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Valuation of Ecosystem Services of Kala Oya River Basin: Implications for River Basin Management

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Abstract

Kala Oya Basin (KOB) is one of the largest river basins in Sri Lanka which covers an area of around 2,870 km² and expands over three provinces and four districts. The river basin covers many different types of ecosystems, valuable biodiversity resources and characterized by conflicting user interests and serious degradation issues. The present study attempts valuation of ecosystem services provided by the river basin and aims at providing recommendations for river basin management.

Carbon storage and soil conservation functions, recreation, production services of homegardens, and mangrove services were valued using data collected from various primary and secondary sources and using benefit transfer approach as the main valuation method.

The annual value of the ecosystem services of the KOB is Rs million 23,500. The highest economic value was resulted from the carbon values (77%). The estimated value represents 1.16% of GDP (of 2004) of the country and 7.33% of the agricultural sector GDP which highlights the significance of the potential economic gains of the basin. Development of appropriation mechanisms for the yet unrealized values and identification of conservation and monitoring priorities are the key issues identified by the present study. However, the study emphasizes the need for more complex models that integrate economics, hydrology, and equity aspects which could ensure long term sustenance of the service provision of the river basin.

Key words : River Basin, Economic valuation, Kala Oya

Introduction

Ecosystem services and the need for economic valuation

Ecosystem functions are defined as the capacity of natural processes and components to provide goods and services that satisfy human needs, directly or indirectly (de Groot, 1992). Ecological goods and services provided by ecosystems are very diverse and of great ecological, socio-cultural and economic value and the concept of ecosystem services have gained much attention in recent years, emphasizing their importance for human societies, (e.g. Costanza, *et al.,* 1997; de Groot, *et al.,* 2002; Daily, *et al.,* 2000; Millennium Ecosystem Assessment, 2003). Various classifications of ecosystem functions are available, both from functional point of view (e.g. production, regulatory and cultural services) and value point of view. Within total economic valuation framework ecosystem functions are mainly defined as an indirect use value and option value incorporates future service values. In addition, consumptive and non consumptive use values and non use values are recognized as ecosystem service values.

However, in environmental planning and decision-making, these benefits are often not fully taken into account and multi-functional ecosystems are continuously being converted into more simple, uni-functional land use types (e.g. agriculture) or left for degradation without adequate investment on conservation. There is enough evidence however that the total value of multi-functional use of natural landscapes is often economically more beneficial than the value of the converted systems. This contradiction is explained in terms of information, market and intervention failures. The value of the functions of ecosystems has been difficult to be converted into monetary terms because most of the benefits are not captured in conventional, market-based economic analysis. There is an information failure with regards to many functions and values of natural and semi-natural ecosystems and, our decisions on trade-offs between different land use options are incomplete and incorrect. Market failures play a fundamental role in driving loss of ecosystems because the benefits from the land use change usually go to private or corporate interest groups while the costs (i.e. the non-marketed externalities) are burdened upon groups who are usually unheard and future generations. The private benefits of conversion are often exaggerated by intervention failures because of tax incentives and subsidies which result in both economic inefficiency and the erosion of natural services (Turner and Jones, 1991 as cited in Balmford, *et al.*, 2002).

Farber, *et al.*, 2002; Wilson and Howarth, 2002 illustrates strengths and weaknesses of various valuation methods available for service valuation. Based on Costanza, *et al.* (1997), de Groot, *et al.* (2002) established a relationship between the main function categories and the preferred valuation methods

River basins, Basin management issues and economic values

A river basin is defined as the geographical area determined by the watershed limits of the system of waters, including surface and underground waters, flowing into a common terminus (Jaspers, 2003). Most of the world's land surface is a part of a river basin (Laconte and Haimes, 1992; Doomkamp, 1985; Lundqvist, *et al*, 1985; Newson, 1988, 1992). Basins can be divided into sections using hydrological and catchment characteristics (upper, middle and lower basin) or sub basins by tributaries. River basins are considered as logical units for water and environmental resources management (Savenije, 2000).

River basins facilitate several water-related human activities, including water storage, diversion, pumping, distribution, purification, and pollution. Multiple sector interests such as drinking water supply, agriculture, hydropower generation, recreation, and fishing are served by the different ecosystems of river basins. River basins are used ever more intensively and many of them are under pressure leading to many water problems such as water use conflicts (e.g., typical upstream downstream problems and between sectors), droughts and floods, and the externalities (e.g., water pollution) Savenije, 2000).

Basin scale analysis provides a comprehensive framework for decision making which emphasize on physical, social and economic efficiency dimensions (Cai, 2007). Warda and Valazqueb (2008) summarize the advances made in the basin scale analysis across various regions in the world in recent years. Integrated hydrologic and economic models are used to assess combined water resources management and policy issues *(McKinney et al,* 1999; Letcher and Jakeman, 2003; Jakeman and Letcher, 2003; Lund *et al.,* 2006; Letcher *et al,* 2007) towards both economic objective or multiple objectives that include environmental and social goals. There are two approaches to combine hydrologic and economic components, compartment modeling and holistic modeling (Braat and Lierop, 1987; Brouwer and Hofkes, 2008). McKinney, *et al.,* (1999) reviewed the development and applications of holistic models for integrated river basin management in the past century.

