CAPTURING THE HIDDEN VALUES OF WETLAND ECOSYSTEMS AS A MECHANISM FOR FINANCING THE WISE USE OF WETLANDS

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Overview. *Article 14 of the Biodiversity Convention requires each contracting party to "introduce appropriate procedures requiring environmental impact assessment of its proposed projects that are likely to have significant adverse impacts on biological diversity" and to identify processes and categories of activities that are or are likely to have significant adverse impacts on the conservation and sustainable use of biological diversity. The Convention further identifies in Article 11 the need for incentive measures as a specific mechanism to help guide national level actions and to promote conservation and sustainable use of resources, as expressed in the convention. The underlying causes of biodiversity loss in wetland ecosystems generally stem from habitat alterations, introduction of invasive species, over-exploitation or pollution and land conversion. The stress caused by these factors may have cumulative or discrete impacts on habitats, resulting in possible biodiversity loss and resource depletion causing social and cultural transformations such as loss of traditional production systems, changes in migration routes and displacement of populations.*

This paper focuses on the use of economic valuation as an incentive for wetland conservation. The environment's services are valuable but these values are a) seldom recognised and quantified and b) are often lost through inappropriate development or used inefficiently. Linkages between use values and ecosystem functions will be stressed in this discussion. The paper emphasizes that appropriate incentives can only be developed once the values derived from these ecosystems are recognized. The role of the public and private sectors in initiating valuation studies is discussed.

Key words: Economic valuation, wetland conservation, ecosystem services

1. Introduction

Wetland ecosystems are associated with a diverse and complex array of direct and indirect uses. Direct uses include the use of the wetland for water supply and harvesting of wetland products such as fish and plant resources, while indirect benefits are derived from environmental functions such as flood water retention, groundwater recharge/discharge, nutrient abatement, etc., depending on the type of wetland, soil and water characteristics and associated biotic influences.

The assignment of monetary values to environmental resources, particularly in order to capture non-use values, invokes moral and ethical arguments. It is important therefore to define what is meant by economic valuation. Economic values are determined by an individual's *own* perception of well being. An economic value is therefore not the same thing as the value of an ecosystem and its services. It is simply *a measure of what individuals perceive to be the worth or usefulness of the good or service being valued* (Freeman, 1993; Bockstael *et al*., 1998). By measuring the economic value of an ecosystem service we therefore measure the contribution it makes in maintaining the present level of human well being.

In general, the direct use of marketed products of ecosystems is easier to measure since marketed products exist and their prices may be adjusted for distortions. In contrast, ecological functions, such as groundwater recharge or discharge, may have indirect use values, which are reflected in the economic activities these functions support. Usually, we measure changes in well being, or *social welfare*, to define and quantify economic value. Therefore, valuing a good or service requires us to study the change in a person's welfare due to a change in the availability of the resource. The theoretically preferred measure of welfare change is the area under the demand curve, measuring the change in combined consumer and producer surplus. This area is bounded by the demand curve for the service and the old and new supply curves. The identification of demand for an environmental good is necessary in order not to overestimate the benefits of an environmental improvement and, as noted by Freeman (1991), the impacts of market conditions and regulatory policies are also important. Economic value expressed in currency units is then, the monetary expression of the trade-off between alternatives, such as having a lower or higher quantity of the resource. Determining the economic value of a resource in terms of how a change in the resource may affect human welfare therefore helps inform policy decisions aimed at maximizing welfare and minimizing costs to society.

However, prior to attempting a valuation of an environmental resource, two essential pieces of information must be elicited. These are: 1) identification of the physical or environmental linkages which result in and maintain the particular ecosystem function or service we are interested in and 2) identification of the economic linkages which help realise the value of these hidden hydrological services. Since the economic value of a change in the level or quality of the resource is defined by the amount of compensation an individual would require in order to be as well off as prior to the change, identifying the level of demand for a resource or an ecosystem function is necessary in order not to overestimate the benefits of an environmental improvement.

2. A Case Study of Valuation in Northern Nigeria

This section provides as example of how direct and indirect values of a wetland system may be derived and used within a cost-benefit framework to better inform policies.

