This leads to soil erosion and flooding downstream, especially in low-lying deltas. Numerous examples of flooding in Bangladesh and the Lower Mekong (Asian Development Bank 2000a) have been attributed to logging practices in upper catchments.

In Namibia, planners have been examining the feasibility of pumping water from the Okavango River in North Namibia (the source of the inland Okavango Delta in Botswana) through a 250-km pipeline to provide industrial and domestic supplies for the city of Windhoek (De Villiers 2000). This proposal has aroused considerable concern amongst environmentalists because of its potential impact on the natural environment of the Okavango delta wetlands and the Moremi Game Reserve. These wetlands provide livelihoods for local communities and income from ecotourism, an increasingly important source of foreign exchange for Botswana.

Where this type of transboundary exploitation of resources still occurs, protected area status may not be sufficient to safeguard biodiversity and hydrological functions. The increasing incidence of transprovincial and transborder issues relating to access to water resources in the Middle East, the Mekong Region, the Nile region and the American West (De Villiers 2000) threatens to compromise the role of protected area in maintaining ecological and hydrological functions.

Irrigation

Achievement: In many countries the creation of PAs has helped protect hydrological functions that regulate water volume and quality and provide benefits for irrigated agriculture.

Public investment in irrigation projects has brought a dramatic expansion in global crop production.

Challenge: A major challenge is for planners to understand the need for an integrated approach to irrigation planning.

This approach incorporates river basin management and PA management, to protect the upstream hydrological functions of watersheds. Such coordination has not occurred in the past.

In many countries governments have promoted and subsidised large-scale irrigation infrastructure that has fundamentally altered downstream water flows and water quality and compromised ecological quality in PAs. This has affected the economic value of the services such areas can provide.

Abstraction for irrigation has been associated with loss of environmental flows and aquifer recharge. Where it is accompanied by clearance of deep-rooted vegetation and replacement with shallow rooting crops, it has also been linked to salinisation of soils, particularly in areas of intermittent rainfall. The Aral Sea, in Central Asia, is a well-known example of the devastating environmental and socio-economic consequences of a large-scale attempt to control water resources for major agro-industrial development (De Villiers 2000).

As with many other structural engineering approaches to water resource management, irrigation works have in most cases been carried out without an understanding of their impact on natural hydrological and biophysical processes. Planners have also failed to understand the economic benefits these processes can provide when properly safeguarded through protected area status. As the Asian Development Bank notes: "Vietnam's past investment program in the water sector was focused almost exclusively on the delivery of water services to meet the increasing demands in each subsector. Like in many other countries, projects have generally been carried out without sectoral coordination and without attention to the sustainable management of the resource itself" (2000b). Arguably, more integrated approaches to water resource management and planning, which take advantage of the contribution of protected natural areas, can lead to more effective water resource management and sustainable economic development.

Section 4

Riverine and estuarine fishing and protected areas

PAs provide a key component in maintaining water quality and volume. This in turn provides economic benefits in the form of river and lake environments with high ecological productivity and biodiversity. The Tonle Sap Lake system in Cambodia, for example, part of the Tonle Sap Biosphere Reserve, is one of the most productive freshwater fisheries in the world (Stuart et al. 2000).

Forest cover in protected areas is an important and complex contributor to sustaining aquatic productivity. According to one source: “Trees shade waterways and moderate water temperatures. Woody debris provides fish with habitat while leaves and decaying wood provide nutrients to a wide array of aquatic organisms” (Johnson et al. 2001, p.3.). Furthermore, “The condition and quality of fisheries is often linked to the condition of adjacent or upstream watersheds...valuable sport and commercial fisheries such as Chinook salmon in British Columbia can be very sensitive to water quality. Beneficiaries of this service... [i.e. protection of water quality] ...include sport and commercial fishermen, fisheries management agencies, and the tourism industry” (Johnson et al. 2001 p.8).

Achievement: Protecting watersheds, catchments and floodplains helps maintain natural flows and hydrological processes.

These processes provide economic benefits for millions of people, through fishing, aquaculture, mariculture, cropping and grazing, and protection of habitat.