More comprehensive integrate water policy assessment tools are provided by Brouwera, *et al.,* (2008) where national accounting framework has been used. Ya'n~ez-Arancibia and Day (2004) justifies the need for an ecosystem approach that recognizes the inseparable interactions between the environment atmosphere, water, land, biota) and human activities (social, cultural, economic systems); environmental thresholds and needs of current and future generations. Similar ideas on sustainable river basin management have been proposed by Cai *et al.,* 2002, 2003b; Rodgers and Hellegers, 2004; Jenkins *et al.,* 2004; Booker *et al,* 2005); (McCarl *et al.* (1999), Marques *et al.* (2006), Schoups *et al.* (2006), and Pulido-Vela'zquez *et al.* (2006); Cai *et al.* (2003b). Teclaff (1985) and Mostert (1999) in addition suggest further dimensions on legal, political and administrative involvements in integrated basin management.

These models have been useful in many respects. Economic models are mainly useful to identify best resource allocation strategy in a river basin and to model the use of economic instruments such as taxes (vanHeerdean? *et al,* 2008). Integrated approaches have basin-wide planning scope; attention is paid to management of water quantity, quality and environmental integrity. Such integrated models have helped to establish linkages between different uses especially trade-off between different uses (Watkins and Moser, 2006), and to show how the improvements of water use efficiency in one use (e.g. agriculture) minimizes damages of other use (e.g. environment), balancing different uses (Cai *et al,* 2003 a,b), and the analysis of different interests, demands and equity in water supply (Letcher and Jakeman, 2003; Letcher *et al.,* 2004).

Such integrated river basin models have often utilized economic values in prioritization of uses, water allocation among users. Such economic values could also be used to design appropriate policy instruments that could reverse accelerated degradation, enhance water conservation and provides justification for rehabilitation of degraded ecosystems.

Economic values could also provide justification for inter basin transfers and would provide guidelines for management of global resources of rover basins.

The study therefore attempts valuation of ecosystem services of KOB (Kala Oya Basin). Kala Oya represents typical characteristics of a river basin with diverse ecosystems different jurisdictions under different institutions along with multiple users and sectors with conflicting interests. Study of this complex river basin as a case study would be useful in learning lessons for other basins of the country. Establishing economic values for a river basin has several important implications at several levels.

The paper is organized as follows: the next section provides general framework for the study, followed by methodology, results, implications for basin management and conclusions and policy implications.

General framework for the study

Many resources in the KOB could be identified as public goods (both local and global) and there are few private goods such as privately held lands. Those public goods along with the failures operating at various levels (local market, global market and policy failures) contribute to the degradation of the basin services. In order to correct such failures, environmental valuation of the non marketed goods and services is needed. This is illustrated in Figure 1.

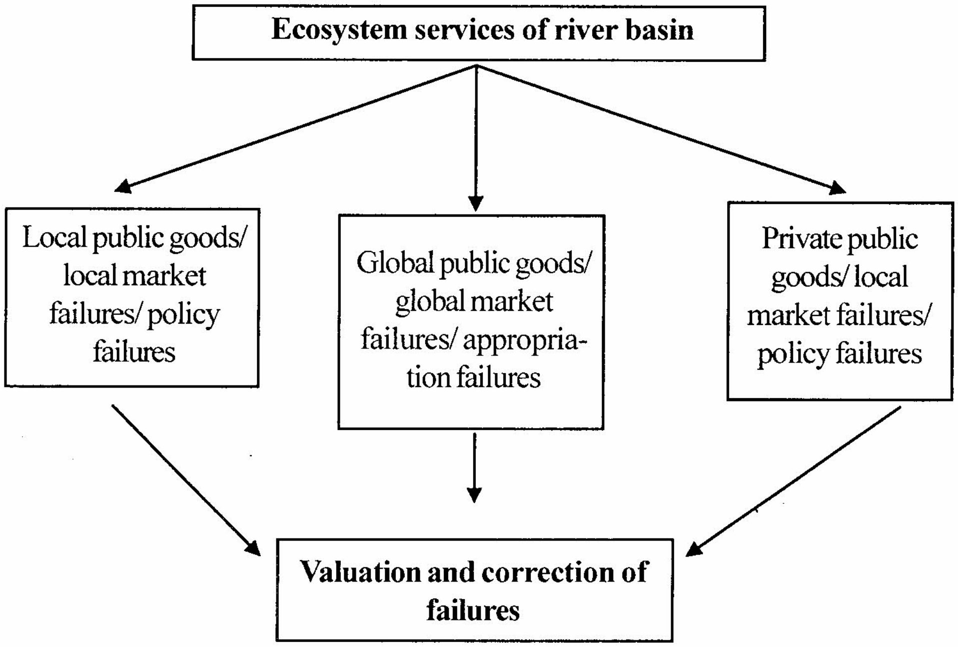

Figure 1 Market failures and public goods in river basins

Economic valuation is about discovering the demand curve for environmental goods and services. The main problem of economic valuation is that deriving credible values where there are no visible markets or presence of very imperfect markets. The derived values could be used in land use decisions. Economic values could provide useful guidance on reversing both market and policy failures and suggesting the types and sizes of economic instruments that could be used in correction of such failures. Yet unappropriated values also can be identified through economic valuation and appropriation mechanisms could also be developed as an internalization mechanism.