The basin of the Komadugu-Yobe River covers an area of 84,138 km^2 in North-eastern Nigeria. The rivers Hadejia and Kano, arising in Kano state, and the Jama'are river arising in Plateau and Bauchi states, drain into the Yobe, and flow into Lake Chad. The portion of the floodplain where the Hadejia and Jama'are rivers meet is known as the Hadejia-Jama'are wetlands while the area of floodplain lying between the towns of Hadejia and Gashua and South of Nguru, is widely referred to as the Hadejia-Nguru wetlands (see figure 1). The semi-arid zone of West Africa is subject to strongly seasonal patterns of rainfall and river flow. Most of the annual rainfall in Northern Nigeria occurs in just 3-4 months, between June and September. During this season, the rivers flood, providing support for a large number of varied activities, dependent on the floodplain and admirably adapted to the seasonal fluctuations within the area. The rivers that maintain this floodplain are affected by a number of dam and reservoir projects, some built and some proposed (Table 1) . Dam construction and the withdrawal of water for irrigation and industrial uses can cause changes in water volumes velocities and general hydrological circulation and flow patterns.

The harsh and variable natural conditions that naturally prevail in this region can be exacerbated by inappropriate changes in water regimes induced by water resource development schemes. By minimising water flow within floodplains, by-pass canals and dams essentially reduce flooding in downstream areas, resulting in ecological and economic changes in these areas. Biological diversity associated with flooding patterns, groundwater reservoirs and agricultural production can be adversely affected by these changes. Adams (1985) notes that the Bakalori Dam in northwest Nigeria reduced flood extent and depth by over 50% in parts of the downstream floodplain of the Sokoto River. As a result, in areas below Bakalori Dam, agricultural production patterns have been affected, as have fish catches.

Water diverted to upstream areas as a result of development projects on rivers do however benefit upstream areas, albeit at a cost to downstream areas. Water resource development projects are often designed to meet increasing demands for drinking water, electricity, and other urban requirements. However, in order to use the water resource efficiently, schemes that influence water allocation decisions for upstream and downstream uses must be based on a careful assessment of relative benefits of water used within the entire river basin. Failing this, changes in flooding patterns in downstream areas may result in the loss of flood dependent resources, causing large welfare losses for a significant section of the society.

A partial valuation of the Hadejia-Nguru wetlands in terms of agricultural production, fisheries and forestry was carried out by Barbier, Adams and Kimmage (1993). It has also been demonstrated that the recharge of groundwater resources is maintained by regular flooding of the wetlands (Thompson and Goes, 1997) and that changes in the recharge function would result in welfare losses for wetland populations (Acharya, 1998a). The dependency of wetland populations on the wild, uncultivated resources found within the wetlands has also been investigated by a recent study (Eaton and Sarch, 1997). These resources are an important source of materials, food and income. The wetlands are, in addition, a valuable site for wildlife conservation and, in particular, for waterfowl. The wetlands support over 60 water bird species from 15 families (Hollis *et al.*, 1993) and are considered to be of international importance as habitats for waterfowl populations. Table 2 summarises the available key floodplain resources and their main use within the wetlands.

TABLE 1 DEVELOPMENT SCENARIOS

Scenario (Time Period)	Dams	Regulated Releases ($10^6 m^3$)	Irrigation Schemes
1 (1974-1985)	Tiga	Naturalised Wudil flow (1974-1985)	No KRIP-I
1a (1974-1990)	Tiga	Naturalised Wudil flow (1974-1990)	No KRIP-I
A (1964-1985)	Tiga	None	KRIP-I at 27 000 ha
B (1964-1985)	Tiga	400 in August for sustaining floodplain	KRIP-I at 14 000 ha
C (1964-1985)	Tiga Challawa Gorge Small dams on Hadejia tributaries	None 348 yr^{-1} * for downstream users	KRIP-I at 27 000 ha
D (1964-1985)	Tiga Challawa Gorge Small dams on Hadejia tributaries Kafin Zaki HVP	None 348 yr^{-1} * for HVP None None	KRIP-I at 27 000 ha 84 000 ha 12 500 ha
E (1964-1985)	Tiga Challawa Gorge Small dams on Hadejia tributaries Kafin Zaki HVP	350 in August 248 yr^{-1} * and 100 in July 100 per month: Oct-Mar and 550 in August Barrage open in August	KRIP-I at 14 000 ha None 8 000 ha

Notes: * Distributed based on Haskoning, 1977
KRIP-I = Kano River Irrigation Project Phase I
HVP = Hadejia Valley Project
Scenarios 1 and 1a represent the production of naturalised discharge data for the Hadejia River at the Wudil gauging station downstream of Tiga Dam, under two alternative discharge assumptions. The remaining five scenarios represent the impacts of a range of operating regimes for various combinations of the proposed water resource schemes. The simulation periods for these scenarios are limited to either 1964-1985 or 1964-87. The impacts of the different scenarios are evaluated by assuming that the dams and irrigation schemes were operational at the start of the simulation period and continued to function in the same manner throughout this period.

