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TWINBAS

Twinning European and third countries rivers basins for development of integrated water resources management methods

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Work Package 8:

Economic Analyses

April 2007

List of contents

WP8 – Economic Analyses

List of Figures

List of Tables

Section 2

Section 3

Section 4

Okavango

Biobío

Nura

Norrström

WP8 report – Economic Analyses

1. Introduction

This summary report presents the results of the economic analyses undertaken for the five river basins studied in TWINBAS: the Okavango in southern Africa, the Biobío in Chile, the Nura in Kazakhstan, the Norrström in Sweden, and the Thames in the U.K.. In each of the five basins, a different approach to the analysis was taken, depending on what were considered to be the main pressures. The **Okavango** and the **Nura** are similar in that they both terminate in internationally important wetland sites. The analyses for these two basins therefore focused on the potential impacts on the wetlands presented e.g. by future land use changes, water extraction plans and climate change. Economic effects caused by hypothetical changes in hydrological regimes resulting from climate change were also investigated for the **Biobío** river. In the **Norrström** basin where nutrient inputs from agricultural activities represent the biggest pressure on water quality, the economic analyses concentrated on calculating the benefits and costs for eutrophication mitigation. Economic analysis in the **Thames** basin is still ongoing, therefore it was only possible to report on studies that had been completed by March 2007.

1.1 Okavango

The Okavango river system flows from the Angolan high plateau through Namibia to form an inland delta in Botswana. Compared with many river basins the Okavango is in a relatively pristine state. However, demands on its water and other resources are expected to grow significantly in future and impacts are expected to be felt mainly at the downstream end in the Okavango Delta.

As a sink for the Okavango River, the Okavango Delta supports a complex ecosystem rich in diversity. It provides a basis for agro-pastoral land use, valuable tourism activities, fisheries, wildlife and natural plant use. In 1997, Botswana became a contracting party of the 'Ramsar Convention' and the Delta was listed as a wetland of international importance. As a natural asset it contributes significantly to the national product and generates significant non-use values in the global context.

In order to ensure the delta's conservation and wise use, the development of an Okavango Delta Management Plan (ODMP) is underway. The strategy for implementation of the ODMP involves creating an improved sense of collective responsibility and accountability among communities and existing institutions with a mandate to manage the Delta and its resources. The TWINBAS project supports this process with parallel funding from Danida, establishing a common base for assessment of the hydrological processes and their importance for the ecological functioning of the Delta as a basis for people's livelihood.

The World Conservation Union (IUCN) also supports the ODMP, providing technical support to elements of the management plan. The economic analyses for the Okavango Delta presented here is an excerpt of the valuation study carried out by Department of Environmental Affairs, GoB and IUCN (Economic Value of the Okavango Delta, Draft, August 2006).

1.2 Biobío

The instruments for the management of water resources in the Biobío basin are based mainly on the Water Code and the Quality Standard for surface water in the basin, the latter at the preliminary draft stage.

The general objective of this study is to design and apply a calculation methodology, which allows performing an economical assessment of the water quality standard implementation in the basin water for different hypothetical scenarios of weather changes. This assessment must be performed through the cost-benefit analysis.

The specific objectives to obtain the general objective are:

a) Characterize the economics of the basin related to the water quality.
b) Design a calculation model which allows assessing the economic effect of different scenarios for future climate and the use of water resources in the Biobío basin, under the current legal framework (focused on the Secondary Standard).
c) Test the methodology with a hypothetical change on the hydrological regime and available flows in the basin, evaluating the economic impact of the Water Quality Standard. Methodology must be developed in such a way that later it can be applied using the results of the hydrological modeling of the sub-basin of Río Vergara, and results of other sub-basins in the Biobío which can be modeled in the future (compatible with the hydrologic model).
d) Describe the efficiency of different instruments of policy which adjust to the Biobío basin, and the economic effects of the development of climate and human change scenarios.

1.3 Nura

The current report provides an economic analysis of the water allocation problems specific to the River Nura. It is based on three papers, listed in the Annex (Appendix A). These outline the decision making and allocation problems inherent in the Nura Basin and how they might differ from those of other basins. The Nura has very specific characteristics and problems which make the immediate transfer of policy recommendations inappropriate without careful analysis of the underlying structure. This report, therefore, sets out what these problems are, and how they can be described in a way that economic analysis can use. Then established techniques are used to formulate evaluate policies that might be used. By setting out how these problems for the Nura Basin relate to underlying characteristics it is possible to see how they relate to problems of other basins.
Underlying all decisions and calculations there is a great importance of uncertainty. Usually, this is handled by the method of 'Certainty Equivalence' where an uncertain variable such as future river flow, or water required for maintenance of eco-systems are replaced by their expected value, and then Cost Benefit Analysis proceeds as usual. An example of this is the economic analysis that underlies the World Bank's Nura Mercury Clean-Up project. However, the expected value that arises from state variables representing economic and ecological variables, taken under the appropriate probability distribution, is not the same as the value when those state variables take their expected value but with certainty. The probability distribution that underlies the Nura Basin makes this divergence large. However to do this requires getting inside of the stochastic structure of decision making and evaluation, and so analysis is rather technical, and has a similar structure to that of modern stochastic financial economics. By doing this, it is possible to see how the Social Price of Water, underlying the European Union's Water Framework Directive, relates to the Precautionary Principle and the timing of decisions when little is known about either the ecology, or the future economics of the basin. The question of Sustainable Use of the River Basin, when the damage caused by water withdrawal policies happen some time in the future, is strongly influenced by uncertainty and variability. Thus, it can be seen how the variability of flow in different basins of different countries with different time preference generates different local and international valuations for environmental damages.

1.4 Norrström

Socio-economic analyses for the Norrström form part of the Twinlatin project and concern the implementation of measures for achieving a sustainable management of the river basin. The focus here is on eutrophication mitigation. Nutrient (nitrogen and phosphorus) inputs from land-based sources (both diffuse and point sources) to many of Sweden's coastal bays and estuaries have increased substantially above background levels.[1] In order to reduce these inputs, measures are undertaken to reach both the national and the regional goals of lower eutrophication.

The study area is limited to the Svartån and Sagån watersheds within the Norrström water basin where the agricultural sector is the biggest emitter of nutrients leading to eutrophication of Lake Mälaren as well as the Stockholm archipelago. The objective of this study is to shed light on the measures to be undertaken in order to diminish leaching of nutrients to water courses. Using the SWAT model, estimations of emissions are made for a baseline and other scenarios including different measures to analyze their cost effectiveness. To estimate the benefits of lower eutrophication, results based on contingent valuation studies are used to conduct a cost benefit analysis. However, the analysis is not related to water pricing or water scarcity and other sources of eutrophication such as households are briefly discussed.

Eutrophication

Eutrophication is derived from two Latin words meaning "good" and "food". It is the over-fertilization i.e., enrichment of waterways which can result when excess levels of nitrogen (N) and/or phosphorus (P) are introduced from urban and/or rural sources to watershed. Other sources of eutrophication are international emissions.

Urban sources include:
-Households: many types of household items might be contributing to eutrophication since many detergents contain P and lawn fertilizer contains N. All these chemicals are emitted to sewage water;
-Industrial discharges to water and especially the mineral and the chemical industries.
-Urban run-off water including oils, heavy metals as well as different nutrients. These waters do not often end up in sewage treatment works but rather directly in watercourses.

Rural sources include:
-Agriculture: the loss of nitrate from agricultural land is largely caused by erosion. The other main source of agricultural eutrophication is the use of fertilizers and livestock farming e.g., P excreted by livestock;
-Forest management; Forests may be regularly fertilized and this forest management lead to local effects on nutrient loading of watercourses;
-Rural dwellings often dispose off sewage into septic tanks, which may cause local pollution.

The main effects caused by eutrophication can be summarized as follows (Mason, 2002):
-Species diversity decreases and the dominant biota changes;
-Plant and animal biomass increase;
-Turbidity increases;
-Rate of sedimentation increases, shortening the lifespan of the lake;
-Anoxic conditions may develop.

The changes in nutrient levels and biology can directly affect human activities. The main

[1] http://www.umces.edu/President/Swedeneutro.pdf

occurring problems can be summarized as follows:
-The water can be injurious to health;
-The amenity value of the water may decline;
-Increased vegetation may impede water flow and navigation;
-Commercially important species of fish may disappear;
-Treatment of drinking water may be difficult and supply can have an unacceptable taste or odour.

The Swedish environmental objectives

Sweden has adopted 16 environmental quality objectives (Fifteen objectives were adopted in April 1999, and the 16th objective was adopted in November 2005). Together, the 16 objectives make up a coherent whole that is essential for successful implementation of environmental policy. The goals were formulated in the course of fruitful cooperation between elected representatives, public authorities, industry and environmental organizations. The objectives that were adopted unanimously by Parliament are a platform for all environmental action, at all levels, in Sweden and within the framework of the international cooperation. One of the goals is zero eutrophication.

In Sweden there are both national and regional goals related to water and eutrophication.

According to the Swedish EPA the national goals are:
-Abatement program relative to the EU's Water Framework Directive (WFD) should be available no later than 2009. The WFD advocates the integration of its requirements, which relate to improving water quality, into other EU and domestic policies within the European member states.
-until year 2010 the provision of P to lakes, watercourses and coast relative to human activities would have been reduced continuously from 1995 level;
-until year 2010 the provision of N to lakes, watercourses and coast relative to human activities would have been reduced continuously from 1995 level;
-until year 2010 emissions of ammoniac would be reduced by at least 15 percent;
-no later than 2010 should all emissions of N oxides to the air be reduced by 148000 tonnes.

The Regional goals concerning the Norrström water basin are:
-The provision of P and N to lakes and watercourses will be reduced by 10% in 2010 based on the levels of 1995 (Vattenvårdsförbund, 2004).

1.5 Thames

The Thames River basin covers an area of 13,000 km^2, representing some 4% of the area of the UK. However, it houses a growing population of over 13 million people (one fifth of the UK's population), and generates more than a quarter of the Gross National Product (GNP). The basin contains a high proportion of "knowledge-based" industries e.g. information technology firms, pharmaceuticals, specialist manufacturing and professional service industries. Business services makes up almost one fifth of the economy of the Thames basin and, between 1995 and 2002, service sector output increased by 3.8% per annum. Over the same period, there was a sustained decline in the manufacturing sector, with the largest decline recorded for the textile industry. The manufacturing sector is now a small part of the economy, as is the agricultural sector, with livestock husbandry and crop-growing the largest agricultural activities in the rural parts of the basin. The transport sector is also important, with the port of London providing deepwater facilities for international marine traffic.

The Thames basin is one of the driest parts of the UK, and the demand on land and water for homes, offices and other developments creates intense pressure on the natural environment and stress on the basin's water resources and waste disposal capacity. The population of the

Thames basin is forecast to grow by 0.7% between 2002 and 2015, and the total number of households is predicted to increase by around 1% per annum, increasing both water demand and development pressure. Service sector output is forecast to rise up to 2015, with a corresponding increase in employment. Output forecasts from the manufacturing sector are mixed, with only paper and chemicals expected to increase, and therefore some reduction in employment. Predicted impacts of climate change include warmer and wetter winters, hotter and drier summers, and deteriorating air quality and water quality, with a greater risk of flooding in winter, and possibly drought and water shortages in summer. Effective and sustainable management of the basin's water resources is becoming increasingly important.

