Irrigation and Drainage Systems **15:** 99–115, 2001.
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A framework for valuing ecological services of irrigation water

A case of an irrigation-wetland system in Sri Lanka

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Accepted 12 April 2001

Abstract. In many countries, irrigation water is used for several purposes other than irrigating field crops. In Sri Lanka, irrigation water from canals, wells, and reservoirs is used for domestic purposes, industry, livestock, and fisheries, and it also contributes to sustain the environment. However, policy makers and water managers in irrigation systems only take into account water used for irrigating the field crops and sometimes water used for domestic purposes. Owing to the failure to recognize the different uses and users of water, the water in irrigation systems has been undervalued. This paper presents the environmental impact of irrigation and a framework for valuing water for its multiple and often competing uses, especially focusing on water uses for ecological services, in this case wetlands. The south coastal area of Sri Lanka was selected as a site for a case study, including 2,610 ha of irrigated area and a downstream wetland area of 2,250 ha which has five lagoons. This wetland area combines coastal, marine and freshwater ecosystems in a tropical environment in which distinct plant and animal species coexist in a delicate balance. All users of water and other resources, and their environmental problems were identified. This paper discusses the policy and management implications of valuing water for competing uses.

Key words: drainage, economic valuation, ecosystem, irrigation, multiple uses, wetland

Introduction

In most developing countries, irrigation water provides a wide range of services besides irrigating field crops. Water from reservoirs and canals is used for livestock watering, fisheries, industries, domestic purposes and to sustain the environment (Bakker et al. 1999). Many of these services go unrecognized and system managers only pay attention to the services and functions for which the system is designed, irrigation. To ensure efficient, equitable and sustainable water use, irrigation and water resources policies need to take into account all uses and users of water within the irrigation system. This is especially important because a lot of water users are threatened by the increasing water scarcity. Economic valuation of the different uses of water can be used as an input in decision-making. Better informed water allocation decisions can be made when the full range of services and values provided by irrigation water are taken into account.

The environmental services of water are among the water services threatened by the increasing scarcity. A good example of this is the wetland ecosystems. Water is the primary resource controlling the ecosystem in wetland areas. Wetlands are broadly defined as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters" (Ramsar Convention Manual 1997). Wetlands are among the earth's most productive ecosystems and directly support millions of people by their rich resources, in addition to providing goods and services to the world outside the wetlands. Direct and indirect human activities, especially related to irrigation development, have considerably changed wetland ecosystems (Barbier et al. 1997). Often, wetland ecosystems have to compete with irrigated agriculture for fresh water. In Africa, many floodplains came under increasing pressure from drought and upstream water resource developments that are diverting water from the floodplains (Barbier et al. 1991; Acreman & Hollis 1996). These developments are taking place because there is a failure to account adequately for the impact on the wetland ecosystem and the benefits it provides. While most wetlands are threatened by a shortage of water due to extraction of water upstream, some other wetlands receive too much water because of the diversion of water for irrigation development.

This paper presents a framework to value water for its multiple uses, especially focusing on the ecological services of water, in this case wetland benefits. The wetland area in the Bundala National park (Figure 1) located along the southeastern coast of Sri Lanka was selected as a case study site. We did not aim to value the complete wetland ecosystem but mainly focused on the benefits of fresh water within the ecosystem. This study is based on inter-disciplinary field research, co-ordinated by the International Water Management Institute (IWMI).

Methodology

Most of the studies done on valuing benefits of water have focused on a single use of water, for instance irrigation or domestic use of water. The majority of wetland valuation studies are also related to one use or function of the wetland, such as tourism or flood protection. This study attempted to value the benefits derived from the different uses of fresh water in the area, including