Source: Thompson 1995;Barbier and Thompson, 1998

TABLE 2 RESOURCE UTILISATION

Resource	Utilisation
Water	Domestic use, irrigation, livestock watering, navigation
Vegetation	Food, thatching material, ropes, fuel
Land (fadamas and upland), soil	Flooded agriculture, irrigated agriculture, dryland farming, building material
Fish	Fishing, important source of protein
Birds, reptiles, amphibians	Food, hunting, tourism, minor trade

Source: Acharya, 1998a

Hydrological predictions based on studies of the Komadugu-Yobe river basin indicate that the flooding within the wetlands would be dramatically reduced with the construction of the proposed upstream dams. Tables 3 below outlines the simulated results of a hydrological model of the wetlands and shows a fall in both flood extent and groundwater tables under different scenarios of upstream project completion.

TABLE 3 CHANGES IN FLOOD EXTENT AND WATER TABLE CHANGE ASSOCIATED WITH DAM SCENARIOS

Scenario	Change in flood extent (hectares)		Change in water table elevations (m)	
	Scenario 1	Scenario 1a	Scenario 1	Scenario 1a
Scenario 2	97,775	91,697	-1.13	-1.27
Scenario 3	103,592	107,234	-0.82	-0.95
Scenario 4	86,315	80,257	-1.21	-1.34
Scenario 5	25,768	19,710	-4.28	-4.41
Scenario 6	55,350	49,292	-1.21	-1.34

Notes: Scenario1 refers to flows between 1974-1985 with the effects of Tiga Dam, naturalised Wudil flow and no KRIP-I; Scenario 1a refers to flows between 1974-1990 with the effects of Tiga Dam, naturalised Wudil flow and no KRIP-I. *Source: adapted from Thompson and Goes, 1997 and Thompson, pers. communication, 1998*

The impact of diversions to upstream areas will be felt within the wetlands primarily through a reduction in flooding and subsequently through changes in groundwater tables. This will, in turn result in :

1. loss of water and available soil moisture for cultivated species
2. loss of habitat and water resources for uncultivated species, and
3. increased pressure on fewer food and water resources.

In terms of floodplain agriculture, Barbier *et al*., 1993 and Barbier and Thompson, 1998 have shown that reduced flooding within the wetlands would result in welfare losses due to reduced productivity of the wetlands from surface water use. Barbier and Thompson (1998) conclude that in all the scenarios outlined in table 1, the additional value of production from large-scale irrigation schemes does not replace the lost production attributable to the downstream wetlands, since gains in irrigation values account for at most around 17% of the losses in floodplain benefits.

In addition, as asserted by hydrological research in the wetlands, the floodplain provides various environmental benefits such as groundwater recharge and habitat for migratory waterfowl (Hollis *et al*., 1993). These environmental benefits are *indirect* benefits deriving from the regular inundation of the floodplain. Groundwater recharge is regarded as possibly the most important environmental function supported by the wetlands. Groundwater is used within the wetlands for two main uses, namely, dry season agricultural production and domestic water consumption. Irrigation is carried out mainly with the use of small pumps and shallow tubewells and draws water from the shallow aquifer within the wetlands. Domestic water use also relies on the shallow aquifer, and water is abstracted from village wells.

Acharya (1998a) has shown that the indirect effects of changes in flood extent would cause groundwater levels to fall within the wetlands, resulting in welfare losses from reduced agricultural productivity during the dry season and from increased prices or higher opportunity costs of time for water used in domestic consumption. Given an average consumption of 232 litres per day per household (24 litres per capita) the recharge function of the wetlands is shown to have a value of 0.25 Naira per litre of water consumed by households per day. These results suggest that the value of the recharge function is 1,530,450 Naira or US$ 17,391 per day for the wetland area and an average welfare change per household of 47.5 Naira or US$ 0.54. In terms of groundwater irrigated agricultural production, a value of at least 2,863 Naira or US$ 32.5 per farmer per dry season is attributable to the present rate of groundwater recharge. This would result in a total welfare change of US$ 1,182,737 for the wetlands, per year.