The economic analyses of sectors that use water (based on forecasts of population, housing, employment and economic output) and those that provide water (based on, for example, analysis of the recovery of the costs of water services and the cost-effectiveness of actions required to meet WFD objectives) will help predict what the likely socio-economic trends are in the future, and how these might affect the activities and resulting pressures on water bodies within the Thames basin. These predictions, in turn, help inform the best combination of measures to ensure that the objectives of the WFD are met. In the Thames river basin, the organisation responsible for implementing the WFD is the Department for Environment, Food and Rural Affairs (defra), working with the Environment Agency. The first stage of the economic analyses was completed by defra, in parallel to the water body classification and pressure and impact assessment studies carried out by the Agency. The economic analyses draw on four national economic studies commissioned by defra, and overseen by the Economic Steering Group (ESG) and the Economic Advisory Stakeholder Group (EASG):

- The economic importance and dynamics of water use relevant for river basin characterisation (ERM, 2004);
- Cost recovery and incentive pricing (ERM and Stone & Webster, 2004);
- Cost-effectiveness analysis and development of a methodology for assessing disproportionate costs (RPA, 2004);
- Private water services (not yet available).

The resulting Economic Supportive Document (defra, 2005a) and summary report (defra, 2005b) provide the basis for the Thames basin contribution to this TWINBAS report.

2. Baseline scenarios

2.1 Okavango Delta

2.1.1 Objective and Approach

The **overall objective** of the ODMP is to protect the Okavango Delta and ensure a sustainable use of the Okavango Delta in future. The **specific objective of the economic evaluation** is to provide for management recommendations on a sound economic basis.

It is anticipated that the results of the economic evaluation study will assist the ODMP to:

- strengthen Botswana's negotiating position with Angola and Namibia regarding water allocation and river basin options,
- compare development options (considering environmental costs and values),
- document the different functions of the Delta (production, regulation, generation of information, cultural, etc),
- determine the extent to which current and future generations depend on resources
- point to incentives to support sustainable management, especially community-level benefits
- determine the value of the use and or sale the Delta's plant resources,
- diversify Community Based Natural Resources Management (CBRNM) beyond wildlife-based tourism, and to identify resources and activities that have economic potential for CBNRM,
- assess the long-term sustainability of the Delta's tourism, in the context of global trends in tourism demand,
- assist in the resolution of conflicts (e.g., between tourism companies and communities),
- determine the degree to which the game reserve underpins tourism,
- inform economically efficient pricing of tourism royalties, concession/lease fees and other charges,
- determine the economic opportunity costs of choosing to use particular areas and resources in particular ways,
- evaluate relationships between wildlife, photography, hunting in Delta

Approach

The total economic value of the Okavango Delta was studied within the framework of total economic value, including direct use, indirect use and non-use values. These values were considered at various scales from local (e.g. contributions to livelihoods) to national or regional (e.g. effects on national economic growth and employment), as appropriate. The use values were estimated in compatibility with the DEA's natural resource accounting system, and the national economic accounting system.

Initial review of existing information and field reconnaissance was followed by development of a conceptual ecological-economics model. Interview surveys were conducted in the study area and region to identify direct use and non-use values. Relevant ecological and economic data were gathered from existing sources to estimate indirect use values.

The conceptual model was then used to identify trade-offs and guide the development of methods used to assess the implications of alternative management scenarios relating to water allocation and land-use issues. The dependency of different types of activities on ecosystem functioning and conservation action was evaluated as well.

Limitations

The study had to be carried out over a very short period, from December 2005 to July 2006, and with a rather limited budget. Primary data collection was therefore somewhat restricted concentrating on the setting values gained from the direct consumptive use of delta resources. Estimates of other types of value, including tourism value, was based of secondary information.

2.1.2 Study Area

The Okavango Delta is situated at the northern most edge of the Kalahari sandveld in north western Botswana, below the Caprivi Strip in Namibia. It is the largest designated inland wetland in the world and is fed by the water of the Okavango River with between 5-16 thousand million cubic metres of water per annum from the river's headwaters in Angola. The economic valuation study was concentrated within the boundaries of the Okavango Delta Ramsar site, depicted in Figure 2.1 below. The Ramsar site covers a total of 55 599 km^2, and the Okavango Delta (the wetland area) covers some 13 000 km^2 within this.

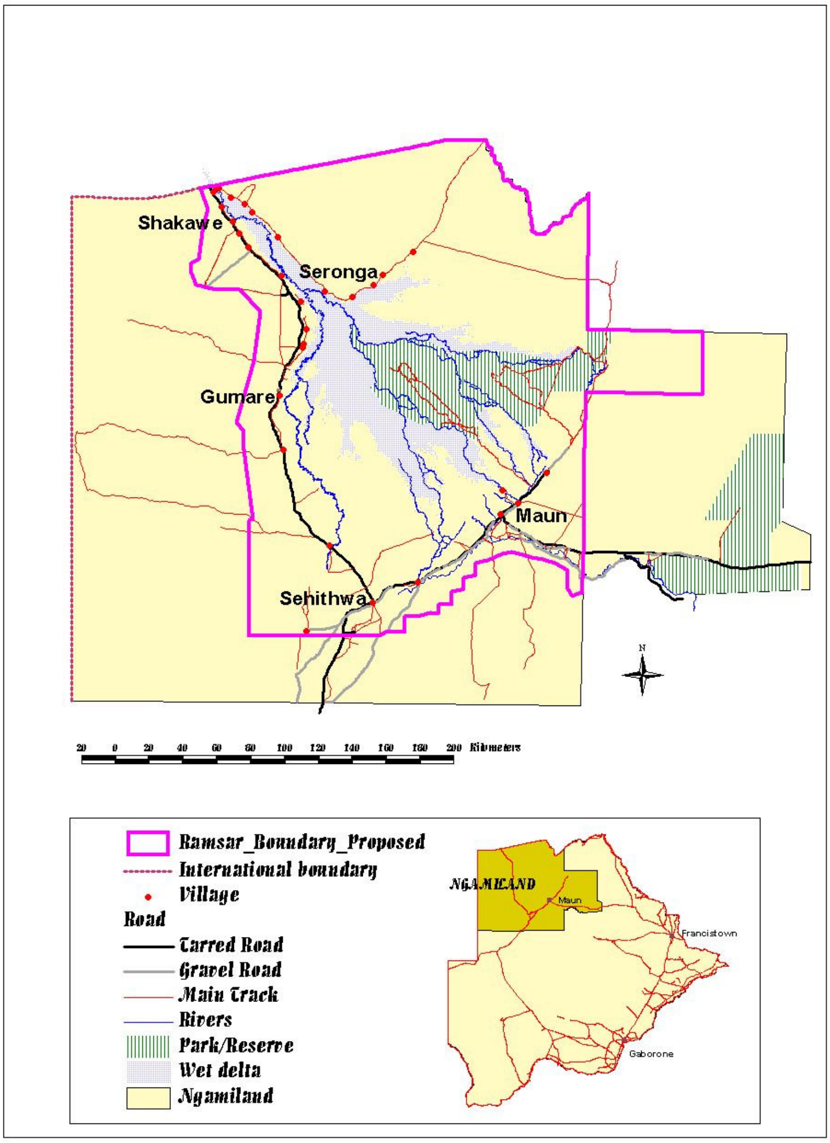

Figure 2.1. Boundary of the Okavango Delta Ramsar site

The Ramsar site occupies more than half of the Ngamiland District, one out of ten districts of Botswana. Very few people live in the delta itself while most of the population otherwise depending on the wetland is living within the Ramsar site area.

Topography and Soils
The study area is a vast, very gently undulating plain. The only topographic feature which stands out is the slightly elevated Ghanzi ridge which contains the Tsodilo Hills, in the extreme west of the study area.

The soils of the delta itself reflect the organic and sandy sediment load for the Okavango (Thomas & Shaw 1991, SMEC 1987, in TLB 2006). Around the delta, the dry land soils are mostly Kalahari sands. There is no agricultural potential in the Ramsar site (TLB 2006).

Climate and Hydrology
The Okavango Delta is located in a semi-arid region with hot, wet summers and cold, dry winters. Because of its location in semi-arid north-western Botswana, evaporation is about 2100 mm per annum, and amounts to far more than the average rainfall of 300 – 500 mm per annum occurring mainly from November to March. Most of the water flowing into the delta is thus lost to evaporation or evapotranspiration, with a very small proportion moving into groundwater aquifers (Jacobsen *et al*. 2005).

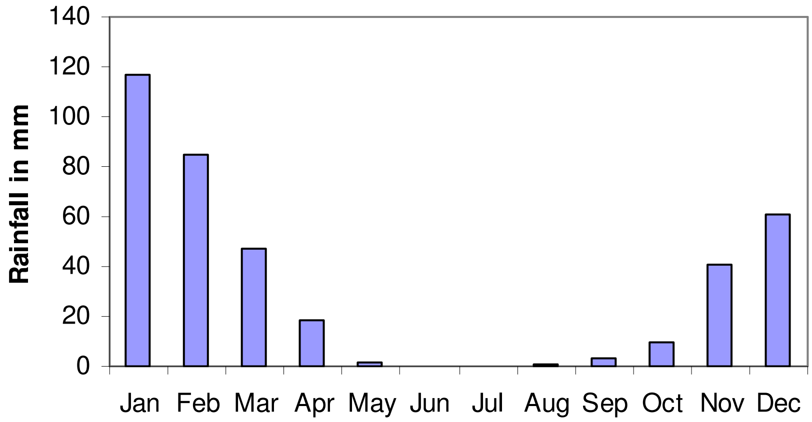

Figure 2.2 Mean monthly rainfall in Maun for the period 1990 to 2004

The pattern of flooding is roughly inverse to the pattern of rainfall. Rain falls in the catchment areas some 600km away during summer, and reaches the top of the panhandle in about April. Some 9.4 cubic kilometres per year reaches the delta on average, although this fluctuates widely from year to year, depending on rainfall in the Angolan catchment area (Mendelsohn & el Obeid 2004). The floodwaters then encounter tremendous resistance as it enters the papyrus swamps of the panhandle and then fan out into the distributaries and floodplains of the delta. The waters thus take several months to reach the distal portions of the delta, finally reaching Maun only in the late dry season (August-October; Mendelsohn & el Obeid 2004) As the floodwaters arrive, the delta expands from about 5000 km^2 to between 6000 and 12000km^2 in extent during flooding, depending on the size of the flood. Very little contribution is made by local rainfall, but in extremely high rainfall years (>800 mm per annum) rain-induced floods can occur (Wolski *et al*. 2005).

Drainage
From where it enters Botswana, the Okavango River flows in a south easterly direction for just over 100 km before fanning out into the delta proper. This section of the river is known as the Panhandle. After travelling down the panhandle the water distributes into three primary channels (Thaoge, Jao-Boro and Maunachira-Khwai) and thence into numerous smaller channels and floodplain areas. The delta is drained by the seasonal Thamalakane River which flows in a south westerly direction from the north-east, and passes through the town of Maun. This river occasionally flows as far as Lake Ngami, and into the Boteti River. However, only a

small portion of the inflow leaves the delta (on average 3% of the inflow; Jacobsen *et al*, 2005).

The delta consists of three major ecotypes: permanent swamp (channels and lagoons), seasonally inundated areas, and drier, higher land masses (Tawana Land Board, TLB 2006). The latter are savanna habitats commonly known as the "sandveld tongues", and are found in the southern and eastern delta. In addition, Chief's Island is a large arid island in the middle of the delta. These are focal areas for tourism because of their wildlife, scenery and accessibility.