Methodology

The study site

Kala Oya River Basin, which is situated in the Northwestern dry zone of the country with 1,450 mm average annual rainfall, covers an area of around 2,870 km^2 and is one of 103 river basins in Sri Lanka. The basin covers three provinces and four districts, namely, Anuradhapura in the North Central Province, Kurunagala and Puttalam in the North Western Province and Matale in the Central Province. KOB receives water from the Mahaweli Ganga, to meet approximately 75% of its annual demand. KOB has a water budget with a net inflow of 800 MCM. In the lower basin, the majority of water is allocated to irrigation. There are about 600 small irrigation tanks within the basin, as well as the large-scale Mahaweli Irrigation Expansion Project. About 65% of water is allocated to these larger-scale irrigation systems.

There exists also number of protected areas such as Wilpattu National Park, part of Kahalla-Pallekele Resvehera sanctuary, Sigiriya sanctuary and Minneriya Giritale Nature Reserve. Kala oya basin also has a large number of natural and man-made wetlands. The Bar reef sanctuary is situated at the mouth of the Kala Oya basin.

The administrative framework within KOB illustrates that there are several agencies such as Agriculture Department, Agrarian Services department, Department of Wildlife Conservation, Forest Department, Mahaweli Authority, Urban

Development authority, that have the regulatory authority on use of land resources. In addition to the above, Provincial Councils (North Western, Central and North Central) also exercise jurisdiction over the land in the basin.

The main objective of this paper is to Establishment of the base line economic value for the ecosystem services of the area and to propose mechanisms how these values could be integrated into the river basin management.

Valuation of ecosystem services

Different values exist in the KOB that are contributing to national economy were identified using total economic value framework (Pearce, 1995). The adopted valuation method was benefit transfer approach. Benefit transfer approach estimates economic values by transferring existing benefit estimates from studies already completed for another location or issue. Such values estimated for other sites have been adjusted and used in the KOB context. Both primary and secondary data were collected to enhance the accuracy of the derived values. Table 1 provides details of the adopted valuation methodologies and supplementary data that were collected for different ecosystem services.

Additional information on conflicting water uses and basin degradation issues were obtained from several rounds of interviews held with the Grama Niladhanis of the villages within the Vanathavilluwa Divisional Secretariat including Aluth Eluwankulama, Parana Eluwankulama, and Ralmaduwa. Further information of the biodiversity resources of the area was obtained from the discussions with biodiversity specialists (both flora and fauna) and a hydrologist, a wetland biologist and a marine biologist. Water usage of the KOB for agricultural areas was obtained from the regional Mahaweli Authority (Thambuththegama) officers.

Table 1 Adopted valuation methods and data requirements in the context of benefit transfer approach

Ecosystem service	Valuation methods	Supplementary primary and secondary data	Sources
Carbon storage value of natural vegetation	Avoided global damage cost	Extents of different vegetation types Carbon values of the vegetation	MASL. 2005 Bundestag (1990. Houghton *et al* (1987)
Soil conservation benefit of the moist monsoon forests	Replacement cost method[1]	Extents of the moist forest	MASL. 2005
Recreation along the river bank	Contingent valuation	Average visitation per year	Interviews held with informed people in the villages Ralmaduwa. Aluth Eluwankulama. Parana Eluwankulama.
Recreation value of the Wilpattu National Park	Travel cost method[1]	Park extent	MASL. 2005
Products from home garden biodiversity	Market price method	Products of different crop species (quantities and prices)	Socio Economic Profile of the Kala Oya Basin: Central Bank of Sri Lanka (2004) Annual Report
Values of wetland ecosystem	Market price method[1]	Wetland extent	MASL. 2005 IUCN. 2004
Value of mangroves	Various valuation methods[1]	Mangrove extent	MASL. 2005 Costanza *et al.* 2000
Non use values of moist monsoon forests	Contingent valuation method[1]		MASL. 2005 Gunawardena (1997)

Values of these methods have been transferred to the present study

Results and discussion

Sequestration of atmospheric carbon by the natural vegetation in the Kala Oya basin

Sequestration of atmospheric carbon is an ecosystem service that can offset green house gas emissions. Soil organic carbon and vegetation organic carbon stocks that are stored in the different vegetation types of the KOB were estimated using secondary data. Table 2 gives details on the different vegetation types of the KOB. These different vegetation types contain different carbon amounts and for the present study, total carbon content (including biomass and soil) in different tropical land uses provided by Bundestag (1990, Houghton *et al.*, (1987) were used.

Table 2: Vegetation types of KOB

Forest type	Extent (ha)
Dry mixed evergreen forests	59857.92
Moist monsoon forests	11394
Riverine dry forests	1517.48
Forest plantations	4345.72
Mangroves	315.99

Source : MASL, 2005

Table 3 shows the results of the analysis of carbon values of the different land use types present in the Kala Oya basin. Dry mixed evergreen forests are the largest store of the carbon while riverine forests, forest plantations and mangroves represent only a small percentage of carbon.

