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Contents

Abstract

The aim of this paper is to apply a simple approach for valuing wetlands at a river basin scale. The approach used takes into account the common problem of limited data availability and allows a rapid assessment of wetland values. For each wetland an inventory of production and information functions is made. The wetland value derived from each function is estimated based on market prices. The approach has been applied to the wetlands of the Zambezi basin in Southern Africa, a typical example of a situation with limited availability of data. The results show that flood recession agriculture is the main contributor to the total economic value of wetlands in the Zambezi basin. The current study has been limited to the quantification of use values, so that the results should be interpreted as a conservative estimate of the total value of the wetlands.

1. Introduction

Wetlands are often associated with people who survive by subsistence utilisation of the services and outputs of wetlands. But wetlands are also important for remote populations because they contribute to larger scale benefits such as climate regulation. In spite of their obvious importance, wetlands have been vulnerable to increasing pressure of economic and population growth. Loss of wetlands by converting them into intensive agricultural areas or urban areas received little attention in the past for many reasons.

Wetlands have been poorly valued, and hence their loss was perceived as a minor cost compared to the expected benefits from wetland development projects. In most cases, any use would seem to have a greater value than the use to which wetlands are put. Therefore wetlands have been viewed as wastelands that can be sacrificed for the sake of increasing social welfare. A second reason for wetland loss is the fact that even when individuals are aware of the conservation values of their wetlands, they prefer to drain their lands for intensive cultivation instead of leaving them in their natural state. This attitude of individuals towards their wetlands and conservation values follows from the lack of financial incentives for preservation (Dugan, 1992). At the national level, the inconsistencies of governmental policies regarding wetland development and conservation have contributed to wetland loss in many regions. Explicit commitment of policies to wetland conservation are often counteracted by measures, such as the provision of soft loans for major wetland development projects or such as maintaining high crop prices by means of subsidies.

It is clear that the pressure for wetland development is fuelled by overwhelming economic arguments and this pressure will continue. Therefore, Hunter (1992) argues that developing non-economic criteria for conservation appears to be compelling and economic criteria will be more convincing. It follows that decision-makers should be able to have insights into the diverse wetland values in explicit forms. In current practices, the true values of wetlands are far from being easily quantified and incorporated in development studies. The challenge for the scientific community is to devise methods for proper valuation of the multiple services and outputs performed by wetlands.

The aim of this paper is to apply a simple and rapid approach for valuing wetlands under limited availability of data. Wetlands of the Zambezi basin are chosen for this application. It is not meant however to conduct an exhaustive valuation of all wetland functions or all the Zambezi wetlands. The structure of the paper is as follows. The next section provides a theoretical background for wetland valuation. The third section describes the valuation approach proposed in this paper. The fourth section is the application to the wetlands of the Zambezi basin. The results and a concluding discussion are finally presented in the last section.

2. Wetland functions and values

An environmental function is defined as the capacity of natural processes and components to provide goods and services that satisfy human needs (De Groot, 1992). Wetlands fulfil a diverse number of functions that result from the interaction between the structural component (soil, flora, and fauna) and the physical, chemical, and biological processes. Many of wetland functions are interdependent because one single process influences more than one function. This basic understanding implies that the continuity of a single function is not separable from other functions; it depends on the maintenance of the integrity of the entire system (De Groot, 1992).

Different frameworks for valuing wetlands are described in literature. Roggeri (1995) for example distinguishes wetland resources, wetland attributes and physical/hydrological functions. Wetland resources include agricultural resources, fisheries, forest resources, forage, natural products, wildlife resources, water, energy, transport, tourism and research and education. Wetland attributes refer to biodiversity, uniqueness, naturalness and cultural heritage. Physical and hydrological functions include nutrient retention and recycling, groundwater recharge, flood control, sediment retention, erosion control, water treatment, climate stabilisation, ecosystem stability and stabilisation of other ecosystems. None of the distinguished categories is exclusive and no one benefit is exclusive to one category.

De Groot (1992) presented an alternative classification of wetland functions, in which four categories are distinguished: production functions, information functions, regulation functions and carrier functions. Although this classification is rather clear, it does not imply that the total value of a wetland is simply the sum of the values of all functions listed under each category, because some functions are pre-conditional to other functions.