The delta defined by the ODMP incorporates dry land or rarely flooded areas. The following categories are distinguished in the hydrological model, and these categories are used in the estimate of the indirect use value.

Table 2.1. Size of the RAMSAR site by different land categories

	Land category	Area (km^2)
5	Water-pan handle	1,446
4	Normally flooded area	2,152
3	Seasonally flooded	2,328
2	Occ. Flooded	3,534
1	Rarely flooded	19,322
	Total delta	**28,782**

Sources: Jacobson *et al.,* 2005.

Vegetation

The Okavango Delta comprises a mosaic of permanent waters, seasonally flooded open grasslands, woodlands and palm-fringed islands with forests. Lush forests line the river banks in the upper reaches, and the mid to lower reaches of the panhandle are dominated by papyrus *Cyperus papyrus* and *Phragmites* reeds. Below the panhandle, the perennial swamps are dominated by Papyrus and the *Phoenix* palm. The distribution of palms, which are slower to respond to change than papyrus, reflects the greater extent of the delta in the past, e.g. along the Thaoge River. By the time the waters fan out into the main delta, it is depleted of much of its nutrient and sediment contents, and the aquatic system is largely oligotrophic. Islands within the delta area contain dry land areas that are a combination of grasslands, forests, woodland and palms, as well as riparian trees.

The delta is surrounded by mopane woodlands to the north east, dominated by the mopane *Colophospermun mopane*, and acacia woodlands to the south west, which are characterised by *Acacia erioloba* and *A. tortilis* (Mendelsohn & el Obeid 2004).

Fish and Wildlife

The Okavango Delta is a 'low nutrient'/ productivity system, with small local patches of higher production, and with good diversity of macro and micro invertebrates but no strong evidence of endemism (i.e. species unique to the delta area)' (Scudder *et al*, 1993, p. 51). Within the Ramsar Site, fish and wildlife are concentrated in the Okavango Delta.

Over 80 species of fish are found in the Okavango basin, but species diversity is generally fairly low in any particular area, in the region of 15 to 30 species, and fish numbers tend to be dominated by just a handful of species (Mendelsohn & el Obeid 2004). In general, the density of fish is highest in the panhandle, decreasing towards the outer edges of the delta, which are poor in nutrients and hence food supply. The fish fauna is dominated by bream (*Oreochromis andersoni, O. Macrochir, Tilapia rendalli, Serramnochromis* spp), catfish *Clarias* spp, and tiger fish *Hydrocynus vittatus* (Mosepele 2005). The floodplains and seasonal swamps are particularly valuable as fish breeding habitats providing fish larvae a food-rich refuge during the flood season. Flooding is thus the main driving force for fish breeding in the delta. Young fish return to the permanent waters as the floodwaters recede, but many fish are trapped in pools during this period, providing an important food resource for both people and animals (Mendelsohn & el Obeid 2004).

The largest wildlife populations are found in Moremi Game Reserve. Lechwe are abundant totalling about 50 – 60 000 individuals. Some 20 – 30 000 elephants spend the dry season in the delta, their numbers having increased rapidly in recent years. In addition, the delta supports about 5000 Tsessebe, 30 – 40 000 buffalo, 5 – 7000 giraffe, 20 000 impala, many sitatunga, small numbers of reedbuck, several hundred waterbuck and thousands of hippopotamus. All large mammals except elephants are restricted in distribution by the veterinary fences which keep them enclosed in the delta. Certain species such as lechwe, sitatunga, waterbuck, hippo and crocodile are largely confined to the permanently wet areas of the delta. Elephants are water-dependent but range widely throughout the area, resulting in human-elephant conflicts.

Over 500 species of birds have been recorded in the delta (Mendelsohn & el Obeid 2004), including rare and endangered species such as Wattled Cranes and Pels' Fishing Owl. The densities of birds are relatively low, however, reflecting the low nutrient status and productivity in this ecosystem.

Land Use and Tenure

Land in Botswana is under three types of tenure, with Tribal Land making up 71%, State Land covering 23% and Freehold Land making up 6% of all land in the country. Within the Okavango Delta Ramsar Site, all but 4.6% of land is under Tribal Land tenure, the remainder being State Land. There is no Freehold Land in this area. Tribal Land is held in trust for communities by the Land Boards which are responsible for land administration. Usage rights are granted to Botswana citizens either communally or to individuals, usually for residential purposes, ploughing or boreholes. These rights are typically passed on through generations. In addition, citizens and non-citizens can acquire 50-year leases for commercial and industrial developments. Land cannot be sold, but the improvements or developments can.

About half of the study area is under wildlife utilisation, with 9.4% being within protected areas (Moremi Game Reserve) and 41.8% being designated as Wildlife Management Areas (WMAs). Moremi Game Reserve is administered by the Department of Wildlife and National Parks (DWNP). WMAs are areas that surround protected areas and serve as buffer zones and migratory corridors. Whereas there is total preservation and protection of wildlife resources within protected areas, sustainable utilisation of wildlife resources is encouraged in WMAs, and they provide the opportunity for establishment of Community Based Natural Resource Management (CBNRM) systems. WMAs can be designated as:

1. Commercial Wildlife Utilisation (Leasehold);
2. Community Wildlife Utilisation (Leasehold);
3. Commercial Photographic area; or
4. Community Photographic area.

The community WMAs are managed by community trusts, while the commercial WMAs are leased by companies.

The remaining 48.8% of the study area is communal land area which includes settlements, arable lands and grazing lands. Pastoral lands are dominant, and arable agriculture is mainly for subsistence. A total of about 48 900 ha are cultivated in the study area, of which about 10 000 ha are planted per year on average. Some 75% of this is for dry land farming, and 25% is for flood-recession farming, known as 'molapo farming' (Bendsen 2003, in TLB 2006). Cattle are kept around the village areas and also at cattle posts many of which are quite far from the villages and the delta. This is made possible by use of boreholes for water supply. However, the traditional separation of village area, agricultural lands and cattle posts is becoming increasingly blurred. The distribution of cattle is limited by a cordon fence in order to limit contact between wildlife and cattle, with most of the wetland area being a cattle free zone. The main veterinary fences are the southern and northern Buffalo fences which cross the study area.

Population and Settlements

The population of the study area is concentrated around the edge of the delta and along the main roads. There are a few small settlements within the delta. Most settlements are concentrated around the Panhandle. Half of the population is located in Maun. Of the approximately 67 settlements in the Ramsar Site, 54 have populations of less than 1000, and 11 of 1000 – 5000. There has also been a proliferation of ungazetted settlements (TLB 2006).

The total population of the study area in 2001 was estimated to be about 110 852 people in 18 277 households (TLB 2006). Growth rates over the last decade were about 4.1% per annum, compared with 3.4% over the previous decade. Children (0 – 19 years) make up 53% of the population. A total of 56 959 people (53% of the population) are of working age (15 – 64 years). Older people only make up 6% of the population. Life expectancy is dropping, as a result of HIV/AIDS and other factors. More than half (55%) of households are female-headed.

The tourism industry is the major employer of labour, with men being employed as polers, drivers, guides, camp builders and security guards, and women employed as maids, receptionists and in catering, cleaning and laundry (TLB 2006). Some villages (e.g. Ditshipi, Daonara, Seronga) have become centres for mekoro-based tourism.

Most people living in the study area are rural and poor. Most households have a diversified production system which is aimed at reducing risks in an unstable environment. The importance of different activities varies between households and communities, and between seasons and years, in response to variations in rainfall, flooding, access to resources, labour and capital and other factors (Scudder *et al.* 1993). The main activities are dry land and flood recession agriculture, livestock, wage labour, a range of commercial activities, fishing, gathering and hunting (Scudder *et al.* 1993). Cattle keeping may not benefit more than 20% of the population (Campbell 1976), but is preferred by most households, who value cattle not only in terms of production but for other reasons including a means of saving and investment (Scudder *et al.* 1993).

2.1.3 Zonation used in the Study

For the purposes of this study, the study area was divided into 5 zones, see Figure 2.3. The <u>Panhandle Zone</u> is characterised by the lack of floodplain area, the high numbers of settlements along the river, and the relatively high density and accessibility of fish and aquatic plant resources. There is little opportunity for recession agriculture (molapo farming). The people living in the <u>West Zone</u> have access to wetland and floodplain resources, including molapo farming areas. The <u>South West Zone</u> is relatively arid and sparsely populated. Its settlements follow what were formerly the outer margins of the delta, but these are now far from the wetland and floodplain areas. The <u>South East Zone</u> is dominated by Maun and is relatively far from the main wetland areas, but does have reasonable access to some of the distributaries and floodplain areas. The <u>Central Zone</u> is largely delineated on the basis of the buffalo fence and has wildlife as the main land use. This zone encompasses most of the wetland area, and there is very little upland area. While dominated by the Okavango Delta, it also includes the Linyanti-Chobe wetland areas on the northeastern border of the study area.

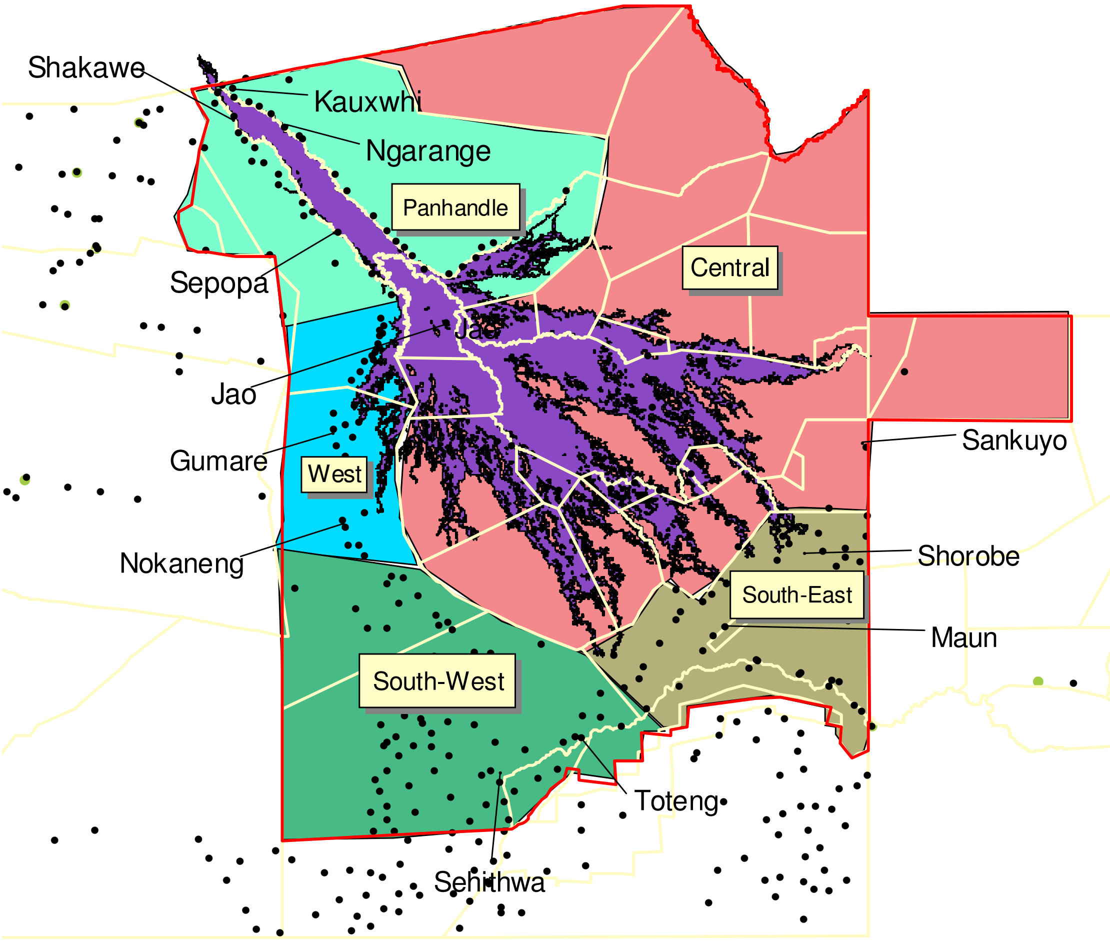

Figure 2.3 Zonation of the study area for this study

Based on GIS population data (note slight discrepancy in total from that reported above), about half of the population of is concentrated in the South East zone, where Maun is located (Table 2.2). The Panhandle contains about a quarter of the population. Very few people actually live in the Central zone.