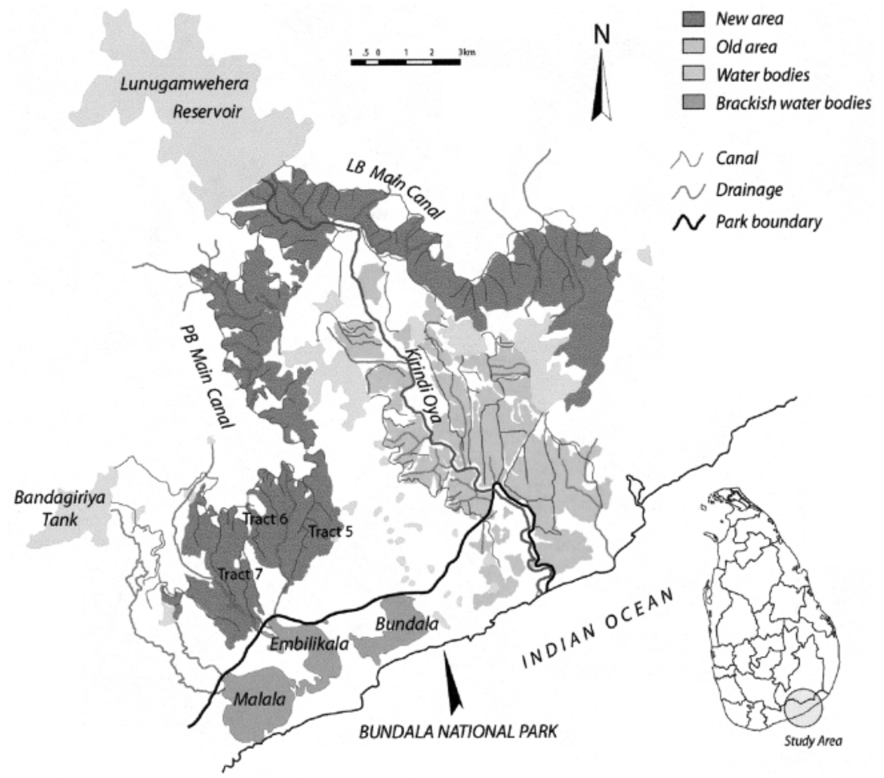

Figure 1. The wetland area in Bundala National Park, Sri Lanka.

the benefits from the expansion of the irrigation project as well as the benefits derived from the Bundala National park.

The economic value of a good or service is generally measured in terms of what we are willing to pay for the commodity, less what it costs to supply it (Barbier et al. 1997). The main objective of valuation of water is to indicate the economic efficiency of various competing uses of water. This can be used as an input for water allocation decision-making, besides other tools and considerations.

Many of the goods and services provided by wetlands are not marketed and are therefore difficult to value. They go unrecognized and are often ignored in development decisions. Therefore, to value and thus quantify the goods and services provided by wetlands, other methods like contingent valuation have to be used. These different methods are not explained and discussed in this paper since these techniques and their limitations are already adequately described elsewhere (Bann 1998; Dixon & Hufschmidt 1986; Pearce & Moran 1994; Young 1996). Although these methods are available and values can be calculated for the goods and services provided by water it is important to recognize the limitations of these techniques and their use in decision-making:

- When benefits of resources are quantified, and much time and effort are spent to get suitable data, the qualitative aspects of such a benefit might be overlooked (Seckler 1966; Roggeri 1995).
- Valuing ecological benefits often occurs through assessment of the willingness to pay. However, willingness to pay depends on the ability to pay. Hence the amount of money somebody is willing to pay is a function of how much income one has among other things (e.g. value judgement, etc.). It therefore looks like people with lower income attach a lower value to the resource benefits, even though this is not necessarily the case (Perry et al. 1997; Seckler 1966).
- According to conventional economic theory, monetary terms are used to analyze the efficiency of resource use and to strive for maximum efficient resource allocation. However, efficient allocation of resources is usually defined in the short run, and is not always compatible with the sustainable use of ecosystems (Bingham et al. 1995).
- Ecosystems have a present and a future dimension. The use now influences future use and also the present and future values. There may be some future values which are currently unknown and unappreciated (Banham 1993; Bingham et al. 1995).

Besides the above-mentioned limitations, valuation of ecosystems or ecological services of water is also a difficult exercise because information is lacking about the physical changes to ecosystems and the socio-economic consequences that might result from alternative courses of action. Furthermore, information is often lacking on the value of these changes (Bingham et al. 1995). Although these difficulties and limitations exist, economic valuation methods can play a significant role in the process of deciding upon conservation and sustainable use of natural resources like wetlands. The main role of economic valuation methods and techniques can and should be the setting of relative values in the project, program and policy appraisal process (Turner et al. 1998).

The total economic valuation approach used by Bann (1998) and Barbier et al. (1997) was applied to a framework for this case study. The first step consists of the identification of the uses and services of water in the area. The second step is the actual valuation of these different uses and services of water. The valuation of benefits take into account only the important direct use values of the study area, which follows the methodology used by Barbier et al. (1991) for a study in Hadejia-Jama'are wetlands, Nigeria.