Many wetlands, river systems and other water bodies in protected areas provide habitats and favourable environments for plant and animal species that have a commercial or subsistence value.

The U.S. EPA (2001) notes: “Wetlands are important spawning and nursery areas and provide plant food for commercial and recreational fish and shellfish industries. In 1991, the dockside value of fish landed in the United States was $3.3 billion, which served as the basis of a $26.8 billion fishery processing and sales industry, which in turn employs hundreds of thousands of people. An estimated 71 percent of this value is derived from fish species that during their life cycles depend directly or indirectly on coastal wetlands. For example, Louisiana’s marshes alone produce an annual commercial fish and shellfish harvest of 1.2 billion pounds, worth $244 million in 1991.”

Challenge: The downstream economic benefits provided by the ecological and hydrological functions of wetlands, deltas and other water bodies are likely to be significantly degraded by population and development pressures unless these areas are protected and managed for conservation and sustainable use.

The fertility of estuarine and deltaic areas makes them highly attractive for human settlement, which results in high population densities. This population pressure leads to draining, clearing and of loss of natural habitats. The establishment and effective management of PAs in such areas is necessary to control development pressures and ensure the continuation of the associated economic benefits.

Section 5

Flushing of nutrients and toxins

Achievement: The establishment and management of PAs in catchment and water storage areas has helped to regulate seasonal flooding, and provide major benefits for agricultural and fishery activity, through allowing inflow of nutrients and removal of wastes.

Protected areas maintain and enhance water quality through the flushing and replenishing effects of seasonal peaks in water flows. This is particularly important for downstream shrimp farms, where decomposing feed and wastes can accumulate in aquaculture lagoons, gradually deoxygenate the water and hamper the growth and even survival of shrimp and fish. Seasonal water flows help flush out polluted waters and replace them with fresh water that carries nutrients. This periodic flushing and replenishing is a necessary element in fish farming, and has a economic value.

In the Mekong Delta 97 million tonnes of alluvial material is deposited by the floods onto farmers' fields each year (Miller et al. 1999). The fertile alluvial load and the flushing action of the floodwater bring benefits to many farmers. The slow release of floodwater also delays the onset of saline intrusion, which assists agriculture in the coastal zone.

Protected areas provide environments where water-borne pollutants can be filtered out. In Uganda, near Kampala, the Nakivubo wetland area provides a wastewater treatment function for 75 percent of Kampala's domestic and industrial waste. This is achieved through plant species removing excess nutrients associated with domestic sewage, and by water-borne bacteria decomposing organic waste matter. The value of this wetland was calculated; it demonstrated the economic benefits of protecting the area (Chapter 5).

The US EPA has evaluated the economic benefit of the water quality management functions provided by protected wetlands in the Congaree Bottomland Hardwood Swamp in South Carolina. It concluded that the least-cost substitute for these wetland functions would be a water treatment plant costing $5 million to construct (in 1991 dollars). Additional money would be needed to operate and maintain the plant (US EPA 2001).

Protected wetlands also protect water quality by removing nutrients, suspended solids and associated pollutants, metals and pathogens from surface water. Solids (such as sediment and organic matter from run-off, litterfall, or inflow from other water bodies) suspended in wetlands prevent turbidity in downstream ecosystems. The US EPA (2001) cites studies to show that typical wetland vegetation traps 80–90 percent of sediment from run-off. This traps sediment that would otherwise accumulate behind dam walls and fill water storages and damage hydro power turbines and other equipment.

Johnson et al. describe some commercial benefits associated with protected areas in maintaining, or improving water quality: "(protected) forests can provide companies with high quality water supplies that have low nutrient and chemical contaminant levels. There are a wide variety of potential beneficiaries, such as rural and urban domestic water users, including distilleries, water and soft drink bottlers, film processors, and micro chip manufacturers" (Johnson et al. 2001, p.8).

Challenge: Planners need to recognise the significant economic benefits that result from the water quality management functions of PAs, particularly in upland water catchments and wetlands.