About a quarter of adults in the study area are employed, with rates of employment being highest in the Central and South-East zones (Table 2.3). Tourism and wildlife are the main employers in the Central zone, are also very important in the South East Zone and are significant in the Panhandle. Government is the main employer overall, and is particularly important in the West and South West Zones.

Table 2.2 Population of the zones

Zone	**Population 2001**	**Household size (this study)**	**Estimated number of households**
Panhandle	25483	7.2	3,531
West	17,108	8.3	2,056
South West	9,193	7.5	1,226
South East	53,497	8.3	6,412
Central	1,475	7.3	202
Total	**106,756**		**13,427**

Table 2.3 Percentage of adults that are employed, and the percentage of jobs in different sectors, for households sampled in each of the zones

Zone	Pan-handle	West	South West	South East	Central	Overall
% adults employed	24%	21%	19%	29%	32%	25%
% jobs in:						
Tourism	4%	0%	1%	15%	51%	13%
DWNP	4%	0%	0%	2%	5%	2%
Other Gov	41%	56%	64%	41%	15%	45%
Farming	15%	12%	1%	1%	0%	6%
Fishing	3%	0%	0%	0%	0%	1%
Trade in natural resources	7%	1%	0%	0%	0%	2%
Trade in agric. products	3%	2%	1%	0%	1%	1%
Other	23%	27%	30%	37%	22%	30%

2.1.4 The Valuation Framework

The total economic value generated by The Okavango delta can be categorised into different types of value (Figure 2.4), providing a useful framework for analysis.

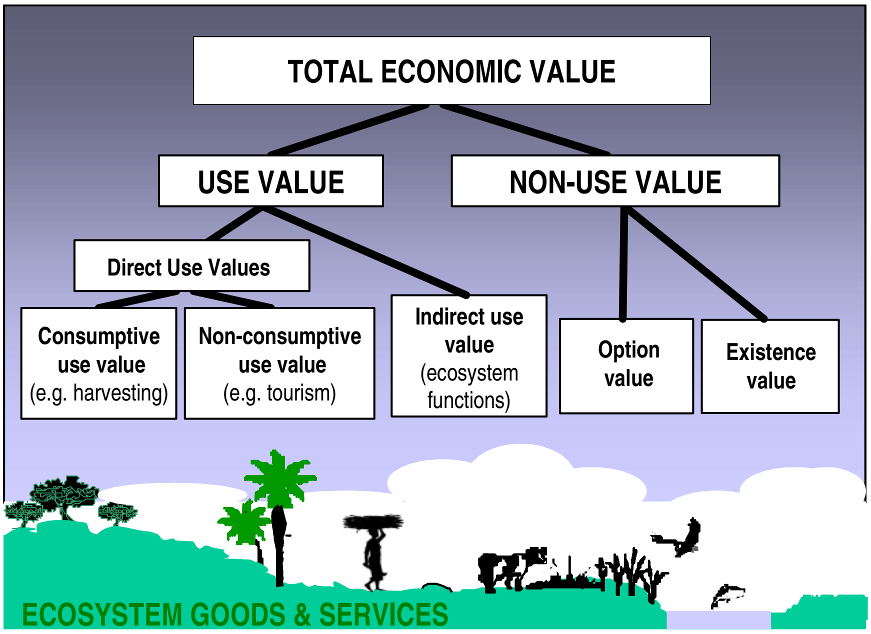

Figure 2.4 The classification of ecosystem values that make up total economic value.

Direct use values result from economic activity and are generated through the consumptive or non-consumptive use of the delta's natural resources. In the delta, direct use values are generated through crop production, livestock grazing, fishing, wild plant use and hunting. They are also generated through consumptive (hunting) and non-consumptive (wildlife viewing) tourism. Rather than separating consumptive and non-consumptive value, as conventionally done within the Total Economic Value framework, we separate household use (largely consumptive) and tourism use (both consumptive and non-consumptive), for ease of analysis.

Indirect use values are values generated by outputs from the Okavango delta system that form inputs into production by other sectors of the economy, or that contribute to net economic outputs elsewhere in the economy by saving on costs. These outputs are derived from ecosystem functions, such as water filtration, flood attenuation, and carbon sequestration. They also include benefits (or costs) arising from the provision of source areas for wild animal populations.

Non-use values include the value of having the option to use the resources and generate use values from the Delta in the future (option value), as well as the value of simply knowing that the resources within the wetland are protected (existence value including specific elements such as cultural, aesthetic, biodiversity and bequest values). Although far less tangible than the use values, non-use values are reflected in society's willingness to pay to conserve these resources, and with appropriate market mechanisms, can be captured through transfers and converted to income. Non-use values are measured using survey-based methods, and were beyond the scope of this study.

Direct and indirect use values are of particular importance in the developing country context of Botswana, for which a critical national objective is to create growth in income and employment. These values are manifested directly or indirectly in tangible income and employment. Existence values inherently are not manifested in income and employment, and they are often highest in foreign countries. Nevertheless, global existence values can be high and the resultant willingness-to-pay can be captured globally and converted to income within Botswana, for example through grants.

2.2 Biobío

The modeling for the Biobío is based on the document "Anteproyecto de la Norma Secundaria de Calidad de Aguas en la cuenca del Río Biobío" and the consultancy performed by the same investigators known as "Análisis general del impacto socioeconómico de la norma secundaria de calidad de aguas en la cuenca del río Biobío" EULA- April, 2006.

In this way, to do the economic analysis in the context of this study, the impacts of the implementation of the secondary water quality standard on the main economic activities of the Biobío basin were identified and evaluated in two scenarios: The first one, considering the current situation of concentration of quality parameters and their projection five years from now, considering also the level of current flows or historical averages and therefore, assuming there will be no important changes in climate that may alter these flow levels, which corresponds to **no climate change situation**; and the second one, analyzing the current parameter concentrations and how these may be altered in the projection, assuming the presence of hypothetical climate changes affecting the flow levels significantly, thus evaluating the economic effects in the production activities of the basin; which corresponds to a **climate change situation**.

2.2.1 Identification of Impacts with No Climate Change

Measurement methodology of the economic impact with no climate change is as follows:

a) Data were obtained from the Monitoring Program of the Biobío of EULA-CHILE and DGA (General Water Directorate), which are used to obtain the parameters corresponding to the preliminary draft of Secondary Standard of Water Quality of Rio Biobío.
b) <u>The current quality</u> is measured with the biannual 66 percentile of season data corresponding to years 2003 and 2004, or if not available, the two last available years were considered, according to the information source (Appendix B section 1a). For season data of the suspended solids parameters, such current quality is measured with the average of all seasons in years 2003-2004. The parameters Phosphorus, Chloride, Sulphate, Molybdenum and Zinc do not have available information in the EULA sources, but there is information in the DGA data base for the two last elements.
c) For the <u>5 year projection</u>, method is the following:

- Construction of data tables with the biannual mobile 66 percentiles from 1995 to 2004, and if not available, until last year available.
- Trends were built on the mathematical basis for each parameter (31 indicators) and for each section (25 monitoring stations).
- A 5 year projection is performed using functions with good adjustment degree (R^2 bigger than 70% and "p" smaller than 10%), assuming there are no significant variations in the flow level (see results in Appendix B section 1b).

d) There is a table for the standard related to the preliminary draft basis, which considers the values corresponding to the calculations for identifying the latency zones and/or saturated zones, where 4 columns are identified (see Appendix B section 1) and have the following meaning:
A: Current Situation
B: Situation Projected 5 years from now
C: Water Quality Standard Preliminary Draft Values,
D: Cutoff values for latency, 80% of standard.

e) Current and projected quality values without climate change are paired (Appendix B section 1a and b) with the value of preliminary draft in the standard and 80% of it (Appendix B section 1c and d). After this, latency zones are determined (L) for parameters (values between the standard and 80% of that value) and saturation (S) (over the standard value) of the current quality and 5 years projection (see Appendix B section 2).
f) Calculations are made to determine the magnitude of reduction in parameters that were saturated, which corresponds to percentage of reduction to reach the value established in the standard (see Appendix B section 3).
g) The most probable causes that produce such latency and saturation zones are identified, for current and projected situation, between the most representative economic activities of the basin sector that may affect the water quality in the basin, the main ones are: forestry, farming, livestock and industry activities
h) Now it is required the identification of each sector, the main economic activity, avoiding duplication and considering as forestry and livestock activities only those sectors without a relevant industrial activity. The sections affected by the industrial activities, are considered according to the discharge point of the effluents with parameters that can be altered by such activities.
i) Calculation of impacts in the livestock activity (in soils subjected to erosion, farming activities that show presence of contaminant debris originated in fertilizers and pesticides and activities related to irrigation is performed as follows:

$$\mathbf{W^1 = (0.228 * 0.5*(Za + Zf))} \quad \text{(Equation 1)}$$

$$\mathbf{W^2 = (0.5*(Za + Zb)} \quad \text{(Equation 2)}$$

$$\mathbf{W^3 = (0.5*(Za + Zb)} \quad \text{(Equation 3)}$$

$$\mathbf{W^4 = (0.5*(Za + Zb)} \quad \text{(Equation 4)}$$

Where:

W^1 = Percentage of impact to be reduced that can be attributed to dairy activities.

W^2 = Percentage of impact to be reduced that can be attributed to agricultural activities, using series of soil subject to erosion.

W^3 = Magnitude of reduction that can be attributed to farming activity that shows presence of contaminant debris originated in fertilizers and pesticides.
W^4 = Magnitude of reduction that can be attributed to irrigation activity in the Biobío basin.
0.5 = Average point between current and future magnitude of the most significant parameter.
Za = Magnitude of reduction of the most significant parameter in current situation
Zf = Magnitude of reduction of the most significant parameter in projected situation.
0.228 =Magnitude of reduction associated to dairy farming when they coexist with human settlements.

j) Calculation of annual reduction magnitude of the industrial sector is executed based on the following equation:

$$PMR_{i,j,x} = \frac{\int_{xt}^{xt+1} \left[C(x)_{i,j} - Vn \right] dx}{\int_{xt}^{xt+1} \left[C(x)_{i,j} \right] dx} = \frac{CAE_{i,j,x}}{CAT_{i,j,x}} \quad \text{(Equation 5)}$$

Where:
$PMR_{i,j,x}$ = Percentage of reduction magnitude of parameter i in section j corresponding to year x identified.
X = Independent variable indicating the period or year of the concentration value of parameter i in the corresponding j section.
C(x) = Mathematic function indicating the trend of concentration levels of parameter i in section j, explained by the period variable.
Vn = Concentration value established in standard of parameter i in section j
$CAE_{i,j,x}$ = Annual Surplus Concentration of parameter i belonging to section j in the corresponding x year
$CAE_{i,j,x}$ = Annual Total Concentration of parameter i belonging to section j in the corresponding x year

k) Benefits in the industrial sector are calculated based on the decrease of potential loss risks in international market due to probable accusations of environmental dumping, as 5% of the growth rate of operational income.