In addition, the floodplain is also a producer of large quantities of doum palm, reeds and sedges. Polet and Shuaibu (in prep.) estimate that the annual market value of doum palm produced from the area may be around 35 million Naira[1]. There is already evidence that the natural distribution and abundance of uncultivated species is changing as a result of altered flooding. Vast areas within the wetlands are now covered by *Typha* sp., known locally as *kachalla* grass. It is believed that the spread of the species, which is difficult to eradicate and has resulted in blocked waterways and reduced areas suitable for rice cultivation, has been due largely to changes in the flow regime of the rivers (Akinsola, 1998). Villagers report reduced availability of a number of uncultivated plant and tree species, not only due to increased demand but due to lower regeneration and survival of seedlings as a direct consequence of changing flood patterns (Eaton and Sarch, 1996). Other resources such as Potash are also dependent on the flood. Potash appears on the soil surface after the floodwaters recede and is an important food supplement. To illustrate the impact of flooding on wild species within the wetlands, Acharya (1998b) partially measures the biodiversity value of the wetlands, in terms of harvested, uncultivated species which are collected from the wetlands and which are dependent on continued flooding to meet the demands of wetland populations.

A summary of all these studies on the value of these wetlands is presented in table 4 below. These results indicate that, based on an analysis which attempts to capture the direct and indirect functional values of the wetlands, the value of this natural ecosystem is far greater than the expected net present value of upstream development projects.

[1] 88 Naira = 1$

TABLE 4 LOSSES IN FLOODPLAIN AND GROUNDWATER USE BENEFITS VERSUS GAINS IN IRRIGATED UPSTREAM PRODUCTION *

	Irrigation Value [1] a	Floodplain loss [2]b	Floodplain loss (2) [3]c	Groundwater welfare loss [4]d	Net loss [2+3+4] - [1]
Scenario A	682,983	-5,671,973	-498	-38,510	-5,027,998
Scenario B	354,139	-4,184,999	-126	-28,807	-3,859,793
Scenario C	682,963	-8,744,240	-797	-40,633	-8,102,707
Scenario D	3,124,015	-24,004,251	-3,146	-133,725	-21,017,107
Scenario E	556,505	-17,059,901	-1,766	-40,633	-16,545,795

Notes:
* All scenarios are based on hydrological conditions under Scenario 1a as defined in tables 1 and 3.
a Based on the mean of the net present values of per hectare production benefits for the Kano River Irrigation Project Phase I applied to the gains in total irrigated area (Source: Barbier and Thompson, 1998).
b Based on the mean of the net present values of total benefits for the Hadejia-Jama'are floodplain averaged over the actual peak flood extent for the wetlands of 112,817 ha in 1989/1990 and applied to the differences in mean peak flood extent (Source: Barbier and Thompson, 1998).
c Based on the mean of the net present values of welfare loss (Source: Acharya, 1998b) from reduced doum palm collection due to a reduction in flood extent (in hectares), using discount rates of 5% and 8% with time horizons of 30 and 50 years for each discount rate and converted to US$ using the 1997 rate of US$1 = 88Naira.
d Based on the mean of the net present values of welfare loss from a 1 metre reduction in well levels in the Hadejia-Nguru wetlands (using discount rates of 5% and 8% with time horizons of 30 and 50 years for each discount rate), averaged over an area of 19,000 ha of land within the wetlands which could support groundwater irrigated agriculture. A welfare loss of Naira 3,566 per ha is used for all the scenarios. Values are converted to US$ using the 1997 rate of US$1 = 88Naira. (Source: Acharya and Barbier, 1997; Acharya, 1998a)

3. Conclusions: The Role of the Public and Private Sectors

Ecosystems provide a multitude of benefits to human welfare, and these benefits are dependent on the interactions within the natural system and between human and natural systems. Measuring the costs of development policies requires us to identify where these costs may occur and how might we measure them. This means that we have to identify linkages between the natural and human systems and we have to have sufficient knowledge of how disturbances to present conditions may affect the ability of the natural system to continue providing the goods and services we are dependent on. In particular, the identification of ecological-economic linkages helps us realise the value of hidden ecosystem functions and services. As this study has shown, by failing to carry out these necessary steps, policy decisions may give up a multitude of benefits in one area in exchange for a relatively small improvement elsewhere.