Recognition of these values needs to be translated into policies and adequate resources, so that these areas can be properly protected and managed and these functions continue.

Internationally, wetlands are under considerable pressure from the direct and indirect effects of development. Well over half of the Mekong Delta is affected by salinity intrusion; this will undoubtedly increase if upstream water diversion schemes are implemented and dry season water use increases. According to Miller et al. (1999): "The effects of increased salinity include decreased agricultural yields, limitation of cropping options for farmers, as well as restrictions on household and garden water use". Saline intrusion will also compromise the water quality management functions of wetlands. An integrated approach to water resource management is needed to ensure that these functions are maintained.

Section 6

Water transportation and protected areas

Achievement: Many PAs have been established to protect unregulated river systems (e.g. Currawinya National Park on the Paroo River in SW Queensland and Tonle Sap Biosphere Reserve in Cambodia).

In many countries protecting these systems supports vital communication links for trade and other economic activity and provides economic benefits for local communities.

In Cambodia, for example, "the inland waterway system has traditionally played a vital role in the national economy. [It] consists of the Mekong and its tributaries of which the most important are the Tonle Sap River and its tributaries and the Bassac River. The entire navigable water way system totals 1,750 km, of which 580 km is navigable all year round" (Niny 1994).

Challenge: Many governments are planning to carry out extensive developments to their river systems to make them major shipping trade routes.

Such development must be carried out without damaging the environmental assets and hydrological functions of protected areas, or their benefits to local communities.

Four countries in the Mekong region, or example, have agreed to carry out major engineering works to upgrade the Mekong River for navigation. This will involve dredging sections of the river and removing instream islands. "...China has already cleared its section of the river to enable big vessels to travel through its waters year round...Thailand, Lao PDR and Myanmar have still to make their sections of the river navigable. This initiative by the Chinese seeks to build 14 ports along the river to facilitate greater economic activity in the region...Cambodia and Vietnam have...aired concerns about the dredging, saying fewer reefs could change the flow of water into their countries, posing problems for farming and other activities" (Macan-Markar 2002).

Proposals for shipping and navigation development on the Danube River have been sponsored by various organisations, including the European Commission and Danube Commission. The navigable sections of the Danube and its tributaries contain some 50 large protected areas, which host a diverse system of natural habitats and unique biodiversity (WWF 2002).

WWF notes that: "If plans go through, projected environmental threats include the cutting off of large natural areas from the river leading to a direct loss of diverse habitats and species, many of which are seriously threatened. Species such as sturgeon and beavers are already significantly threatened. Groundwater levels will decrease, threatening human drinking water supplies and the health of millions that depend on the river for clean water. This will be exacerbated by deterioration in the river's natural capacity for self-purification and curbing pollution. New dams will result in deeper riverbeds downstream, increased erosion, the dissection and separation of natural habitats and disruptions to natural water exchanges. Many unique habitats and their species that depend on fluctuating hydrological conditions in floodplains and wetlands will be lost and freshwater fish will be prevented from migrating upstream, leading to their continued decline. Upstream from dams, dredging will be required which will entail high economic costs and further riverbed destruction" (WWF 2002, p.2).

The economic benefits of PA protection of the hydrological and biophysical functions of the natural environment are threatened by a lack of integrated approaches to water resource management. Sectoral approaches to planning and management fail to take account of the environmental impacts of development, and of the economic benefits that are foregone through uncoordinated planning.

Section 7

Recreational use of water

Achievement: Many protected areas are managed to protect features with high scenic and amenity value for tourism and recreation; for example, waterfalls, lakes, rapids and wetlands.

These areas provide economic benefits to local and national economies from the direct and indirect effects of park management expenditure and associated tourism expenditures.

In the United States, numerous protected areas are managed for tourism and recreation, including national Wild and scenic rivers, national recreation areas, national lakeshores, national river and recreation areas, national rivers, national scenic areas and recreation areas.