2.2.2 Identification of Impacts with Climate Change

The methodology designed to introduce the different climate change scenarios is directly associated to percentage modifications in flow, and is the following:

a) The geographical unit for analysis was selected based on three flow measurement stations the DGA has located in the basin, which include three geographical zones and are heterogeneous in terms of anthropogenic influence in the Biobío basin: Biobío at Desembocadura (lower section of basin, high influence of industrial activity), Duqueco in Cerrillos (middle section of the basin, high farming activity) and Biobío before Huiri Huiri (higher section of the basin, low influence of the production activities mentioned).

b) Analysis period in the last five years is defined; this is, starting from year 2000, to avoid external effects derived from the improvement in production processes and investment in abatement technology for industrial facilities, as well as installation and optimization of processes in secondary treatment plants belonging to ESSBIO, and the application of Supreme Decree DS 90 of MINGEPRES.

c) Observations corresponding to measurements of water quality parameters were extracted from the data base available at EULA Center for stations BB11 (Biobío river in the main section at Planta Mochita), DU1 (Rio Duqueco) and BB0 (Biobío river main section at Huiri Huiri).

d) A correlation analysis is performed between the water quality parameters established in the preliminary plan of the secondary standard and the inter season flow levels, (water quality measurements are taken quarterly or every four months). This allows identifying parameters with greater reciprocity between concentration and flow levels based on the following calculation: of the linear regression (equation 6) and above that the logarithmic regression (equation 7):

$$CP_{ij} = k + Em * NC_n \quad \text{(Equation 6)}$$

Where:
CP_{ij} = Concentration of parameter i at the quality measurement station j used.
k = Estimation constant, which reflects the average effect of other variables influencing the concentration levels of parameters, but are not included in the model, due to lack of information or because they are not relevant for the objectives of the study.
Em = Marginal Effect of the flow levels in the concentrations of parameters.
NC_n = Flow level in the section that includes the n flow measurement station defined.

$$Ln(CP_{ij}) = K + \eta * Ln(NC_n) \quad \text{(Equation 7)}$$

Where:
Ln (CP_{ij}) = Corresponds to the natural logarithm of concentration levels of parameter i at the quality measurement station j used.
K = Estimation constant, which reflects the average effect of other variables influencing the concentration levels of parameters, but are not incorporated in the model. This time it is represented by the Ln (k), which corresponds to the estimation constant previously defined.
Ln (NC_n) = Corresponds to the natural logarithm of the flow level in the section comprising the measurement station for n flow defined.
η = Represents the elasticity indicator parameter-flow

e) For elasticity calculation, the following mathematical calculation was used:

$$\frac{\partial Ln(CP_{ij})}{\partial Ln(NC_n)} = \frac{\Delta CP_{ij} / CP_{ij}}{\Delta NC_n / NC_n} = \frac{\Delta \% CP_{ij}}{\Delta \% NC_n} = \eta \quad \text{(Equation 8)}$$

f) To define the statistical importance that allows classifying between flow associated parameters and not associated parameters, the same criteria utilized in the identification of impact with no climate change were used.

g) Once these average elasticity values are obtained, critical points of flow variation per parameters are calculated, critical points understood as variation percentages of flow levels that modify the condition of parameter between: Normal, latency or saturation.

To achieve the aforesaid, the following mathematical procedure was defined:

$$\Delta\% NC_{ij} = \frac{\left((VL_{ij}^{L,S} - CP_{ij}^{A,F}) \Big/ CP_{ij}^{A,F} \right)}{\eta prom_i} = \frac{\Delta\% ICP_{ij}^{A,F}}{\eta prom_i} \quad \text{(Equation 9)}$$

Where:

$\Delta\% NC_{ij}$ = Percentage change in the level of impact flow in parameter i of section j

$VL_{ij}^{L,S}$ = Limit value established in the standard for latency zone, saturation of parameter i in section j

$CP_{ij}^{A,F}$ = Current concentration, future concentration of parameter i in section j

$\eta prom_i$ = Average elasticity of parameter i for the three measurement stations

$\Delta\% ICP_{ij}^{A,F}$ = Percentage variation of impact in the concentration of parameter i belonging to section j in the current condition, future

h) The table for impact flows is built, where 4 columns are identified and the meaning can be seen in the Attachment 5 of the original report in this study.

2.2.3 Valuation of Impacts

In order to do this, changes in the growth of investment costs and operational costs with the application of the water quality standard are obtained and/or estimated, understood as Abatement Costs of contaminants related to activities associated to economic sectors of the basin that may affect the water quality in the monitoring sections identified as critical. Therefore, we have two kinds of valuations of the abatement costs depending on the pollution source, if it corresponds to a diffuse pollution (mainly characterized by emission sources in the forestry sector) or a direct pollution (characterized by the emission sources in industrial companies). Also, there is impact estimation in terms of costs for the wellbeing state organization, associated to the implementation of this regulation, this includes the monitoring costs.

For the estimation of investment, costs and benefits for the different activities of the forestry sector, the procedure applied is the following (specifications of the calculation assumptions are contained in the original report):

$$C^1a = W^1 * (Io*E) + W^1*(Fn*E) \qquad \text{(Equation 10)}$$

$$C^1b = W^1 * [(E_x * (V1+V2))* 1,05] \qquad \text{(Equation 11)}$$

$$C^2 = W^2 * (He * 83,669) \qquad \text{(Equation 12)}$$

$$C^3 = W^3 * [(E_x * V_y)* 1.03] \qquad \text{(Equation 13)}$$

Where:

C^1a = A cost that can be attributed to secondary quality standard, associated to the dairy farming activities that shows presence of contaminants produced by this activity, through technology of purine lagoon.

W^1 = Percentage of impact to be reduced that can be attributed to dairy activities.

E = Number of exploitations > 100 cows

Io = Unit investment of purine lagoon on a group over 100 cows

Fn = Net unitary flow of purine lagoon of a group with more than 100 cows (benefit due to savings in fertilizer- operational costs)

C^1b = A cost that can be attributed to secondary quality standard, associated to the dairy farming activities that shows presence of contaminants produced by this activity, for a program of Best Dairy Practices.

W^1 = Reduction magnitude that can be attributed to dairy farming showing presence of contaminant debris produced by this activity.

E_x = Exploitations to be treated that will be addressed according to this assumption: Less than 25 cows by INDAP and more than 25 cows by CORFO, assisted percentage 5%.

V1 = Annual value of technical assistance allowance in UF dated 12/31/2005, corresponding to INDAP or CORFO, according to associated stratum.

V2 = Annual value of FDI (Investment Development Found) allowance in UF dated 12/31/2005, corresponding only to INDAP.

1,05 = Total cost of allowance, plus 5% as administration cost for the corresponding institution.

C^2 = Cost that can be attributed to secondary quality standard, associated to the presence of erosion indicators.

W^2= Reduction magnitude associated to erosion indicators

He = Eroded hectares to be evaluated. (from graphic intersection between farming soils use and soil series more sensitive to erosion)

83,669 = Average cost per hectare in erosion control practices

C^3 = Cost than can be attributed to secondary quality standard, associated to farm activities showing presence of contaminants due to fertilizers.

W^3= Magnitude of reduction that can be attributed to farming activity that shows presence of contaminant debris originated in fertilizers and pesticides.

E_x = Exploitations to be addressed, that will be the difference between the number of potential exploitations (5% of universe in each stratum) and the real number of exploitations currently taking part in this support programs.

V_y = Annual value of allowance in UF dated 12/31/2005, corresponding to INDAP or CORFO, according to associated stratum.

1.03 = Total cost of allowance, plus 3% as administration cost for the corresponding institution.

a) Valuation of costs and benefits associated to the standard in the industrial sector is performed according to the following formula (details of the calculation assumptions are in the original report):

$$\mathbf{CAAN_{i,j,x} = PMR_{i,j,x} * CMA_j * CMU_i} \qquad \text{(Equation 14)}$$

Where:
$CAAN_{i,j,x}$ = Annual Abatement Cost of parameter i in section j corresponding to year x, associated to secondary standard
$PMR_{i,j,x}$ = Magnitude Percentage of annual reduction of parameter i in section j corresponding to year x of the evaluation horizon associated to the standard.
CMA_j = Average annual total flow of effluents poured in section j
CMU_i = Average Unit Cost of abatement (per m^3 of flow) of parameter i

$$B\nabla RD_x = \sum_{n=1}^{m} IOE_{n,x-1} * \phi_n * (1-\varphi)^{x-1} * \varphi \text{ ; with x = 1, 2, 3, 4, 5 (Equation 15)}$$

Where:
$B\nabla RDA$ = x Year Benefit due to reduction of risks (loss of market) due to environmental dumping
IOE_n = Operational incomes of previous year of the n company that operates in the basin
ϕ_n = Average growth rate of operational incomes of n company
X = Year corresponding to the evaluation horizon
φ = Ratio of the growth rate where the sales are affected by RDA

2.2.4 Economic Evaluation

Cash Flow
A flow of social founds of the application of the quality standard in the forestry and livestock and industrial sectors is performed, these are relevant sectors in the Biobío basin expressed in M$ up to December 2005, with a 5 year projection, establishing the benefits of implementing the secondary standard that could not be valuated because of their complexity.

Rate of Return Indicators
The NPV indicator is calculated, applying the social discount rate of 8% a year, with a life span of 5 years, according to approximate costs and benefits. 8% corresponds to the official state social discount rate for year 2006 and it is communicated by MIDEPLAN.

2.3 Nura

2.3.1 Basin characteristics

Located in Central Kazakhstan, the river Nura basin drains an area of 53147 km^2. It is the most water deficient basin in Kazakhstan. However, population density in the Nura basin is generally low. To the south of the river it is less than 2 to 3 persons per km^2. To the north, it is 10 to 20 persons per km^2, with higher densities in the areas around Karaganda and Temirtau, and Astana. The population of these oblasts and Astana is 17% of the population of Kazakhstan. The main recent development in the basin is the establishment of Astana as the new capital of Kazakhstan. From 1999 to 2005, the population of Astana increased from 326 thousand to 529 thousand, offsetting an almost equal reduction in the population of the other oblasts. Anacker (2004) suggests that there are a variety of motives for the move of capital and the growth of Astana, but that it is difficult to see economic motives as a reason for movement of the capital. He suggests that it is more likely that they are demographic in nature. Also, the special legal status of the Astana city region, and its economic zone, indicates that the overall objective which determines water use and conservation effort for the city may not be derived from usual principles of social welfare maximisation that underlie the economic interpretations of Sustainability and Cost Benefit Analysis.