The identification of the different uses and services of water was based on 156 interviews in the Kirindi Oya river basin and 100 semi-structured interviews with families living in the vicinity of the Bundala National park, supplemented by secondary information. To assess the impact of drainage water and to value other benefits derived from water in the study area we compared the present situation with that in 1987, before there was drainage inflow from the expanded irrigation system.

Study site

Physical characteristics

The Bundala National park is situated along the south coast of Sri Lanka, 275 km from Colombo (Figure 1). The climate is generally hot and dry, with an annual rainfall of 1,074 mm and a mean temperature of 27°C. The total area of the park is 6,216 ha, including five shallow brackish water lagoons (Maha, Koholankala, Malala, Embilikala, and Bundala) with a total surface area of 2,250 hectares. The Park provides habitat to water birds, elephants, turtles, and other wildlife. The brackish water lagoons serve as nurseries for shrimp, fish, and a variety of other marine organisms (Matsuno et al. 1998). It was declared a Sanctuary in 1969 and upgraded to the status of National park in 1992. Due to the existing natural values the area was listed under the International Convention of Wetlands, the Ramsar Convention, in 1991, so far the only one of its kind in Sri Lanka. The main reason for its establishment was that the area is regarded as an internationally important waterfowl habitat (CEA 1993).

The ecosystems of the Malala and Embilikala lagoons have been severely affected by the drainage flow from the Kirindi Oya Irrigation and Settlement Project (KOISP) and the Badagiriya Irrigation Scheme, which are both located upstream from the Park (see Figure 1). The KOISP was implemented in 1987 and this increased the irrigated area from 4,200 ha to 10,450 ha. As a result, irrigation drainage water started reaching the lagoons of the national park and the salinity level dropped. In 1998 a comprehensive water balance study was performed in the area. The drainage flow from Right Bank tract 5 into Bundala National park was measured at 68 million cubic meters (MCM) for 1998. The total net inflow [in the Right Bank of the KOISP] was 478 MCM, so 14% of the inflow drained into the Bundala National park (Renault et al. 1999).

Table 1 clearly shows the change in salinity levels for Malala lagoon after upstream irrigation development. The change in salinity levels has decreased the population of water birds as it has affected their food supply. Prawn fish-

Table 1. Average annual salinity level Malala Lagoon (in parts per thousand, ppt).

	Year	Lowest	Highest
before KOISP	85/87	10 ppt	41 ppt
KOISP	91/92	5 ppt	10 ppt
	95/97	0 ppt	7 ppt

Source. Kularatne 1999.

ing, which previously sustained 400 families, has also been affected by this change and it has now almost disappeared from the area.

Although drainage water is considered to be one of the major causes of the changes in the lagoon ecology, there is still a lack of knowledge about the impact of drainage water on the ecosystem of the park (Matsuno et al. 1998). For example, the importance of agro-chemical runoff from the irrigated areas has not been quantified. At the moment, a survey is being conducted to estimate quantities and types of fertilizer and pesticides used in Right Bank tracts 5, 6 and 7, and Badagiriya which are brought into the ecosystem of the park through the drainage water, as well as monitoring of flow and quality of the drainage water.

The excess drainage water has also resulted in flooding of agricultural and grazing lands around the park. The lagoon area has increased at the cost of agricultural, grazing and forest land. The maximum surface area of the Malala lagoon increased from 437 ha in 1983 to 650 ha in 1997 (Kularatne 1999). Furthermore, the creation of the KOISP disrupted the livestock grazing system and wildlife habitat by converting grazing land and forest areas into paddy land. Many elephant migratory routes have been disrupted by farmland and this has resulted in human-elephant conflicts because of crop damage by elephants.

Besides farming, the families which were settled close to the Bundala National park under the KOISP carry out a range of other activities which have led to wetland degradation (CEA 1993). For instance the demand for fuel wood has increased due to the settlement project and many families collect their fuel wood in the Bundala National park. This is an environmental damaging activity and it leads to the propagation of undesirable plant species.

Institutional characteristics

Before Bundala attained the status of a National park people were allowed to retain land titles. Being declared a National park has far-reaching implications. First, a National park can only be State Land, so no private land ownership is allowed. Boundaries of the park are now under discussion in Parliament to avoid private land holdings in the park. Second, most human activities, except lagoon fishing and tourism, are prohibited by law (CEA 1993). Despite these regulations the resources in the park are still being used for a variety of purposes. Most of the people involved in these activities are local villagers who have been forced into some illegal activity through either lack of grazing land or fuel or income (CEA 1993).