Table 3: Different land use types of Kala Oya Basin

Land use type	Extent (ha)	Carbon content (t/ha)[1]	Total carbon content (t)	Economic value (million Rs)[2]
Closed primary forest	11,394	283	3224502	3,982
Closed secondary forest	58,349	194.5	11,348,880.5	14,015
Open forest	1225	115	140875	173
Total				18,172

1 Bundestag (1990. Houghton *et. al.*. (1987). The following assumptions with regard to the forest types were made to calculate the carbon content of the KOB: Moist monsoon forests of the K.OB were considered as closed primary forests: dry mixed evergreen forests were considered as closed secondary forests: Riverine dry forests. forest plantations and mangroves were considered as open forests.

2 According to Pearce (1995) the avoided damage cost of releasing one ton of carbon to the atmosphere is $5 - 20. an average of $13 was taken for calculations.

The results have important implications for the management of KOB. If the forests are kept intact, this global benefit will be available forever. However, since this is a global benefit, development of mechanisms for appropriation would be necessary especially under climate change convention. In addition, any conversion of the land uses would need to provide adequate attention to the gains and losses in terms of the carbon benefits.

Estimation of the soil conservation benefit of the moist monsoon forest of the KOB

Conserving soil from erosion is one of the important functions of the forest cover. The soil conservation benefit for moist monsoon forest of KOB was estimated using the benefit transfer approach. Subasinghe and Gunawardena (2003) estimate the economic value of the soil conservation values of the Sinharaja Forest to be Rs 4486 per hectare. There are equivalent 11,394 ha of moist monsoon forests area in the KOB. Therefore, the total soil conservation benefit of the moist monsoon area of the KOB is Rs. 51,593,486. This soil conservation value represents value of the undisturbed forest cover that prevent soil being eroded which might create many costs downstream. Therefore, this is an avoided cost due to the forest cover. The economic value of other forest types was not possible due to unavailability of data.

Estimation of recreational value of the KOB

Kala oya itself and the basin ecosystems provide recreational services to people. Wilpattu National park is one of the major attraction for both locals and foreign tourists. The following section elaborates different modes of recreational services rendered by the KOB and their economic values.

Recreation along the river bank

The banks of the Kala Oya is a popular recreational site among many urban elite groups. Benefit transfer approach was used to estimate this benefit with some verification using primary data. The field observations and discussions held with the informed people of the Eluwankulama village revealed the details of the recreational activities, especially locations of the activity and the visitor numbers. Table 4 illustrates the details.

Table 4: Visitors along the river bank

Location (along the Kala Oya)	Average number of visitors (per day)
Monaravilluwa	50
Murandum villu	50
Kattandipallama and Nochchdimundal	40
Ambalakaravidhidi	25
Nadanagavillu bungalow	30
Mannarakkkama	30
Potanarakkama	30
Total	255

Source: Field observations, 2003 and personal communications with informed people of Eluwankulama 2003

It has been revealed that this activity is being carried out at least for 6 months within a year and total annual number of visitors is reaching up to 45900. The economic value of this could be derived using the benefit transfer approach. Average willingness to pay for recreation has been estimated as Rs 300 per person per year (De Silva and Bogahawatta, 1996 cited in Kotagama, 1998). Therefore, the total value of the recreation activity along the river bank is estimated to be Rs 13,770,000 per year.

This value is a measure of the satisfaction they obtain by the visitation. This activity however, seems to be limited to certain groups of the country and the sites are not known to the general public implying some distributional issues. The area has great potential for tourism. However, intervention from necessary authorities are needed to promote supervised tourist activity as opposed to what is taking place now since such activities could be environmentally damaging if not regulated. Further studies will be needed on this issue before opening up the area for advertised eco-tourism.

Recreation value of the Wilpattu National Park

Most of the wilderness areas within the Kala Oya river basin are restricted to the lower basin of the Kala Oya and Wilpattu National Park is one of the important recreational sites of the KOB. However, the park and the areas surrounding it remained inaccessible to naturalists over the past three decades due to the ongoing civil war. However, an attempt was made to estimate the potential recreational value of the Wilpattu Park using the benefit transfer approach. Steel (cited in Kotagama 1998) estimates recreation value of Yala wildlife sanctuary to be Rs 250 /ha/yr based on the entrance fee. Assuming that the Wilpattu park is able to draw similar visitor numbers, the total recreation value derived by the visitors of the Wipattu park could be derived by taking the total acreage of the park which is 45411 ha. The total value of the Wilpattu Park is therefore estimated to be Rs 11,352,790 per year.

The total value of the recreation of the KOB is therefore Rs 25,122,750 per year. However, this figure does not include any other minor recreational activities carried out by visitors near the major and minor tank systems and therefore an underestimation of the true value.

Implications for management include several issues. First, the present unplanned recreational activities could be mainstreamed by charging an entrance fee and by providing some basic facilities and guidelines on the allowable activities. The visitation to the park is presently very low and the advertising campaigns could improve the situation and the income situation could be improved, which gives a considerable source of income for the government. The third issue is that the mainstreaming of recreation along the major and minor tank systems. These places provide ideal eco tourism sites. However, in any development of the area, extreme care has to be taken in order to minimize the physical and social disturbance to the area.