Apart from Astana, the main freshwater consumers are ferrous metallurgy, electric power industry, and the fuel industry. In Soviet times, the area was substantially developed for metallurgy and wheat production. These relied heavily both on subsidy and irrigation. Construction of the Irtysh-Karaganda-Canal in 1976 led to intensive industrial growth in the Karaganda – Temirtau region and a notable increase in water consumption. Since the collapse of the Soviet Union, the basin has experienced at first serious economic decline, but now growth is beginning to restore economic conditions, although it is unlikely they would return to anything near previous volumes. However, as most economic data relates to production and economic activity in the 1980's, precise empirical statements are not possible.

As a share of the GDP of the country as a whole, for the two oblasts and Astana it has declined from 20% to 18.7%, with an even larger decline if Astana is excluded. For Akmola and Karaganda oblasts share of GDP declined from 15.7% to 12.2 % between 1999 and 2004. Although in this period, GVA in real terms increased by 36%, with GVA in industry increasing by 70%, reflecting the recovery from economic collapse. The most remarkable change is, of course, for other services which includes governmental administration where Astana shows an increase in real terms of 370% in that period. During Soviet times, wheat was produced under irrigation. Now, during years of adequate moisture, good harvests of high quality grain can be produced. However, production is barely profitable even though substantial subsidies have returned. The metallurgy and chemical industries in the basin also suffered a substantial drop in production in the aftermath of 1991, the loss of subsidy and of traditional markets and end users in the Russian Federation. Again there has been some restoration in their fortunes. However, the dramatic increase in exports of energy resources from Kazakhstan has led to significant Dutch Disease effects, where there is an effect on the real exchange rate, and this is likely to mitigate the potential for exports of metallurgical products. It is therefore unlikely that problems will arise from those sectors. It is the planning of water supply for the new developments in Astana where economic and environmental problems are most likely to arise, and so the focus will be on that.

The Nura basin has many environmental problems, and these dominate any economic discussion of the basin. As well as potential water deficiency, there is a high level of pollution, by heavy metals, oil products, and other chemicals. The main pollutant is mercury which has entered into the river over many years with outflow from a chemical plant in Temirtau as a result of accidents and old technological processes. Water quality is generally a serious problem: 31% of water samples do not meet minimum chemical composition standards. As there are no organized sewage/wastewater disposal from cattle-breeding or agricultural fields diffuse pollution occurs especially during snowmelt and during rains.

The Nura differs from other river basins in that it flows into a closed lake system in the Tengiz depression which includes the Kurgaldzhino wetlands, an internationally important site for wildlife. These are mainly dependent on water inflow from the river Nura, and are recognised as being a very important ecosystem, which is an essential habitat for many species such as Pink Flamingo, and White Crested Duck. There have been large international expenditures on wetland conservation and biodiversity through a GEF/UNDP project and NABU, mainly in order to restore its Ramsar status.

Currently, mercury pollution in the river prevents the use of its water. But a World Bank Study reports that 90% of projected Astana water demand could possibly be met from diverting water from the River Nura., and consequently lost to the wetlands. The World Bank study reports that the cost of water in Astana coming from the Nura is $0.07/m^3$ compared to a cheapest alternative of $ 0.17/m^3. However, we shall show later that if environmental costs are included in both of these prices, then it is concluded later that it is highly likely that this ordering would be reversed Whilst the World Bank Nura Clean Up project includes consideration of the Kurgaldzhino wetlands, there are many difficulties and problems in doing this even if there were more knowledge about the ecological behaviour of the area. An important aspect of this is the extent to which the analysis incorporates uncertainty and variability, especially of sequences of dry years. Because of variability in river flow, there is, *in extremis*, a danger that if water inflow were to be substantially reduced, then wetlands could dry up completely, leading to the Korgalzhyn lakes becoming saline with a consequent loss of its ecological value. Even if such a catastrophe were avoided, reductions in water inflow will lead to a reduction in the area of the lake with consequent loss of its special habitats. As water inflow is reduced into the lakes, there will be an increasing environmental cost due to two factors. One is the value of area of lost habitat, the other is a cost to being nearer to the potential of a catastrophe for the lakes, either in the near or long term.

Increasing salinity and retreat of the wetlands, caused by extraction of water from the Nura, had been reversed when the discovery of substantial mercury contamination from past industrial activity caused the prohibition of Nura water use. Proposals to extract and use water from the Nura, once the mercury contamination has been removed, could lead to similar problems to those of the Aral Sea.

The wetlands are a complex system, and have the important characteristic of being shallow lakes. For such systems, there will be ecological problems of the lakes due to hysteresis, where there exists a high biodiversity state and the other a low one, and the system has a possibility to flip from one state to the other. This produces ecological thresholds, where if large damage were to be imposed then the consequences would be irreversible. But in the case of shallow lakes, large damage can arise from a small increase in water abstraction, and when flow is a stochastic process such a possibility may arise inadvertently. This is different to situations for other basins, where if the situation is reversible, then costs can be incorporated into the decision problem or Cost Benefit Analysis. With irreversibility, separate account needs to be taken of this.

Catastrophe arises from the crossing of a threshold, the location of which we are uncertain about. In terms of water withdrawal, if water levels exceed that at which catastrophic effects could occur then we are able to use water up to the point where a risk of catastrophe emerges, but cautiously because of the presence of catastrophic effects. Given the variability in flow, a threshold for catastrophic effects could be reached as part of the natural hydrological cycle. If it does then lowering the flow will increase the probability that the threshold would be reached, and we would expect this to occur sooner than otherwise. In order to appropriately answer these questions, it is necessary to have a stochastic process model for river flow.

2.3.2 The underlying stochastic model for river flow

By looking at the density function for data on river flow, it is clear that the distribution for the Nura is highly skewed. We take a log-normal stochastic, or Geometric Brownian Motion (GBM), model for water flow into the Kurgaldzhino wetlands as described in Ingham, et al. (2006). This is supported by evidence from stochastic modelling for other rivers, and also yields a log-normal distribution, and replicates the pattern of serially correlated years of high flows and low flows, which is a feature of the Nura. The log-normal distribution is used widely as a good representation of various data processes. An approximate log-normal distribution for the

Nura is shown in the following diagram compared to a river where the mean/median ratio = 1.007, such as the Rhine (Figure 2.5).

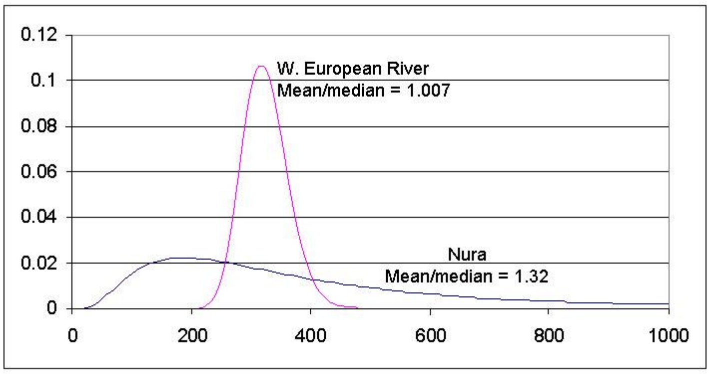

Figure 2.5 Stochastic distribution for the Nura compared to a typical Western European river

This approximation allows for an analytic treatment of results, and gives an expression for the social value, or shadow price of water taken from the river. The analysis here has the advantage of being quite general, and translatable between countries and river basins, when appropriate local conditions are included.

Formally, if X(t) is the water flow at time and dz is a standardized Wiener process, X(t) is given by Geometric Brownian Motion: $(dX)/X) = \nu.dt + \sigma.dz$ .Water flow generates ecological value, and reductions in it on a permanent basis generate ecosystem damage. We capture this by a value function f(X). This function includes many components of the river and its ecosystem, depending on both the hydrological model for the wetlands and the socioeconomic valuations.

Expected Present Value of flow is then given by: $E(V)=E\{ \int f(X)e^{-\rho t}\} dX \}$. X will depend on various parameters such as the rate of water withdrawal perhaps expressed as a water management strategy, This expression is the forecast of value that is required for the analysis of shadow price outlined by Arrow et al. (2003) shows that if the quantity variable for which we require a shadow price is y then the price that should be used is $\partial E(V)/\partial y$ This requires that we are able to derive an expression for the integral. For an important class of functions of $f(X) = X^{\lambda}$. This fits in with standard models of the valuation of wetland. And for those models for which we can obtain valuation parameters and estimates, this allows expected present value and marginal changes in it to be calculated.

2.3.3 The Determination and Importance of the Discount Rate

Time plays a pivotal role in the analysis of water extraction options and their costs. Investment costs will occur early in the planning period and benefits will be spread over many years into the future. We use the social discount rate as outlined by Pearce et al. (2003). They show that the it is given by the Ramsey equation: $s = \rho + \mu.g$ where s = social discount rate, ρ = the `pure' rate of time preference , μ = elasticity of marginal utility of consumption, and g = growth rate. For a western economy such as the UK, Pearce et al. use parameters in the Ramsey equation of : $\rho = 0.05$, $\mu = 1.0$ and $g = 0.02$, so that $s = 0.025$. Clearly for a transition economy, and one with a high growth rate due to oil production such as Kazakhstan, such numbers would be inappropriate. Using a figure from Evans (2005), $\mu = 1.58$. This would give an overall value of s for Kazakhstan of $s = 0.208$. This discounts future costs and benefits very rapidly, and costs and benefits after 12 years carry a weighting of only 0.1.

However, it may be that such a high theoretically justified discount rate is observed in practice, such as discussions between Kazakhstan and UNESCO relating to the question of withdrawal of Nura river flow from Tengiz-Kurgaldzhino lake systems, UNESCO (2002) Consideration of water for Astana and supply to the lakes was considered only within a two or three year horizon. This is consistent with a very high discount rate.

In the Ramsey equation it is taken that the parameter values are constant and known certainty. However, even if other values remain constant, the growth rate will be stochastic, if only because of uncertainty in the ecological value derived from variability in climate and rainfall. Using a two sector model, one with a certain growth rate, g, starting from a base of Y_0 and an stochastic ecological given by a value $E_t(t)$, then the Total Economic Value of Output is given by $V(t) = Y_0 \, e^{gt} + E(t)$ It is the growth rate of V(t) which ought to enter into the expression for the discount rate. The appropriate certainty equivalent discount rate when the growth in the economy is uncertain and has a mean of $\mathcal{E}(g)$ and a variance of var(g). is given by:
$\delta = \rho + \mu.\mathcal{E}(g) - 0.5.\mu^{*}(1+\mu).var(g)$; μ^{*} is the elasticity of marginal utility of income with respect to static risky choices. If there are substantial risks in the future then we should take more account of it. If risks are large, then discount rates should be low.

This measure of the degree of risk aversion is also quite likely to vary across countries. If the growth rate of GNP is 10% pa, for indicative purposes, then the only uncertainty arises from the stochastic nature of ecological value. Using a linear relation for wetland loss, then the Total Economic Value of output and ecological resource $= V(t) = Y(t) + \nu E(t)$ where the appropriate value of the ecological resource is ν, so $var(g) = w_E.\sigma^2$ where σ is the parameter in the GBM for river flow and hence quantity of wetland. Data for the river Nura suggest that $\sigma^2 = 0.397$, hence : $\delta = 0.208\text{-}1.8\times w_E$ where $w_E = \nu E/V$. So the discount rate is reduced from the previous figure, dependent on the share of the services derived from the wetlands in Total or Green GNP. If this takes a value of 0.01, then $\delta = 0.19$, if it takes a value of 0.1 then $\delta = 0.0208$. Constanza et al. (1997) estimated that the ratio of ecosystem services to GNP, at a world leve, is 1.8, so if the wetlands counted as 5% of the ecosystem services of Kazakhstan then $w_E = 0.09$ and so $\delta = 0.046$, which seems a reasonable figure. In this case, the high wealth effect for Kazakhstan arising from the high growth rate of an oil rich economy is entirely offset by the prudence effect that should be included because of a very high level of uncertainty relating to river flow and consequent ecosystem damage.