The Bundala National park covers five local administrative units (Grama Nilidari Divisions) with a total of about 1100 families living in the park. The Department of Wildlife Conservation (DWLC) is responsible for the overall management of the park and also for the enforcement of regulations. Strict enforcement of regulations is virtually impossible because of lack of staff and transport (CEA 1993). In 1997 no patrolling or evidence of law enforcement was observed (Kularatne 1999). Besides a lack of resources for enforcement, there was no incentive to stop these illegal activities because the fines were so small that it was still beneficial for the people to continue. Recently, the fines have increased, which may change the incentives (C. Jayawardena, personal communication).

Another management problem of the Bundala National park is that most of the institutional authorities are defined along sectoral or geographic lines that do not correspond to the range and types of environmental problems in the area. These problems cross the boundaries and authorities of Departments. Policies and decisions of one authority have an impact outside their geographical and sectoral lines. A clear example is the impact of the upstream irrigation system on the ecosystem of the Bundala National park. The Irrigation Department is the responsible agency for the management of the upstream irrigation system but the protection of the Bundala National park is not in its mandate. This shows the need to co-ordinate water management related problems, preferably at river basin level, under proper environmental regulations and their enforcement.

Results

The uses and services of water were identified as shown in Table 2. The importance of the natural resources of the Bundala National park is paramount for the communities in the vicinity of the Park. Water is crucial for the Bundala National park, largely determining the quality of the habitat and variety of wildlife. Furthermore, water makes the area important for farmers, fishermen, livestock and salt production. The irrigated areas upstream of the park provide important livelihood opportunities for 3000 farm families. Besides the contribution to the livelihoods of the families, either in cash or

Table 2. The uses and services of water.

	Total economic value		
	Use values		Non-use values
Direct use value	Indirect use value	Option value	Existence value
Agriculture	Habitat for fish	Future uses as per direct and indirect	Biodiversity
Fish	Habitat for wildlife		Uniqueness
Fuel wood	Catchment for drainage water		Historical/cultural
Medicinal plants			Scientific
Livestock	Micro-climate functions		
Salt mining	functions		
Shell mining	Salinity buffer for agricultural lands		
Tourism	Shoreline		
Wildlife harvesting	stabilization		
Benefits:	Benefits:	Benefits:	Benefits:
Local level	Regional level	Local & regional level	Global

Adapted from Bann (1998) and Barbier et al.(1997)

subsistence, the direct uses in the area also have some other impacts. The value, beneficiaries, level of benefits, and environmental impact are summarized for each livelihood activity in Table 3 and discussed in more detail below.

Agriculture

Agriculture is the most important income generating activity in the area. Within the park boundaries agriculture is limited to a few rainfed plots. To estimate the benefits derived from the 2,610 ha of irrigated agriculture upstream of the Bundala National park, data from a farm survey in Right Bank tracts 5, 6, 7 and Badagiriya irrigation system were used. Table 4 shows the data calculated for one season in 1998 on a hectare basis and per m^3 of crop evapotranspiration (ET). The CROPWAT model (FAO 1992) was used to obtain figures for crop evapotranspiration. Accurate inflow data are not yet available for these areas, but if the gross and net values of output were calculated on the basis of m^3 inflow, the values would be even lower. Based on the estimation in Table 4 and assuming the cropping intensity of around

Table 3. Summary of values, beneficiaries, level of benefit and environmental impact of direct water use activities in the study area.