Products from home garden biodiversity

Home gardens within the Kala Oya basin provide a production value to the inhabitants. Home Gardens are agroforestry based land-use systems where multipurpose trees and shrubs are found in close association with perennial or annual agricultural plants and animals near human dwellings (Helvetas, 2001). Home Gardens provide a wide range of products such as fruits, vegetables, spices, medicinal products, timber, fuel wood, fodder and livestock products.

Agricultural crops form the main part of the home garden biodiversity within the KOB. There are commercial crops such as tea, rubber coconut that are grown in areas where the land holding size is more than 40 perches and there are small home gardens which have more crop diversity where land size is less than 40 perches. Table 5 gives extents of main permanent crops (in acres) and their economic value in the lands where the holding size is more than 40 perches in the KOB.

Table 5: Extents of main permanent crops (in acres) and their economic value in the lands where the holding size is more than 40 perches in the KOB

Crop	Apura	Matale	Kurunegala	Puttlam	Total area (acres)	Total value[1] (/Ac/yr)	Unit value
Tea	0	77	0	0	77	8.691	669.207
Rubber	0	140	0	0	140	14.284	1.999.760
Coconut	7.033	8.283	13.703	2.105	31.124	21.710	675.702.040
Cashew	1.140	668	1.415	5.171	8.394	100.000	839.400.000
Total	8.173	9.168	15.118	7.276			1.517.771.007

(Source: Socio-Economic Profile of the Kala Oya Basin [1]Central Bank Annual Report, 2004

Table 6 provides information on permanent crops scattered in the lands where the holding size is less than 40 perches.

Table 6: Permanent crops scattered in the lands where the holding size is less than 40 perches in the Kala Oya basin

Crop	Anuradhapura	Matale	Kurunegala	Puttlam	Total	Unit value (/Ac/yr)	Total value
Coconut	39,595	21,536	15,583	2,318	79,032	800	63,225,600
King Coconut	6,055	2,326	1,382	255	10,018	280	2,805,040
Coffee	292	2,505	230	0	3,027	200	605,400
Pepper	224	9,542	515	0	10,281	1200	12,337,200
Cashew	5,714	3,608	3,954	802	14,078	5000	70,390,000
Cloves	145	131	86	0	362	500	181,000
Areca nut	2,299	2,911	623	0	5,833	315	1,837,395
Mango	14,331	7,582	3,915	450	26,278	250	6,569,500
Orange	10,137	3,745	2,471	440	16,793	500	8,396,500
Lime	12,377	4,806	4,379	358	21,920	200	4,384,000
Jak	10,903	6,610	2,747	218	20,448	600	12,268,800
Banana	27,792	14,325	9,888	1,914	53,919	300	16,175,700
Papaw	9,433	3,208	2,632	494	15,767	200	3,153,400
Breadfruit	14	121	0	0	135	500	67,500
Avacado	177		0	0	177	500	88,500
Total							202,485,535

Source: Socio-Economic Profile of the Kala Oya Basin

The economic value of permanent crops scattered in the lands where the holding size is less than 40 perches in the Kala Oya basin is therefore Rs 202,485,535. The high level performances of the home garden systems indicate the importance of these resources to the people and also the important role played by water in these areas. The major part of this income from the gardens is attributed to the water provided by the Kalaoya both indirectly or directly.

Values of wetland ecosystem services

Wetlands play a critical role in protecting water quality and moderating water quantity. Wetland habitats serve as home for many plants and animals and they improve water quality by breaking down, removing, using or retaining nutrients, organic waste and sediment carried to the wetland with runoff from the watershed. They provide food and other products - such as commercial fish and shellfish - for human use and provide food habitat, breeding grounds, and resting areas for wildlife.

The main water source in the KOB is the Kala Oya with major tributaries originating from Dambulla hills at an elevation of about 2000 ft above mean sea level. Kala Oya, its tributaries and the associated major and minor tank systems provide the main wetland system within the KOB. There are six major tanks/ reservoirs (irrigating more than 250 ha) built across Kala Oya and its tributaries. The minor tanks play a major role in the economic activities related to agriculture, domestic and livestock. The total number of minor tanks in different districts in the KOB is estimated as 266 (MASL, 2005). Table 7 presents the total water spread area in the KOB.

Table 7: Total water spread area in the Kala Oya basin.

Type of water body	Number	Extent (ha)
Major tanks (working)	6	5734.1
Minor tanks (working)	871	10025.6
Minor tanks (abandoned)	106	1129.2
Rivers	-	870.5
Total	**983**	**17759.4**

The economic value of water spread extent was calculated using the benefit transfer approach. Table below presents economic value per water spread Hectare of the minor tanks in the KOB estimated by IUCN study (2004) and the transferred values for the KOB.