Water-based recreation in protected areas is increasingly popular, e.g. in the Rio Filos (Filo-Bobos ecological reserve) in Mexico. Costa Rica promotes white-water rafting in protected areas as a major tourist attraction (Costa Rica Expeditions 2001); tours on the Pacuare and the Reventazón Rivers are an important source of income for nearby communities.

Many parks services and countries depend on the economic benefits that can be derived from their protected area system, especially in connection with water. Examples include the Okavango Delta (Moremi Game reserve) in Botswana and Murchison Falls National Park in Uganda.

In Lao PDR, ecotourism may provide income from the use of protected areas; at least one company offers boat tours on the Nam Hin Boon River in Lao through the karst areas of the Khammounne National Biodiversity Conservation Area.

Challenge: Effective visitor management is needed to ensure that the economic benefits of tourism do not compromise the ecological and hydrological values of the water resources safeguarded by protected areas.

As well as basic visitor management initiatives, PA managers will also need to consider less obvious impacts. This includes prevention of feral infestation by introduced recreational species; the introduction of exotic carp species for recreational purposes into some Australian rivers has led to a variety of environmental impacts, including destabilisation of riverbed sediments, increased water turbidity, decreased water quality and loss of native fish species.

Section 8

Microclimate impacts on environs

Achievement: The establishment of protected areas encompassing larger forested and vegetated areas may have subtle beneficial effects on local climatic conditions, particularly in semi-arid and arid regions. This can create production benefits for local agriculture.

There is some evidence that the existence of large areas of forested ground cover increases the rate of evapo-transpiration to the atmosphere in comparison to cleared agricultural landscapes (Ogawa and Naito 2000). Higher rates of evaporation from forested cover allow wetter, more stable air masses and cloud cover to develop. This leads to fewer dust storms and less wind erosion and extremes of daytime temperature variation. These moderated climate conditions can provide conditions for agriculture in adjacent areas.

The higher rates of evaporation from vegetated areas are associated with slower rates of surface run-off. This enables more moisture to be retained in soils and water tables, and be available for downstream (economic) uses, rather than being lost to the atmosphere.

Challenge: Agricultural development planners need to be aware of the positive climatic and water regulation benefits that areas of native vegetation can provide for agricultural production, and to encourage the protection of such areas as part of an integrated approach to sustainable land management.

According to De Villiers (2000 p.74): "The draining of Sudan's Sudd marshes, or at least the creation of the Jonglei canal which will push the Nile's water more quickly through them, will benefit downstream Egypt by ensuring a larger proportion of the Nile waters reaches its territory. But a lessening of the evaporation from the marshes risks changing the microclimate that makes Sudan's grain growing areas possible...".

Section 9

Conclusions

This chapter has raised a wide range of issues associated with the relationship between protected areas, water resources and economic development. Two challenges are particularly acute:

1. Protected areas managers need to demonstrate to water resource agencies and national development economists that PAs can play a major role in water resource management, and thereby provide economic benefits to local and national communities.
2. Incorporating the role of PAs into water resource management will require the development of an integrated approach to water resource planning, and an awareness that structural engineering solutions are not the only option, and in many cases not the best option, for the management of water resources.

There are signs that the need to address these two challenges is becoming better understood among international donors and economic development agencies.

Ayres et al. (1997), for example, have stressed the need for the World Bank to move to a more coordinated approach to at least some areas of water resource management which will "...integrate lake and reservoir management policy into its training programs for integrated river basin management and integrated coastal zone management; support preventative and restorative measures and support a Lakes Management initiative...". The increasingly important role of PAs in water resource management must also be taken into account.

This growing awareness can also be seen in the Mekong region in the creation of the Mekong River Agreement, funding for capacity-building at the Mekong River Commission (MRC) and the establishment of a Mekong Unit in the Asian Development Bank in Manila to coordinate projects relating to overseas development assistance for the development of the region.

In addition, the Global Environment Facility is providing US $11 million funding to the MRC Water Utilisation Project for sustainable water management in the Mekong basin, protection of the environment, aquatic life, and the ecological balance of the basin, and establishing guidelines for water use and ecological protection for sensitive systems, including wetlands and flooded forests.