Activities	Annual value[1] (in constant US $)	Level of benefits and beneficiaries	Environmental impact	Specific group affected
Irrigated agriculture	GVO[2]: $0.9 to $1.2 million ($ 780 per ha or $ 0.12 per m^3)	Local: Farm families in RB[3] 5, 6 & 7 and Badagiriya	Yes negative impact	Fishermen and lagoon ecosystem
Fisheries	GVO: $30,240 ($28 per ha of surface water)	Local: Fishing families around the park	Yes negative because of over-fishing	Fishing families
Fuel wood collection	Highly important	Local: Villagers in the vicinity; town inhabitants; shell miners	Yes negative impact	Villagers themselves and ecosystem
Livestock Grazing	Highly important since no alternative pasture areas	Local & regional: Livestock owners	Yes negative impact	Wildlife and lagoon ecosystem
Medicinal plant collection	Unknown	Local & global: Villagers and potentially the pharmaceutical industry	Unknown	Unknown
Salt farming	GVO per ha: $ 5,104	Local up to global: Laborers and management, flamingoes and small wading birds	Not at this level of activities	Expansion will affect ecosystem of park
Shell mining	Important form of self employment	Local: Shell miners and permit holders	Yes negative impact	Ecosystem (soil and vegetation)
Wildlife hunting	Unknown	Local: Villagers around the park	Yes negative impact	Wildlife and biodiversity
Wildlife grazing	Important since surrounding areas are all developed for human activities	Global: Wildlife, global biodiversity	No	Local villagers because of elephant problem
Tourism/ recreation	Important total income from entrance fees: $ 83,352	Regional up to global: Government, jeep drivers, guides, hotel owners and employees, tour operators	Yes negative impact	Local villagers because of elephant problem and ecosystem damages

[1]If quantitative values are not available we give a qualitative indication of the value; [2]GVO = Gross Value of Output; [3]RB = Right Bank

Table 4. Gross and net values of output of paddy cultivation per ha and per m^3 ET (in US$), Yala season 1998.

	Per hectare	Per m^3 ET
Gross value of output	780	0.12
Input cost (seed, chemicals, machinery etc.)	250	
Hired labor cost	190	
Family labor cost (against contract labor rate)	102	
Net value of output	238	0.03
Net value of output without charging family labor	340	0.05

150% to 200% per year, the total net value of output in tracts 5, 6, 7, and Badagiriya area of 2,610 ha is US$0.9 to US$1.2 million per year.

Fisheries

Since the implementation of the KOISP, shrimp production has declined to zero. Fishing still continues in these lagoons at a low intensity. Besides the change in fish species composition the fishermen observed an increase in the number of fishermen, a change in the type of nets used (57% use prohibited small mesh gill nets) and a decrease in fish breeding behavior after upstream irrigation development (Kularatne 1999). The national park status does not allow the implementation of aquacultural techniques, for instance, to increase shrimp production in the lagoons.

Table 5 shows the average fish and shrimp production over the years for the Malala lagoon. The table indicates that the lagoon is no longer suitable for shrimp production but is favorable for other fish types, mainly cichlid. This is not surprising since the acceptable salinity range for shrimp culture is between 5 and 35 parts per thousand [ppt], with an optimum range of 15 to 25 ppt (Jayasinghe 1997) and the current maximum salinity level of the lagoon is 7 ppt (see Table 1).

It is only possible to calculate the gross value of output of fish per ha since no data are available on the input costs. For 1995–1997 this amounted to US$ 28 per ha of water body surface. Based on this number, the fish production of 60 kgs per ha of water surface (Table 5), the total gross value of fisheries in Embilikala (650 ha) and Malala (430 ha) is US $ 30,240. Because economic data on shrimp production are not available we are not able to quantify the impact of the KOISP on the fisheries sector. However, discussions with the

Table 5. Average fish and shrimp production per year in kg/ha for the Malala Lagoon.

	Before 1987	1991–1992	1995–1997
Average fish production	not available	120	60
Average shrimp production	15–31	5–15	no shrimp production

Source: Jayakody 1993, NARA 1997.

fishermen around the area revealed that the gross value of output from shrimp farming before the KIOSP was much higher than the current value of output.

Tourism

Tourism is a major income-generating activity of the Bundala National park with only minor impacts on the economies of the nearby villages. Since the declaration of the Bundala National park in 1992 the DWLC is entitled to charge entrance fees. Revenue (15%) from these entrance fees goes to the Head Office of the DWLC and to the Provincial Council (85%) (M. Gamage, personal communication). It is not used to pay staff, maintain roads, enforce regulations, or perform management and conservation activities. While the activity generates a considerable amount of income for jeep drivers, guides and guesthouses, it seems that none of the villagers from the vicinity receive benefits from the presence of tourists. The people involved in the tourist industry are all from villages and towns away from the park.

The way tourism is currently practiced in the park has a negative impact on the ecosystem of the park. The habitat is being destroyed by vehicles driving off the road, leaving the established roads, in search of wildlife. This, in addition to harassment of animals, makes the park increasingly less attractive and less habitable for wildlife (CEA 1993). Another effect of tourism, according to the villagers, is that the animals, particularly elephants, have become accustomed to human presence, making it even harder for the farmers to drive them away when they damage the crops. These conflicts result in death and destruction of both humans and elephants (Rajapakse 1998).