Table 8: Economic value per hectare for various wetland services

Product	Economic Value per ha[1]	Total value[2]
Paddy	15916	374,037,280
Domestic Use	145454	3,418,180,750
Livestock	32593	765,944,900
Industrial use	1227	28,846,250
Fishery	34790	817,565,000
Lotus Flowers	7136	167,696,000
Lotus Roots	10590	248,886,150
Total		3,231,572,476

[1] - IUCN (2004);[2] - for total water spread area

Economic return from the direct uses of tanks is Rs 3.2 billion. This value represents the economic values of the above mentioned uses of tanks of the KOB. Implications include the importance of managing the water supply in order to sustain these economic values, which are vital in the rural economy.

Values of mangrove ecosystem

Economic value of the mangroves in the KOB was valued using the benefit transfer approach. Estimates of Costanza *et al.,* (1997) were used. Table 9 indicates the economic value of mangroves and the estimated values for mangroves for KOB. These values imply the importance of protecting this valuable mangrove resource in the KOB. In addition, an understanding on responses of these functions to environmental changes would guide us on the ability of these ecosystems to maintain functionality under a range of stress and shock conditions.

Table 9: Value of mangrove services

Value category	Unit Value (in US$)[1]	Total value (Rs million)[2]
Coastal protection	1839	55
Waste treatment	6696	201
Food production/ biological control	797	23
Recreation	658	19
Total		299

[1] Costanza *et al.,* 1997

[2] derived by multiplying the unit value by the total area of mangroves, 316 ha; 1 $ = Rs 95

Non use value provision of the KOB

Non use values are pure public goods provided by the natural ecosystems. Non use values are knowledge related values that a particular ecosystems exists and are available for future generations. Gunawardena, (1997) estimates total nonuse value of the Sinharaja forest as US$ 78 million. This is equivalent to per ha value of Rs 741000. If it is assumed that the moist monsoon area of the KOB is directly comparable to the Sinharaja forest, the non-use value of moist monsoon part of the KOB is equivalent to Rs 253 million.

This implies a very significant economic value. It is the duty of the KOB management that development of suitable strategies in order to appropriate these values through various mechanisms including economic instruments.

Discussion

Implications for water management

According to the above analysis, there is considerable economic value in the Kala Oya basin. There is no doubt that majority of these values are attributable to the water in the Kala Oya.

Table 10 summarizes the economic values, key issues related to each resource and the implications for river basin management. The annual total value emanating from the KOB is Rs million 23,500. The highest economic value (77%) was resulted from the carbon values. Therefore, more attention needs to be paid on developing mechanisms that could realize such benefits and also to prevent the stock depletions. It is important that any conservation programmes that focus on preservation of the terrestrial ecosystems should look into the justifications provided by such values.

Table 10: Summary of economic values, Issues, Responsibilities and Implications for basin management

Ecosystem service	Annual Economic values (Rs million) Percentage in parenthesis	Key issues	Responsibilities/ Institution/s	Implications for River basin management
Carbon storage value of natural vegetation	18.172(76.5)	Stock depletions from illegal extractions and planned	Forest Department Global affairs division of Ministry or Environment	Incentives for conservation Development or carbon appropriation mechanisms
Soil conservation benefit of the moist monsoon forest of the KOB	51(0.1)	Erosion due to illegal activities could reduce the level of benefit and downstream impacts	Forest Department Central Environmental Authority	Up and down stream user conflicts due to water quality deterioration (fishery depletion. loss of recreational values)
Recreation along the river bank	13 (0.1)	Possible degradation of the banks Equity issues	Forest Department	Charging user fees
Recreation value of the Wilpattu National Park	11 (0.05)	Visitor management	Department of Wildlife conservation	Incorporating values into entrance fees
Products from homegarden biodiversity	1720(7.2)	Use of fertilizer that reduce water quality	Households Central Environmental Authority	Correction of government failures (fertilizer subsidies) or more regulated use
Values of wetland ecosystem	3.231 (13.6)	Siltation of tanks due to degradation of catchments	Irrigation department Forest Department	Development of property right mechanisms Water allocations

Value of mangroves	299(1.3)	Stock depletion due to shrimp farming	Forest department Coast conservation Department	Mechanisms for sustainable utilization of products and services
Non use values of moist monsoon forests	253(1.1)	Stock depletions from illegal extractions and planned conversions	Forest Department	Incentives for conservation Development of nonuse value appropriation mechanisms
Total	23.500			

The estimated value represents 1.16% of GDP (of 2004) of the country and 7.33% of the agricultural sector GDP which highlights the significance of the potential economic gains of the basin.

How the estimated economic values could provide guidelines for basin management is one area that needs immediate attention. The question arises whether we need to prioritize the monitoring or conservation according to economic values or whether allocation of water to be done according to economic values? The results of the present analysis would not suffice to provide a complete answer immediately. More detailed analysis which includes some hydro-economic modeling is needed to determine the optimum quantity and quality of water needed by one user group and what is available for the next group and matching those availabilities with the requirements.

Equity of resource use is another aspect that needs more detailed attention. Income differences of different user groups and essentiality of some of the usages pose additional dimensions for the management of the river basin. For example, urban affluent recreationists affect the water quality in the lower basin area affecting the drinking water quality for the poor downstream users. Agrowells constructed by the large scale farmers might reduce the water availability for the small scale farmers and other users.