Interdependency exists also between wetlands. One dimension of such interdependency is the upstream-downstream effect in a river basin context. For example, the nursery function for fish may be performed by a certain wetland while the fish are harvested in a downstream wetland. Such connectivity between wetlands maintains the integrity of ecosystems at large spatial scales.

3. A rapid valuation approach

The classification of wetland functions presented by De Groot (1992) is used as the starting point for the development of the valuation approach. Wetland functions such as physical and hydrological functions are pre-conditional to other functions. In general, regulation and habitat functions are pre-conditional to production and information functions. Therefore, one can assume that there is no need to value regulation and habitat functions as far as their value can be captured in the values derived from production and information functions. This assumption holds for assessing the use values of wetlands that accrue to the population within the ecosystem. At a higher spatial level, regulation and habitat functions may contribute to values generated in areas distant from the wetland itself, and hence, their value is not captured by the products and services delivered within the wetland.

The valuation approach consists of three steps. Firstly, the main freshwater wetlands are identified. This includes the size of the wetland, its status regarding protection and conservation and the main utilisation of the wetland as reported in literature. Secondly, marginal values of the wetland products and services are estimated based on market prices. For each product or service, the marginal value is calculated in terms of monetary units per unit of area. In cases where the good or service is not traded, market surrogate methods are used. As market data are not available for all sites, marginal values known for one site are transferred to other sites that have no data. Finally, the use value derived from a certain production or information function is calculated as the product of the marginal value of the function and the area of the wetland that contributes to the function. The assumption here is that there is a linear relationship between the area of wetland that contributes to a certain function and the use value delivered by that function. This might be an approximation of a rather complex relationship, however, its validity varies for different wetland functions. The total economic use value of a wetland may be expressed as follows:

$$TEV = \sum_{i=1}^{n} MV_i \times A_i \qquad (1)$$

Where i denotes the wetland function,

TEV: total economic use value (USD/year),

MV: marginal value of a product or a service derived from a wetland function (USD/ha/year),

A: area of the wetland that contributes to the wetland function under consideration (ha).

4. Application to the Zambezi wetlands

4.1. Main wetlands in the basin

Several wetland types exist in the Zambezi basin. The largest by area is the riverine type, which includes all floodplains of the Zambezi; e.g., the Barotse, Kafue and Luangua floodplains. Dambos form another type of wetlands and can be found throughout the basin. Fringe wetlands also exist and include mainly the wetlands of Kariba, Cahora-Bassa and Itzhi-Tezhi. Most subsistence utilisation of wetlands in the Zambezi is associated with the riverine type. Therefore, the valuation is limited to this type of wetlands. Table 1 lists the major riverine wetlands of the Zambezi, which are considered in the valuation here.

Table 1. Major freshwater wetlands in the Zambezi basin.

Wetland	Area (1000 ha)	Utilisation	Conservation status
Kafue flats	650	Fishery, grazing, wildlife, limited agriculture	Partly protected
Lukanga	250	Fishery, grazing, transport.	Unprotected.
Barotse plain	900	Fishery, grazing, wildlife, limited agriculture	Partly protected
Liuwa plain	350	*	*
Linyanti-Chobe	20	Fishery, tourism, area in general not utilised by local population	Almost all the wetland is protected.
Cuando	200	*	*
Elephant marsh	52	Fishery, grazing, agriculture	Unprotected.
Luangwa	250	*	Partly protected.
Busanga	200	Unexploited wildlife refuge.	Completely protected.
Luena	110	*	*

Source: Hughes and Hughes (1992) and Davies (1986).
* = No data available.

The use value of the wetlands listed above is estimated in the next sections. Most of the data available on production and market prices are for 1990; therefore the valuation is carried out for that particular year.

4.2. Marginal values

The most frequently reported products and services of wetlands in the basin include floodplain recession agriculture, fish production, wildlife resources, cattle grazing, eco-tourism, biodiversity, natural products and medicine. The following explains how marginal values of these wetland products and services are estimated.