One of the possible impacts of drainage water inflow in the national park could be a drop in the number of tourists visiting the area because of the changing ecosystem. However, the available information is not sufficient to analyze such a relationship. Table 6 shows the number of tourists visiting the area and the income derived from this. The economic contribution to the national park obtained from the tourists would be much higher than its direct income by entry fee (US $ 83,352 in 1997) if the travel cost of visiting the

Table 6. Number of tourists and the total revenue of entrance fees for Bundala National Park.

	1995	1996	1997
Number of foreign tourists	16,350	11,301	16,448
Number of local tourists	16,824	11,024	17,300
Total	33,174	22,325	33,748
Total revenue in US dollars	82,786	57,109	83,352

park is accounted for. Without in-depth investigation, it was estimated to be somewhere between US \$0.5 and US \$1.5 million.

There was a sudden decline of the number of tourist visits in 1996 and an increase in 1997 to the same level as 1995. Possible explanations of this decline are that in 1996 there were severe power shortages in Sri Lanka and a security problem due to political instability, which made Sri Lanka less attractive for tourists in this particular year.

Salt farming

Because the Bundala lagoon has its own small catchment, it has not been affected by irrigation development, the water has maintained its natural salinity level. Though salt production is not directly linked to or affected by fresh water inflow, we take it into account because it is an important employment generating activity and thus important to the livelihoods of the villagers. We also consider salt farming because otherwise we risk overlooking important ecological relations which are unknown at the moment. In 1978 the Salt Corporation became operative, first under ownership of the government and later as a private company. The Salt Corporation exploits 100 ha of the Bundala lagoon despite the fact that human activities and private land ownership are not allowed within the park boundaries. Because the salt farm creates a lot of employment for the villagers, the DWLC allows the salt farm to continue its operations but the area cannot be extended beyond the existing 100 ha.

Salt production is seasonal and limited to periods of low rainfall (July-October and February-May). The salt farmers live within a 15 km radius. The value of the benefits of salt production is given in Table 7.

The water inlet pond, where water from the ocean is pumped into the salt pans, is an important feeding place for birds. The water level in this pond is controlled at low depths and therefore provides a valuable feeding ground especially for flamingoes and small wading birds. Since the salinity of the Embilikala and Malala lagoons is too low and water levels fluctuate too much,

Table 7. Benefits of salt farming in 1998 (in US$).

Total output	US$ 510,450
Total labor costs	US$ 245,167
Other costs	Unknown[1]
Total Max. Net Value of Output	US$ 265,273 (2,653 per ha)

[1]Not much machinery input is used in this salt farm; salt is sold in bulk so no packaging etc. takes place.

the salt farm is the favorite place in the national park for these birds. Despite this important ecological function of the salt farm it is argued that an over-extension causes an imbalance in the ecology (Rajapakse 1998).

Other direct uses

The following direct use values are not yet quantified. Research is still ongoing and data collection and analysis is taking place. However, we would like to mention them and provide information which is of a more qualitative than quantitative nature.

Livestock

Livestock, mainly buffalo and cattle, is important for subsistence and income generation in the study area. The animals are mainly used for milk and to produce curd for which the area is well known. Livestock productivity is quite low because a large part of the herd is not used for milk production but as a capital asset. The ownership of livestock is recognized as a status symbol and size of the herd is much more important than the quality of the herd. Some large herds are owned by people outside the study area.

Large numbers of domestic cattle and buffalo use the resources of the national park. Although it is illegal to graze domestic animals within the park boundaries, it happens quite often. In the yala (dry) season, livestock is mostly found along the northern boundary of the park and the adjacent fallow rice fields in tracts 5, 6 and 7 and Badagiriya. In yala 1997, 4,000 domestic cattle and 1,700 buffaloes were counted in this area (Bopitiya et al. 1998). Livestock moves into the park during the maha (wet) season when the rice fields are cultivated. The continuous supply of fresh water from the upstream irrigation systems encourage even more livestock to come to the Bundala National park. They compete directly with the wild animals, like elephant and spotted deer, for food in the park. All this leads to overgrazing of the area and to serious soil degradation. Furthermore, dung and urine of the livestock enriches the lagoon system and causes eutrophication.