For management of water and other natural resources, a large number of institutions exist in Sri Lanka which function at national, provincial, district, divisional and community levels as mentioned in section 2.1. Therefore getting consensus on any one management issue would be a rather difficult issue which involve more than 10 government institutions, 3 regional numerous sub institutions operating at the Kala Oya basin.

Methodological issues

The river basin is essentially represents conflicting user groups who have wide range of user patterns for the resources of the basin. The reduction of water quality in the upper reaches will diminish the quality of the recreational experiences and fishing income in the lower reaches of the river. Such factors that could affect the derived values however were not considered in the analysis. The estimated values also could have overlaps and double counting for which explicit treatments were not attempted.

There are other values that were not estimated in the present study which includes, non timber forest product value of the different forest types, productive use values (due to unavailability of the data in relation to production improvements out of the biodiversity resources), and many other functional values such as pollination functions, watershed protection value etc. Some stream flow values such as natural water directly consumed or used by households for direct consumption was also not valued.

Conclusions and policy implications

Economic values of ecosystem services leads to implications for policy from several dimensions. Estimated economic values provide clear economic justification for allocation priorities. However, within a river basin, allocation is a complex phenomenon which includes many concepts other than mere water quantity concerns. Water quality, seasonality, different types of water and the rapidity of transfer of water among different compartments need consideration before any allocation decision. The complex interactions within the river basin that ensures provision of ecosystem services provides further dimension for the policy. In addition, equity and physical sustainability of the system requires additional considerations. The study emphasizes the need for more complex models that integrate economics, physical flows and equity aspects that ensures long term sustenance of the service provision of the river basin.

Appropriation of missing values

Global environmental markets are one way of creating global missing markets. There are both regulation induced and spontaneous markets and resource franchise agreements (Pearce, 1995). Creating markets for global resources requires two stage procedure of demonstrating the economic value and capturing such values through mutually profitable trades.

Institutional mechanisms

A very important way to improve water management is provision of appropriate institutional mechanisms. For example, property rights to land and water, and access to affordable credit (Ellis, 1992, 1993; Heltberg, 2002) and public sector investments in agricultural research, teaching, and extension programs providing farmers with information required to evaluate and adopt appropriate improvements (Fujihara and Kikuchi, 2005).

Future challenges

It is also important to understand the impacts of global change on ecological, economic, and social elements of river ecosystems and the development of management approaches to mitigate such effects. Global change impacts include changes in temperature, rainfall, river discharge, wetland loss, salinity and sea level rise.

Consensus among stakeholders

Since it is very unlikely any water management policy could maximize the satisfaction of all interested stakeholders and therefore, it is necessary to get involvement of all interested stakeholders with agreement on the tradeoffs that must be made. It can and should adapt over time to changing interests and scientific knowledge (Holling, 1978; McLain and Lee, 1996).

References

Balmford, A., Bruner, A., Cooper, P., Costanza, R., Farber, S., Green, R.E., Jenkins, M., Jefferiss, P., Jessamy, V., Madden, J., Munro, K., Myers, N., Naeem, S., Paavola, J., Rayment, M., Rosendo, S., Roughgarden, J., Trumper, K., Turner, R.K., 2002. Economic reasons for conserving wild nature. Science 297, 950-953.

Booker, J.F., Michelsen, A.M., Ward, F.A., 2005. Economic impact of alternative policy responses to prolonged and severe drought in the Rio Grande Basin. Water Resources Research 41

Brouwera, R, Marjan Hofkesa, Vincent Linderhofa (2008) General equilibrium modelling of the direct and indirect economic impacts of water quality improvements in the Netherlands at national and river basin scale, Ecological Economics 66 (2008) 127 - 140

Cai, X (2007). Implementation of holistic water resources-economic optimization models for river basin management e Reflective experiences, Environmental Modelling & software (2007) 1-17

Cai, X., McKinney, D., Lasdon, L., 2003a. An integrated hydrologic agronomic economic model for river basin management. Journal of Water Resources Planning and Management 129(1), 417

Cai, X., McKinney, D.C., Lasdon, L., 2002. A framework for sustainability analysis in water resources management and application to the Syr Darya Basin. Water Resources Research 38 (6).

Cai, X., Rosegrant, M., Mckinney, D., 2003b. Sustainability analysis for irrigation water management in the Aral Sea region. Agricultural Systems 76, 104-1066.

Central Bank of Sri Lanka (2004) Annual Report

CORDIO (1999) Coral reef degradation in the Indian Ocean , SAREC Marine Science Program, Sweden.

Costanza R, d'Arge R, deGroot R, Farber S, Grasso M, Hannon B, Limburg K, Naeem S, O'Neill R, Paruelo J, Raskin R, Sutton P, Vander Belt M(1997) The value of the world's ecosystem services and natural capital. Nature 387:253-260
Daily, G.C., Soderquist, T., Aniyar, S., Arrow, K., Dasgupta, P., Ehrlich, P.R., Folke, C, Jannson, A., Jansson, B.O., Kautsky, N., Levin, S., Lubchenco, J., Maler, K.-G., David, S., Starrett, D., Tilman, D., Walker, B., 2000. The value of nature and the nature of value. Science 289, 395-396.