Several factors must be addressed to meeting the challenges listed above:

- the need to carry out robust studies to value the economic benefits of the hydrological and ecological services provided by PAs for water resource-based development;
- the need for economists and PA managers to encourage national planners and donor agencies to appreciate the role of protected areas in creating economic benefits, especially with regard to water resource management; and
- the need to incorporate PA establishment, management and resources into an integrated framework for water resource management.

It is hoped that this chapter will help to stimulate further discussion of these issues and encourage a greater appreciation of the benefits that PAs can bring to local and national economic development aspirations (Table 2). This would provide a basis for the development of strategies and programs to better integrate PA establishment and management into a comprehensive, integrated approach to natural resource management and national economic development.

Table 2. Some economic benefits of PA environments for water resource-based development

Environment	Hydrological and biophysical functions	Economic contribution
Headwaters, watersheds	Catchment protection	Avoided costs of flood damage
	Smoothing of peak flows and reduction of downstream flooding	Water available for additional cropping (e.g. second rice crop)
	Provision of flows during dry seasons; climate and moisture regulation through evapo-transpiration	Less arid microclimates for crop production
	Prevention of soil erosion through reduction in velocity of precipitation, increased percolation, and maintenance of soil moisture	Retention of soil fertility, savings from reduced need to apply artificial fertilisers as replacements
	Water filtration and protection/improvement of water quality for downstream processes including domestic consumption	Avoided costs of alternative methods of water filtration; economic benefits benefits to industries dependent on high-quality water for processing and production
	Environments for ecotourism	Low cost/free input of goods and services for recreation experiences
Instream	Provision of habitats for commercial fish species	Moderation of water temperature and water chemistry for healthy growth of commercially valuable species, free source of food supply for commercial species
Wetlands	Nursery grounds	Supply and maintenance of suitable water quality and other conditions as free input into growth and reproduction of commercially valuable species
	Source of commercial species, e.g. crab, shrimp	
	Sediment replacement	
	Source of fibres and plant products	Source of commercially valuable raw materials, e.g. plants
	Wastewater treatment and nutrient removal	Provision of biological wastewater treatment functions as alternative/supplement to structural engineering treatment methods
Estuaries	Provision of habitats for fisheries, e.g. mangroves, flushing, sediment replacement	Commercial value of fisheries and NTFPs, improved growth performance from farmed/harvested species from less polluted growth environment, commercial benefits of maintaining food sources for harvested species from seasonal flood-borne organisms

Section 10

References

ACIAR. 1999. *Management of Irrigation Areas: Irrigation Management in the Red River Delta of Vietnam.* Research Notes RN22 12/99. Australian Centre for International Research, Canberra.

Amornsakchai, S., Annez, P., Vongvisessomjai, S., Choowaew, S., Thailand Development Research Institute (TDRI), Kunurat, P., Nippanon, J., Schouten, R., Sripapatrprasite, P., Vaddhanaphuti, C., Vidthayanon, C., Wirojanagud, W., Watana, E. 2000. *Pak Mun Dam, Mekong River Basin, Thailand.* A WCD Case Study prepared as an input to the World Commission on Dams, Cape Town.

Asian Development Bank. 2001. *Greater Mekong Subregion.* ADB Basics. ADB, Manila.

Asian Development Bank. 2000a. *Emergency Assistance to Rehabilitate Viet Nam's Disaster Damaged Infrastructure.* ADB News Release 165/00.

Asian Development Bank. 2000b. *Viet Nam Water Resource Management Given Boost.* ADB News Release 116/00.

Asian Development Bank. 2000c. *A Wealth of Opportunity: Development Challenges in the Mekong Region.* ADB, Manila.

Asian Development Bank. 2000d. *Environmental Strides: Greater Mekong Subregion Undertakes Capacity Building in Environmental Management.* No.8. Environment Division, ADB, Manila.

Asian Development Bank. 1999. *ADB Loan to Improve Environment in Ho Chi Minh City.* ADB News Release 89/99.