The expression for the discount rate is in fact time dependent, and if the value to be placed on the wetlands by the local community increases over time, as has been obtained by meta-analysis of CVM and other valuations for wetlands, then there will be a declining discount rate into the future. The calculations undertaken here for Kazakhstan suggest that similar high discount rates would be derived if ecosystem services and their potential variability were to be ignored.

An important conclusion from this is that there will be a difference between the discount rates used, quite rationally, by governmental and other decision making bodies in different countries and at an international level. This will impact on time horizons considered and how conservation agreements are interpreted and implemented. In subsequent analysis, the appropriate discount rate depends on the question to be answered. For the value of the wetlands and the damage cost arising from water extracted from the Nura, then we use two discount rates depending on whose values are being considered. For international conservation value we use a rate similar to that quoted for the UK. For locally based values then we take the discount rate as that used by a prudent but local management agency.

2.3.4 Valuation of the Wetlands

Ecological Value is derived from the area of wetland. In the long run, this depends on water flow into the wetland system, so if area of wetland = W, then on average over several years and hydrological cycles W=θX. So the shadow price for wetland will be an expression ζ(W). This will reflect issues of returns to scale, or relative scarcity, the communities interested, one local/regional, the other international. These will give different valuations. In particular, we expect that local values will depend on the size of the local population and incomes.

For wetland value, Van Beukering and Hirsch (2000) use a "Conservation Supply Price", derived from a study of Ruitenbeek (1992). The basic idea is that International Agencies such as UNEP, GEF and so on provide funding for conservation projects, and this gives an indication of what values they put on the environmental resources whose conservation they fund. In the context of the Nura and the Tengiz-Kurgaldzhino wetlands we can see a process of choice taking place within the World Heritage Thematic Study for Central Asia, of the IUCN. This method has advantages over other methods for estimating these values in that it is based on actual payments, and not on what individuals or governments say they might pay Secondly, it measures values directly related to conservation and biodiversity values. The value that Ruitenbeek derives for the supply price, or WtP is 15.76 ecu per ha per annum in 1989 prices. In terms of 2000 prices, using the same inflation and exchange rates as elsewhere gives a Willingness to Pay of € 27.55. Using an 8% discount rate, the present value price for the total flow of biodiversity services would be € 344.3 per ha. Using this value directly to the wetlands gives a total capital value of € 89.5 million.

An alternative approach to valuation is based on meta-analysis. This is a recognised technique for investigating valuation methods and the values that they generate, and enables the transfer of valuations between locations to be undertaken, whilst recognising differences between those locations. Two different meta- analyses are used, firstly that of Brander et al. (2006), and then that of Woodward and Wui (2001). Using the coefficients obtained by Brander, and data for the Kurgaldzhino wetlands and the locality gives an expression for the value of wetland ecosystem services per unit of area s_1 which is given by

$s_1 = \alpha_1 \left(\frac{GDP_0}{N} \right)^{1.16} \left(\frac{N}{A} \right)^{0.47} X^{-0.11}$, so that if we assume that GDP and population N grow at constant rates g_1 and g_2 .and if base levels are indexed by the subscript 0, then the value of wetland ecosystem services for the whole wetland at time t will be given by

$s_1 = \alpha_1 \left(\frac{GDP_0}{N_0} \right)^{1.16} \left(\frac{N_0}{A} \right)^{0.47} \left(X(t) \right)^{0.89} e^{(1/16 g_1 - 0.69 g_2)t}$. Table 2.4 gives two sets of the constant parameters α. These show the effect of permitting hunting on value, and are for when a non marginal change is being considered, such as total loss due to a catastrophe, α_1 or for when marginal or reversible loss of wetland area, α_2

Table 2.4. Effect of permitting hunting on wetland value

		Hunting included	Hunting excluded
Marginal	$\ln(\alpha_1)$	-6.42	-5.32
Non-marginal	$\ln(\alpha_2)$	-7.37	-6.27

The equation allows for consideration of how values would increase as the wealth of the country increases over time. That we should allow for such increases in value reflects the well established fact of the Environmental Kuznets Curve.

Woodward and Wui (2001) consider a somewhat different set of variables. In particular, they omit local variables such as population density and GDP. Thus, their specifications can be used to obtain an alternative valuation to the wetland, which being independent of local variables, can be taken to be equivalent to a CVM study for international values such as conservation and biodiversity, and so represent the values inherent in Ramsar status.

The value equation for the Kurgaldzhino wetland, derived from Woodward and Wui is, for a value per ha, $s_2 = \alpha_2 X^{-0.17}$. V_2, the international value, is derived from estimates obtained by them, and for specific local data, it is $V_2 = \alpha_2 E\left\{\int_0^\infty (X(t))^{0.83} e^{-\varsigma_2 t} dt \mid X_0 = X\right\}$ where ς_2 is the discount rate appropriate to international inter-temporal valuations. This displays a slightly greater degree of diminishing returns, than the Brander et al. calculations. The degree of diminishing returns can be seen as a measure of risk aversion, and the lower the exponent giving returns to scale, then more concave is the value function and consequently the more risk averse is the underlying welfare function.

The value derived from the Supply Price approach (€ 89.5 million euros (2000)) is close to that of V_2.. Both are substantially greater than those calculated from the Brander et al. meta-analysis. One obvious reason for this is that the Brander calculation is based on local variables such as regional GDP and population. So this must be interpreted as being the value that can be ascribed to the local population. However the main benefits of the wetlands lie in its provision of biodiversity and habitat for endangered species. This is recognised in its listing as a Ramsar site and in its nomination for World Heritage Status, recognition of which would appear to depend on having appropriate management strategies in place. Valuation depends critically on whether the coefficient for bird watching is included or not. Including this causes a reduction of one sixth in value. Bird watching is an important aspect of the Kurgaldzhino nature reserve and there is a developing eco-tourist business in promoting this.

2.3.5 Water Supply in the Basin

Supply is divided into the five options that are being considered for Astana water supply, with two possible levels of usage for water from the river Nura (Table 2.5). These correspond to full usage as envisaged by the World Bank study, and 50% usage reflecting a limitation, that might be imposed because of potential ecological cost. The other options are the existing use from the Ishim river via the Vyacheslav reservoir, the use of the new link from the Irtysh-Karaganda canal, and improved water management techniques by the Astana Vodokanal.

Table 2.5. Water supply options for Astana

	Nura 1	Nura 2	Ishim	Ishim + IK canal	Demand Management
Capacity good state	45	45	56	27	20
Capacity bad state	33	33	36	27	33.3
Initial Capital Cost	0	0	0	28	10.8
Ecological cost from catastrophe	0	94.8	0	0	0
Variable cost good state	0.8	0.8	1.03	2.64	1.99
Variable cost bad state	0.8	0.8	1.03	2.64	1.99

The different numbers supplied by different sources are used to give values for the good and bad states. So, for example, the amount of water that can be provided from the River Nura to Astana City is given as 90 million m^3 by World Bank (2003), but a range of 78 declining to 66 million m^3 is provided by van Beukering and Hirsch (2000). The World Bank figure is taken to be an optimistic one that would apply to good states (good referring to high rainfall/non-drought conditions), and the Van Beukering and Hirsch figure is taken as a pessimistic one that applies to bad, or low rainfall, states.

2.4 Norrström

2.4.1 Analysis of water use in the Norrström, Sagån and Svartån water basin

The Norrström river basin covers an area of 22.600 km^2, which corresponds to about 5% of the area of Sweden. The basin includes two of Sweden's largest lakes; Mälaren with an area of 1000 km^2, and Hjälmaren which is about 500 km^2 (Figure 2.6). The number of people living in the area is approximately 1.2 million. Forests and mires dominate the basin area and cover about 70%. There are also large agricultural areas, covering approximately 20%, while lakes cover around 10 % of the area (Wallin et al., 2000). Mälaren and Hjälmaren are connected through the river Eskilstunaån. The outlet of Lake Mälaren to the Baltic Sea is situated in central Stockholm.[2]

The Norrström river basin is situated in central Sweden and includes vast forested areas, but also large agricultural areas. Some of the main cities of Sweden are also located in the basin.

Figure 2.6. The Norrström river basin

The municipalities in the Norrström, i.e. Sagån and Svartån water basins are Sala, Norberg and Västerås.[3] These municipalities belong to the county of Västmanland. Table 2.6 shows water use in the three municipalities. The data applies only to users who are connected to the municipal water system. As shown households are the dominant users of water supplied by the municipality. In general, however, the industrial sector is the biggest water user including both surface and ground waters that are often withdrawn directly from the source.

Table 2.6. Water use in 1000 m³ (1995)

Region	Norberg	%	Sala	%	Västerås	%
Households	436	38	1457	53	9310	41
Industries	310	27	78	3	4742	21
Agriculture	21	2	442	16	792	4
Other	367	32	783	28	7611	34
Total	1134		2760		22455	

[2] http://ivl.dataphone.se/twinbas/norrstrom.asp
[3] Ån = river

In the county of Västmanland agricultural productivity has increased in average by more than 40 percent during the period 1998-2003. The increase has been more pronounced for the following crops: Autumn wheat 31 %, spring wheat 49%, spring grain 57% and oats 37% (SCB (2005)).

Sala: socioeconomic data[4]

The municipality of Sala includes 7 agglomerations (Sala, Möklinta, Ransta, Salbohed, Sätra brunn, Kumla kyrkby, Västerfärnebo) and the total population is relatively small with more than 21000 inhabitants in year 2004.

Table 2.7: Population in Sala

Year	1970	1980	1990	2000	2004	2004/1970
Population	19595	20936	21820	21548	21554	1.099

In 1970 the total population of Sala municipality was 19595 inhabitants and increased to 21554 in 2004. As shown in Table 2.7 this is almost a 10 percent increase during these 34 years where the age repartition in 2004 is as follows:0-19 years: 24 %, 20 - 64 years: 59 %, 65 years + : 17%. When it comes to average income in the municipality, it has been 232000 SEK (Euro 25778)[5] for men and 175000 SEK for women (Euro 19444).

The proportion of persons connected to the municipal water is around 71 percent. The proportion of households living in apartments is around 35 percent and 65 percent is in villas. When it comes to water purification, the municipality of Sala has six water purification plants and around 200 kilometres water pipes. The yearly production of water from the six water purification plants is 1.9 million m^3.

The agricultural sector

The proportion of the population engaged in agriculture, hunting and fishery is estimated to around 5 percent. The total agricultural land is 28067 hectares. Table 2.8 shows land use in agriculture during the period 1999-2003. As shown, land use has increased for most crops but for wheat it has increased most.

Table 2.8. Land use in Sala municipality 1999-2003

Crop	Percent increase
Wheat (autumn)	198
Wheat (spring)	65
Ray	37
Oats	2
Ray-wheat	19
Mixed grain	57

The industrial sector (and services)

There are several manufacturing and service industries in the Sala municipality. For manufacturing industries the number is 577 and for services the number is 569.