De Groot, R.S. (1992) Functions of Nature, Wolters-Noordhoff
Millènnium Ecosystem Assessment (2005) Ecosystems & Human Wellbeing: Synthesis
Report, Island Press,

De Groot, R.S.,Wilson, M.A., Boumans, R.M., 2002. A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecological Economics 41, 393-408.

Farber, S.C., Costanza, R., Wilson, M.A., 2002. Economic and ecological concepts for valuing ecosystem services. Ecol. Econ. 41 (3), 375-392.

Frank G.W. Jaspers (2003) Institutional arrangements for integrated river basin management, Water Policy 5 (2003) 77-90

Fujihara M and Takao Kikuchi (2005) Changes in the landscape structure of the Nagara River Basin, central Japan, Landscape and Urban Planning 70, 271-281

Gunawardena U. A. D. P (1997) Economic evaluation of conservation benefits: A case study of Sinharaja Rain Forest Reserve in Sri Lanka", Unpublished PhD Dissertation submitted to University of Edinburgh, U.K.

Hatchett, S., Ruun, N., Burke, S., 2006. Economically driven simulation of regional water systems: Friant-Kern, California. Journal of Water Resources Planning and Management 132 (6), 468-479.

Hemasiri Kotagama, 1998. Estimates of Environmental Unit Values in Sri Lanka Applicable to Extended Benefit Cost Analysis of Investment Projects, The Post Graduate Institute of Agriculture University of Peradeniya

Holling, C. S., ed. (1978) Adaptive Environmental Assessment and Management, John Wiley & Sons

INFOTECHS - Socio Economic Profile of the Kala Oya Basin (Final Report) INFOTECHS, Colombo, February 2004

IUCN (2004) Integrating wetland economic values into river basin management: Sri Lanka component, draft report prepared by the IUCN Sri Lanka country office. Jenkins, M.W., Lund, J.R., Howitt, R.E., Draper, A.J., Msangi, S.M., Tanaka, S.K., Ritzema, R.S., Marques, G.F., 2004. Optimization of California's water system: results and insights. Journal of Water Resources Planning and Management 130 (4), 271e280.

Kotagama H (1998) Estimates of environmental unit values in Sri Lanka applicable to extended benefit cost analysis of investment project

Laconte and Haimes, 1992 Laconte, P. and Haimes, Y. Y., eds. (1992) Water Resources and Land-Use Planning: A Systems Approach. Martinus Nijhoff, The Hague.

Letcher, R.A., Jakeman, A.J., 2003. Application of an adaptive method for integrated assessment of water allocation issues in the Namoi River Catchment, Australia. Integrated Assessment 4 (2), 73-89.

Letcher, R.A., Croke, B.F.W., Jakeman, A.J., 2007. Integrated assessment modelling for water resource allocation and management: a generalised conceptual framework, Environmental Modelling & Software 22 (5), 733-742.

Lund, J., Cai, X., Characklis, G., 2006. Economic engineering of environmental and water resource systems (editorial). Journal of Water Resources

Lundqvist, J., Tortajada, C, Varis, O., Biswas, A., 2005. Water management in megacities. Ambio 34 (3), 267-268.

Mahaweli Authority of Sri Lanka (2005) Kala Oya River Basin: Survey of Biodiversity, Wetland Issues and Options for Sustainable Management, unpublished report prepared by Environment & Management Lanka (Pvt) Ltd

Marques, G.F., Lund, J.R., Leu, M.R., Jenkins, M.W., Howitt, R.E., Harter, T., McCarl, B.A., Dillon, C.R., Keplinger, K.O., Williams, R.L., 1999. Limiting pumping from the Edwards Aquifer: an economic investigation of proposals, water markets, and spring flow guarantees. Water Resources Research 35 (4), 1257-1268.

McKinney, CD., Cai, X., Rosegrant, M., Ringler, C, Scott, C.A., 1999. Integrated Basin-Scale Water Resources Management Modeling: Review and Future Directions. SWIM Research Paper No. 6. International Water Management Institute, Colombo, Sri Lanka.

Ohman M C (1999) Coral reef bleaching effects on reef fish communities and fisheries in Coral reef degradation in the Indian Ocean , SAREC Marine Science Program, Sweden.

Pearce D W (1995) Blue print 4: Capturing the global value, Earthscan Publishers UK

Subasinghe S A G L and Gunawardena U. A. D. P. (2003) Economic value of the soil conservation benefits of Sinharaja Rain Forest, Proceedings of the 59th Annual Sessions of the Sri Lanka Association for the Advancement of Science

Tanaka, S.K., Ritzema, R.S., Marques, G.F., 2004. Optimization of California's water system: results and insights. Journal of Water Resources Planning and Management 130 (4), 271-280.

Turner, R., Jones, T., (Eds.), 1991. Wetlands: market and intervention failures. Earthscan, London.

Warda Frank A and Pulido-Velazquezb (2008) Efficiency, equity, and sustainability in a water quantity-quality optimization model in the Rio Grande basin Ecological Economics 66 (2008) 23-37