Floodplain recession agriculture: The marginal value of products from floodplain subsistence agriculture is estimated based on the average production value of both rice and maize, which represent the main crops in terms of area cropped. According to SARDC *et al*. (1994) and Mbewe (1992), the yields of rice and maize in Zambia are about 3500 and 600 kg/ha if grown under residue moisture and the prices for 1990 are 4 and 3 ZK/kg respectively. Using the exchange rate of 1990 (37 ZK = 1 USD), the average production value of both crops is estimated at 214 USD/ha/year. Since producing these products involves the employment of resources other than wetland resources, only a fraction of the production value can be attributed to the wetland. This fraction is roughly estimated at 60 percent.

Fish production: Data on fish catch and fish prices for Kafue flats and Lukanga swamps are used here to assess the production value of fisheries. Kasimona and Makwaya (1995) report that for the period from 1971 to 1982 fish catch was 11,200 tonne/year from Kafue wetland and 1300 tonne/year from Lukanga swamps. Assuming that 40 percent of the wetland area contributes to fish production, fish productivity is calculated as 43 kg/ha/year for Kafue wetlands and 13 kg/ha/year for Lukanga. For the total area of the two wetlands the average fish productivity is 35 kg/ha/year. The producer value of fish catch as reported by Masundire and Matiza (1995) for that period was about 1830 USD/tonne. Thus, the value of fish catch per unit area is calculated as 64 USD/ha/year. Of this production value, 80 percent is attributed to wetlands.

Wildlife services and goods: The example of Kafue flats as a source for earnings from wildlife utilisation is used here. Sources of earnings related to wildlife include hunting rights and licenses fees, cropping revenues and donations, which can be interpreted as a proxy for the willingness to pay for preserving wildlife. SARDC *et al*. (1994) estimate that in 1990, the total earnings from wildlife utilisation in a protected area of 517,500 ha in Kafue flats was at least 62,500 USD/year, which means earnings of 0.12 USD/ha/year.

Livestock grazing: According to Bingham (1982), the cattle population depending on dry season grazing on the Kafue flats exceeded 250,000 in 1982. With a market price of 80 USD/head and assuming that the cattle are on average 5 years old the market value of the cattle is 4 million USD/year. Because other resources are required for livestock production, it is assumed that 60 percent of the production value can be attributed to wetlands. It is also assumed that 40 percent of the wetland area is used for cattle crazing, unless it is protected. It follows that the marginal value of the wetland derived from cattle grazing is about 9.2 USD/ha/year.

Eco-tourism: Here the example of the CAMPFIRE project in Zimbabwe is used, where the total area of national parks is estimated at 9.76 million ha. It generated total revenue in 1990 of approximately 6.4 million USD/year (SARDC *et al*, 1994). It follows that the marginal value of wetland eco-tourism is about 0.66 USD/ha.

Biodiversity: In order to assess the value of biodiversity, the protected areas of Kafue flats and Banguelu are used as an example. These areas amounting to about 1.17 million ha were exchanged for a debt of 2.27 million USD under the “debt for nature exchange programme” (SARDC *et al*., 1994). Using a discount rate of 5 percent and a time horizon of 50 years, an annuity of the debt of about 124,000 USD/year is calculated, which means each protected hectare has a marginal value of 0.11 USD/year.

Natural products and medicine: Due to the lack of any data on the utilisation of wetland natural resources and medicine products, data from Tanzania are used here. According to SARDC *et al*. (1994), the total area of wetlands in Tanzania is 1,828,000 ha and it generates a gross income from wild resources of 120 million USD/year, which is about 65.6 USD/ha/year.

4.3. Total economic use value of Zambezi wetlands

The marginal values estimated in the previous section are assumed to be applicable for the Zambezi wetlands listed in Table 1. This implies that all wetlands are similar in their functions and similarity exists as well for markets and prices. The total use value is calculated using Equation 1 which give the results presented in Table 2. In assessing the wetland area that contributes to a certain production activity the following assumptions have been made:

1. 10 percent of a wetland area is used for floodplain recession agriculture (SARDC *et al*., 1994) unless the wetland is completely protected.
2. About 40 percent of wetland area contribute to fish production unless the wetland is protected.
3. For biodiversity and wildlife services and products the wetland conservation status is used to assess the fraction of the total wetland area that is contributing to these functions. The areal contribution fraction is assumed 90 percent for fully protected wetlands, 10 percent for partly protected and zero for not protected wetlands.
4. Wetland area used for grazing is assumed to be 40 percent of the total area unless the wetland is protected.
5. 30 percent of wetland area is assumed to have a contribution to eco-tourism.
6. 10 percent of the wetland area is assumed to contribute to the production of natural products and medical resources.