Asian Development Bank. 1997a. *ADB Loan to Viet Nam Will Provide Safer and More Plentiful Water.* ADB News Release 012/97.

Asian Development Bank. 1997b. *ADB Loan to Viet Nam to Design Water Project.* ADB News Release 139/97.

Ayres, W.S., Busia, A., Dinar A., Hirj, R., Lintner, S. F., McCalla, A.F. and R. Robelius. 1997. *Integrated Lake and Reservoir Management: World Bank Approach and Experience.* Technical Paper No. 358, The World Bank, Washington D.C.

Costa Rica Expeditions. 2001. *Costa Rica Whitewater*. www.raftingexpeditions 2001.com.

De Villiers M. 2000. *Water: The Fate of our Most Precious Resource.* Houghton Mifflin Company. New York.

IUCN, WCPA and WCMC. 1994. *Guidelines for Protected Area Management Categories.* IUCN, Gland.

Johnson N., White, A. and D. Perrot-Maitre. 2001. *Developing Markets for Water Services from Forests: Issues and Lessons for Innovators.* Forest Trends. Washington D.C.

Macan-Markar, Marwaan. 2002. *Southeast Asia: Mekong River Development May Trigger Conflict.* Inter Press Service.

Miller F., Thinh, Nguyen Viet, and Duc, Do Thi Minh. 1999. *Resource Management in the Vietnamese Mekong Basin.* Working Paper No. 74. The Mekong Basin Series. Asia Research Centre, Murdoch University, Perth.

Niny, Sin. 1994. *Mekong Water for Cambodia and Activities for Mutual Cooperation.* Paper presented to the International Symposium on Regional Infrastructure for the Mekong Basin Area, Tokyo.

Ogawa, Susumu, and Naito, Nobuaki. 2000. *Land Cover Change and Long Term Fluctuation of Evapotranspiration.* Poster Session 2. www.gisdevelopment.net/aars/acrs/2000.

PAD Review. *2002a. Lessons learned from Protected Areas Management Experience in Thailand: 1992–2001.* Draft Report. Review of protected areas and their role in socio-economic development of the four countries of the Lower Mekong Region. www.mekong.protectedareas.org.

PAD Review. *2002b. Economic Incentives and Protected Areas: Economics Financing and Market Mechanisms*. Review of protected areas and their role in socio-economic development of the four countries of the Lower Mekong Region. www.mekong.protectedareas.org.

Postel, S. 2002. *From Rio to Johannesberg: Securing Water for People, Crops and Ecosystems.* World Summit Policy Brief No.8. Worldwatch Institute, Washington, D.C.

Stroud Water Research Center. 2002. “Water for Gotham: Stroud Center Tackles New York City’s Internationally Envied System.” *Stroud Center Newsletter*, Fall 2000. www.stroudcenter.org/newsletters.

Stuart B., Smith J., Davey K., Din P., and Platt S. 2000. “Homalopsine Watersnakes: The Harvest and Trade from Tonle Sap, Cambodia.” *Traffic Bulletin* Vol. 18, No. 3.

Trade and Environment Database. 1997. *TED Case Studies: Lesotho Water Exports.* Case Number 196. TED Projects, American University, The School of International Service, Washington, D.C.

US EPA 2001. *Values of Wetlands.* Office of Wetlands, Oceans and Watersheds. Website http://h2osparc.wq.ncsu.edu/info/wetlands/values.

UNOCHA. 1999. *Vietnam: Floods.* OCHA Situation Report No. 2, 10 December 1999. United Nations Office for the Coordination of Humanitarian Affairs.

World Commission on Dams. 2000. *Dams and Development: A New Framework for Decision-Making.* The Report of the World Commission on Dams. Earthscan, London.

World Commission on Dams Secretariat. 2000. *Dams and Global Climate Change.* WCD Thematic Review Environmental Issues II.2. Prepared as an input to the World Commission on Dams. Cape Town.

WWF. 2002. *New Shipping Canals Will Destroy Last Chance for Blue Danube.* WWF Backgrounder. WWF Danube Carpathian Programme, Vienna.