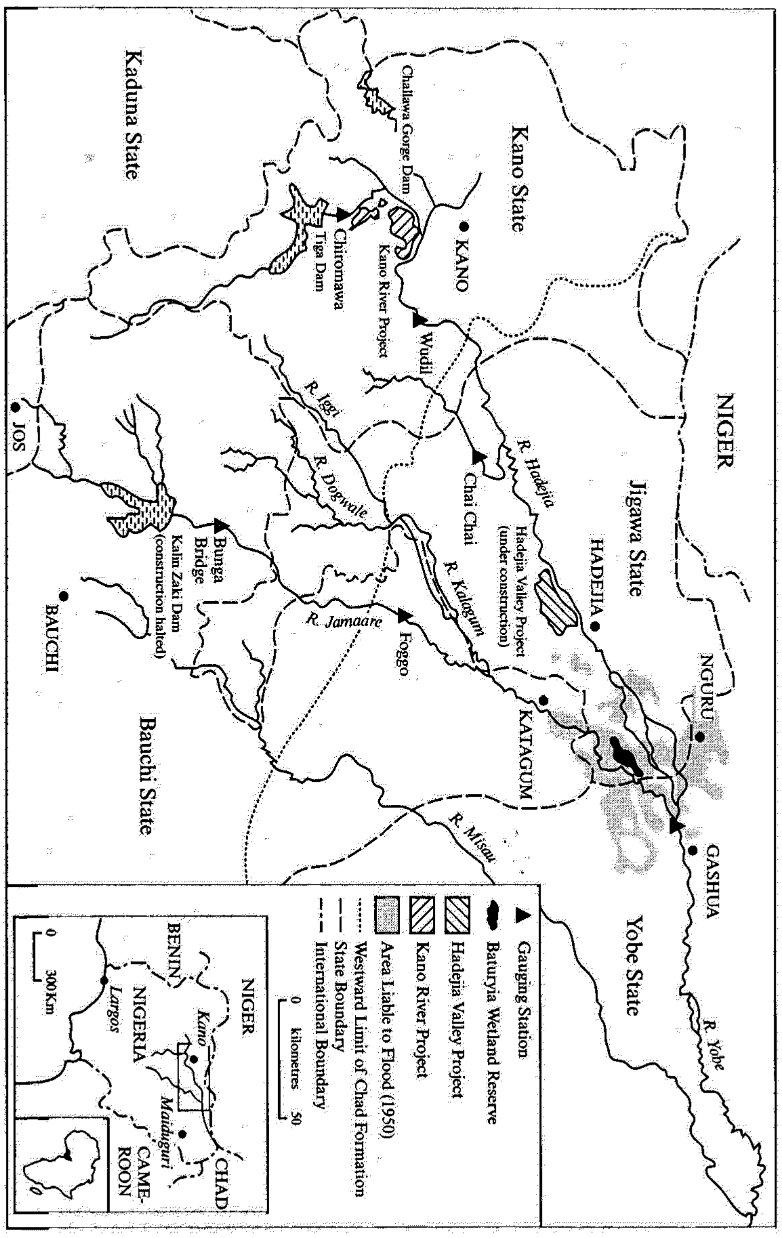
In whose interest is it to value wetland services? A recent study of New York's Catskills watershed shows that its role in maintaining water quality is significant. In 1996 New York City was faced with the choice of investing in restoring the health of the Catskill ecosystems or building a filtration plant at a capital cost of $6-8 billion, plus annual running costs of $300 million. Investing in the environment was a more attractive investment for the city, with expected costs around $1-1.5 billion and benefits including improved water quality and other services (Chichilnisky and Heal, 1998). Recognising the value of the watershed in providing improved water quality was therefore influential in the city's decision to invest in its environment.

The public good nature of wetland services makes it somewhat more difficult to make a case for private involvement in valuing these services. Despite this, private sector utilities providing services such as drinking water, and interested in maximising profits or minimising their private production costs, would also benefit from similar valuation procedures. While there will doubtless be positive externalities created for other users, the potential returns to private companies involved in the provision of drinking water, tourism or other private goods dependent on the public good may be high enough to encourage them to value and conserve these natural systems.

In addition, conservation and development organisations play a role in providing economic values of ecosystems and environments which are threatened by policy decisions made with inadequate information. By informing such policy decisions valuation studies provide a better basis on which we can make sensible and cost-effective trade-offs between development and the environment.

Development of waterways to provide irrigation and drinking water supplies do not necessarily have to be an antithesis of wetland conservation. The analysis presented in this paper has shown that if the marginal benefits of development are equal to the marginal costs of development (in terms of lost wetland goods and services) then the development process must stop and allow all remaining resources to continue to support the wetlands. Under the Biodiversity Convention, the environmental consequences of a country's programmes and policies must be assessed and minimised or avoided. Without adequate recognition of the marginal value of wetland conservation (or the opportunity costs of development) it is unlikely that such disturbances and conversions will stop at an optimal level, thereby resulting in the loss of wetlands and social and economic welfare in downstream communities.

It is argued in this paper that it is in the interest of a number of groups to carry out a more complete valuation of costs and benefits associated with development projects. Economic valuation of environmental resources is a tool whereby we can not only improve our present understanding of economic-ecological linkages, but also a way in which we can improve social welfare by making informed decisions with regard to development and environmental concerns.



Source: Hollis et al. (1993).

Figure 1: The Hadejia-Nguru Wetlands

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