Table 2. Total use values of the Zambezi wetlands.

Wetland service or product		(1)	(2)	(3)	(4)	(5)	(6)	(7)	Total use value of the wetland
Marginal value (USD/ha/year)		128	51	0.12	9	0.66	0.11	66	
Area contribution to the service %		10%	40%	*	40%	30%	*	10%	
wetland	Area (10^3 ha)	Total use value of the wetland service or product (10^6 USD/year)							10^6 USD/year
Barotse plain	900	11.6	18.4	0.01	3.3	0.178	0.010	5.90	39
Kafue	650	8.3	13.3	0.01	2.4	0.129	0.007	4.26	29
Liuwa plain	350	4.5	7.2	0.00	1.3	0.069	0.004	2.30	15
Luangwa	250	3.2	5.1	0.00	0.9	0.050	0.003	1.64	11
Lukanga	250	3.2	5.1	0.00	0.9	0.050	0.000	1.64	11
Cuando	200	2.6	4.1	0.00	0.7	0.040	0.002	1.31	9
Busanga	200	0.0	0.0	0.02	0.0	0.040	0.020	1.31	1
Luena	110	1.4	2.3	0.00	0.4	0.022	0.001	0.72	5
Elephant marsh	52	0.7	1.1	0.00	0.2	0.010	0.000	0.34	2
Linyanti-chobe	20	0.3	0.4	0.00	0.1	0.004	0.002	0.13	1
Total	2982	36	57	0.05	10	0.60	0.05	20	123

(1): Floodplain recession agriculture.

(2): Fish production.

(3): Wildlife services and goods.

(4): Livestock grazing.

(5): Eco-tourism.

(6): Biodiversity.

(7): Natural products and medicine.

* Fraction of area protected is determined in light of Table 1 where completely protected wetlands are assigned a fraction of 90%, partly protected areas 10% and not protected areas are assigned a fraction of 0%.

5. Discussion and conclusions

The results show that fish production, floodplain recession agriculture, natural products and livestock grazing account for the main share in the total use value of the Zambezi wetlands. The wetlands of Kafue and Barotse account for about 55 percent of the total use value of the Zambezi wetlands. Obviously the valuation is not exhaustive, and hence the results represent a conservative estimate of the total use value. Yet it is interesting to note that the total use value of the 10 wetlands (123 million USD/year) is equivalent to some 4 percent of Zambia's GDP in 1990 which was 3120 million USD (World Bank, 1992).

Most if not all the marginal values are low, which reflects the fact that subsistence utilisation of wetland products and services is often associated with low efficiency. The data used in this study to assess the marginal values of wetland products show that there is a high potential for increasing wetland productivity and hence enhancing the total use value. Wildlife, for example, is associated with costs of managing parks, which are not at present offset by revenues from wildlife services.

It is important to notice that this valuation study was not exhaustive. The full value of wetlands in the Zambezi basin might be far beyond the calculated value of 123 million USD/year for three reasons. The first reason for that disparity is the fact that important values were not included in the valuation. Among the use-values that were not included are the values generated from forest resources, water supply, transport, and flood control. The conservation value of protected areas and non-use values were not included as well. The second reason is that for those products and services valued, market prices were used. That may underestimate the real value of wetland products and services due to possible distortion of market prices. Thirdly, only the major well-known and studied wetlands of the Zambezi were considered. Certainly there are other wetlands which are valuable such as Dambos.

The valuation approach and the illustrative application to the Zambezi wetlands show that some insight into wetland values can be obtained with little data. Although huge uncertainties surround the resulting values, the results still can be useful in the sense that they at least serve as a bottom line estimate and they represent a first effort that can be expanded. One strong point of the valuation approach is that, though it is not exhaustive, it prevents double counting.

Further research is required to integrate wetland valuation by considering a larger system within which wetland functions and their values interact. This would help in understanding the effects of upstream-downstream dependencies between wetlands, wetland values and wetland users. In addition, the dynamics of the natural system need to be incorporated in the valuation approach so that the effects of changes in the natural system on the wetland values can be assessed.

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