Fuelwood collection
The main source of energy for cooking in the area is fuel wood. It is collected by the local population for domestic and commercial purposes in the forest areas around the lagoons. They sell it to shell burners who use it in their shell kilns and to people from the towns nearby (Kularatne 1999). Because this is an illegal activity, quantitative data are lacking. However, it is clear that fuel wood collection is of high importance for the livelihoods of the families around the park.

Shell mining
Together with fuel wood collection, shell mining is one of the most environmentally destructive activities in the study area. It extracts fossil shells from beds, which can be found just beneath the ground surface. The shells are shifted, washed and either sold as shells or burned and sold as lime. This is a highly destructive activity because it disturbs the soil structure, destroys the vegetation cover, and leads to increased soil erosion (CEA 1993). The relationship between the upstream irrigation project and shell mining requires some further investigation.

Shell mining, within the national park and in areas in close proximity, is a major source of self-employment. Because of the environmental destructiveness, it is prohibited by the DWLC, but it continues to take place. In 1998 it was estimated that there were 13 illegal shell mines inside the park and 15 illegal mines outside the park. There are also 12 permitted (legal) shell mines outside the park (Kularatne 1999).

Medicinal plant collection and hunting of wild animals
So far, not much is known of the role planned by medicinal plant collection and hunting of wild animals in the livelihoods of the local communities.

Discussion

Using the total economic value framework and listing all the use and non-use values, particularly the direct uses, we can get a better picture of what is happening in the area. Furthermore, it reveals linkages and interactions of people and institutions in a certain ecosystem and the impacts of their activities.

The framework of total economic values also makes clear at what level benefits of the use and non-use values are obtained. This information can be helpful for policy makers to set priorities and guide them during the decision-making processes. Moreover, it makes clear who are affected by their decisions, which might have been overlooked without the framework.

It is obvious that substantial conflicts exist between direct uses of the resources by the local community and sustainable development of the ecosystem. The biggest conflict in the area (between ecosystem and livelihoods of the local people) is caused by drainage water from irrigated paddy fields, which enters the lagoon ecosystem. In this context it is important to evaluate the trade-off between the output of irrigated agriculture and the loss of ecological value of the Bundala National park from an economic point of view. This ecological value is indicated by the use and non-use values of the ecosystem. Increase in paddy production was likely offset by shrimp production and fishing in the lagoons as far as its economic value and the employment generation in the area are concerned. However, we are at this moment unable to assess the full impact of it and to come up with a concluding statement on the conflict. Its impact on decrease in ecological value in the park needs to be further investigated.

On the other hand, it is too early to conclude that the people in the area would have been better off in terms of livelihood opportunities with or without the irrigated paddy cultivation. In the first instance it provided them with a plot of land to cultivate their staple crop and a source from which to draw water for domestic purposes, but on the other hand, it has affected the opportunities for livestock grazing and fishing. In any case, it has negatively affected the ecosystem in the area, not only by draining fresh water into the lagoons, but also by increasing population pressure on natural resources in the area (e.g. fuel wood, pasture land).

Strict conservation of the Bundala National park, which the DWLC is aiming for by restricting all human activities in the park, will improve the ecological character of the park and this is bound to increase the number of tourists visiting the area. To create incentives for conservation to attract tourists, the local people should receive more benefits from tourism than is currently the case. Furthermore, opportunities should be created to satisfy their resource needs, for instance, fuel from another area or an alternative source.

Technically, there are several options that could be considered to reduce the impact of drainage by changing the irrigation water management practices (Matsuno & van der Hoek 2000), such as:

- Diversion of drainage water to other lands, or reusing drainage to expand the irrigated area.
- Cultivate non-paddy crops so that the drainage will be much reduced.

– More efficient irrigation practices. For example, application of rotational irrigation for paddy would reduce the amount of irrigation application, thereby reducing the drainage.

Some other options have also been proposed by the Department of Wildlife Conservation (1999), which includes an earth embankment with an iron sluice-gate to control the water flow between Malala and Embilikala lagoons, and a new channel constructed from Embilikala direct to the sea.. In any case, the initial investment is considerable. The cost of these interventions was estimated at between US$ 4,000 to US$ 45,000. Additionally, the relevant authorities will need to increase their institutional capacity to implement and enforce these management changes that may include establishing and enforcing the environmental regulations for drainage outflow. Nevertheless, the above first two options are attractive, since increasing the irrigated area or cultivating more high valued crops would increase the benefits from agriculture. It is therefore necessary to further evaluate and identify the feasible management options when considering all the possible outcomes of the interventions.

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