4 http://www.Sala.se/

5 1 Euro = 9 SEK

Västerås: socioeconomic data[6]

The municipality of Västerås includes 13 agglomerations where the city of Västerås is the largest.[7] Total population is relatively large with more than 130000 inhabitants. This population has increased by 12 percent during the period 1970-2004 (see Table 2.9).

Table 2.9 Population (Västerås)

Year	1970	1980	1990	2000	2004	2004/1970
Population	116725	117487	119761	126328	131014	1.12

In 2004 the population in the municipality of Västerås was distributed as follows: for the ages 0-15 = 19%, 19- 64 = 64 and 65+ =17%. Further, average income (2003) is equal to SEK 265000 for men (29444 Euro) and SEK 186000 for women (Euro 20667).

The proportion of households living in apartments is around 42 percent where the rest i.e., 58 percent is living in villas. Households' water consumption is around 210 litres/day. The proportion of persons connected to the municipal water is around 87 percent.

The agricultural sector

The proportion of the population engaged in agriculture, hunting and fishing is 1 percent of the total population. The total agricultural land is 30249 hectares. For many cereals land use has increased during the period 1999-2003 as shown in the Table 2.10.

Table 2.10. Land use in Västerås 1999-2003

Crop	**Percent increase**
Wheat (autumn)	182
Wheat (spring)	1
Grain (autumn)	469
Grain (spring)	76
Oats	96
Ray-wheat	135
Mixed grain	483
Rape (spring)	13

The industrial sector (and services)

There are several industries in the Västerås municipality including both manufacturing and services. For manufacturing industries the number is 1212 and for services the number is 3589.

Norberg: socioeconomic data[8]

The Norberg municipality has almost 6000 inhabitants. Table 2.11 shows that the population has decreased by around 14 percent in the period from 1970-2004. The age repartition of the population is as follows: 0-15 = 18%, 19- 64 = 62% and 65+ =20%. The average income in the municipality is in average SEK 192000 (Euro 21 333) for men and SEK 127000 for women

[6] www.vasteras.se/
[7] Västerås, Barkarö, Dingtuna, Hökåsen, Kvicksund, Skultuna, Tillberga, Tortuna, Irsta, Enhagen-Ekbacken, Tidö-Lindö, Kärsta and Bredsdal,Munga
[8] http://www.norberg.se/

(Euro 14111).

Table 2.11. Population in Norberg

Year	1970	1980	1990	2000	2004
Population	6794	6843	6665	5939	5949

The proportion of persons connected to the municipal water is around 98 percent. The proportion of households living in apartments is around 42 percent where the rest i.e., 58 percent is living in villas. Water consumption per household is around 155 litres per day.

The agricultural sector

The proportion of the population engaged in agriculture, hunting and fishing is almost 1 percent. Of the 1669 hectares used for agriculture, land use has mainly increased for wheat, grain and oats. On the other hand fallow field has increased by 24 percent as shown in Table 2.12.

Table 2.12. Land use in Norberg 1999-2003

Crop	Percent increase
Wheat (autumn)	-
Wheat (spring)	3
Grain (spring)	7
Oats	11
fallow field	24

The industrial sector (and services)

The number of industries including both manufacturing (i.e., 116) and services (i.e., 160) is relatively large in the Norberg municipality. For the manufacturing industry only two firms have more than 50 workers.

2.4.2 Emissions to Sagån and Svartån

In Sweden in general and Västmanland as well as the related municipalities in particular, the sources of eutrophication are many. Table 2.13 shows the average leaching of N and P using the SWAT model. As shown the agriculture areas are the dominant source of leaching of the nutrients to Sagån during the years 1998-2004. Leaching of N and P from these areas is more than 78 percent and 80 percent, respectively. The other sources with high leaching are point sources including water treatment plants, forest and households.

Table 2.13. Leaching of N and P to Sagån water basin (kg) 1998-2004

Parameter	N	P
Households	11582	1698
Point sources	72274	1094
Agricultural areas	421547	25342
Forest	22812	1675
Open land	1321	147
Transitional woodland	5791	452
Urban fabric	1761	146
Wetland	1819	67
Total	538907	30621

For the case of Svartån, Table 2.14 shows the average leaching of N and P during the years 1998-2004. Here again, the dominant emitter of nutrients is the agricultural sector with more than 60 and 70 percent of N and P emissions, respectively. The other sources with high leaching are forest and households and point sources.

Table 2.14. Leaching of N and P to Svartån water district (kg) 1998-2004

Parameter	N	P
Households	6091	895
Point sources	14996	253
Agricultural areas	92132	6479
Forest	29996	1090
Open land	1962	14
Urban fabric	5418	629
Wetland	704	22
Total	151299	8234

2.4.3 The agricultural sector: Baseline scenario

Since the largest emitter of N and P is the agricultural sector, the remainder of this study will concentrate on this sector. As mentioned in WP7, the IPCC's A2 and B2 scenarios are expected to result in a series of significant changes to the climate system in Scandinavia.[9] These changes will also have a significant impact on the agricultural practices of the region considering such impacts as an increase in the growing season and drier summers. This in turn is expected to imply changes of the type of crops grown and changing harvest times.

The assumptions included in the baseline scenario underlying the changes to agricultural practices in Sagån and Svartån watershed are:

- Most crops are grains for food production (barley, wheat);
- Approximately 100 % of all agricultural land is in use;
- Growing season of approximately 5-6 months;
- Planting takes place in the end of April or beginning of May;
- Harvest takes place in the end of August or beginning of September;
- Increasing real fuel prices coupled with increasing agricultural productivity keeps energy crop land use in check;
- Increasing pesticide use from reduced tillage;
- Swedish agriculture remains internationally competitive;
- Bio fuels become economically viable;
- Soil types remain unchanged;
- Fertilizer usage remains constant.

[9] For the IPCC scenarios see IPCC Third Assessment Report 2001

2.5 Thames

The economic importance of water has two components: the importance of water to the user (i.e. availability of water, quantity used, quality of water) and the importance of the use in economic terms (i.e. in terms of value added to the economy) (EASG, 2004). The baseline scenario reflects information on how these factors are likely to change over time i.e. the dynamics of water use. An investigation of the dynamics of water use relevant for river basin characterisation will aid the assessment of forecasts of key economic drivers likely to influence pressures on water bodies and, thereby, water body status. This involves a review of changes in general socio-economic variables, key sector policies that influence water use, economic growth and planned investment linked to existing water regulation, as well as assessment of how important water is to the economy and socio-economic development of the basin, and investigation of likely trade-offs between socio-economic development and water protection. This process will involve economic profiling of basins in terms of general indicators (FWR, 2004). Baseline scenario development is, therefore, a means of identifying significant water management issues for the future, by complementing the water body classification and characterisation of the basin with an assessment of probable trends in driving forces. This information provides useful inputs to both decision-making and public participation processes, and to the development of programmes of measures for water bodies at risk of not achieving good ecological status. A baseline scenario presents a general statement of the basin's evolution in the near future, as a support to the development of river basin management plans.

The following sections provide an overview of the socio-economic importance and dynamics of water uses in the Thames river basin (defra, 2004a), and forecasts for population, number of households, output (in gross value added terms) and employment (all to 2015). The information is based on ERM (2004), which includes a comprehensive review of data sources relevant to the economic analysis of water use, profiles of the main sectors associated with pressures in water bodies, and contextual information supplied by interested stakeholder groups. Sector profiles were compiled for: power generation, petrochemicals, other chemicals, metal manufacturing, paper industry, other manufacturing, extractive industries, quarries and aggregates, transport, public water supplies, private water supplies, wastewater treatment and recreation. Profiles for the agricultural sector were provided by Cambridge University (2004). Economic forecasts of population, housing, employment and economic output were complied by Experian Business Strategies Limited, using information from the Office of National Statistics, and are available in Annex 2 of defra (2004a). The methodology for the derivation of baseline scenarios in the Thames river basin has largely utilised the relevant EC guidance documents (EC, 2003; 2004).

2.5.1 Driving forces

This section, drawing on defra (2005a; 2005b), summarises the limited information available about the driving forces and future development pressures associated with the water uses which form the main components of the baseline scenario (households, industry and agriculture), and also with the predicted impacts of climate change, in the Thames river basin.

Population and households

Information relating to the historical change in the Thames river basin population, the number of households and the population per household, assists in understanding the levels of domestic water use specific to the basin. Being one of the most densely populated countries in the world, housing growth is a significant issue in the UK. The majority of the estimated 200,000 new households likely to form per year over the next 20 years will be concentrated in south-east England, covering much of the western and northern parts of the Thames river basin. The population of the basin is forecast to grow by 0.7% between 2002 and 2015. The size of households is in decline, and the total number of households is predicted to increase by around 1% per annum, increasing both water demand and development pressure (defra, 2005b).

Output and employment

Output and employment levels are used to assess the economy of the Thames river basin. Analysis of historical trend data enables identification of the areas of the economy that have expanded or contracted in recent years which, in turn, allows an appreciation of the key sectors that are driving the basin's economy. Other socio-economic characteristics collected that provide useful information relate to employment in the basin e.g. the level of deprivation, the level of unemployment, the level of working age population with no qualifications. These statistics help build an understanding of the potential need for Government intervention (defra, 2005a).

Economic activity in the Thames river basin is predicted to continue to increase at a strong rate. Both the services sector and some parts of the more water-intensive industrial sector are expected to grow, with the manufacturing sector largely in decline. Business services, communications, banking and insurance and other financial services are important growth sectors. These trends are consistent with the Regional Economic Strategies of the regions (south-east and east) within which the basin is located, as well as the Economic Development Strategy for London. These strategies identify sectors which have major significance for the future of the basin. These are based on emerging technologies (pharmaceuticals, life sciences, biotechnology and healthcare, information and communication technologies, multi-media/creative industries, and environmental technologies), major employment concentrations (tourism and leisure, freight transport and logistics, construction and property services, financial and professional services, and land-based industries) and high value-added manufacturing industries (advanced engineering (including automotive), aerospace and defence, and marine technologies). In addition, the London Plan identifies six different types of area with particular importance to economic development and regeneration, including the east London location for the 2012 Olympic Games. The priority, where possible, is for brownfield regeneration, protecting green land and minimising negative impacts on neighbouring regions (defra, 2005b).

Agriculture and forestry

Agricultural sector activities in the Thames river basin predominantly comprise livestock husbandry and crop-growing in the rural parts of the basin. The common agricultural policy (CAP) has led to land use changes over the last 30 years. Agricultural intensification, such as increased stocking, fertiliser and pesticide use, has resulted in increased pressures and impacts on water bodies. Intensification has slowed in recent years, and the growth of organic farming and CAP reform are expected to consolidate this trend and, thereby, provide some landscape, water quality and biodiversity benefits. Within the basin, a slight decrease in overall agricultural area is predicted, though this may hide potentially significant changes in the structure and intensification of the industry and how businesses are managed. The England Forestry Strategy encourages and anticipates a continued steady expansion of woodland with the focus of new woodland creation in the lowlands, including areas close to towns and cities. Regional forecasts indicate that output from the agricultural sector in the basin will decline over the period to 2015 (defra, 2005b).

Climate change

It is agreed that climate change will affect all aspects of the water environment, but there remain many uncertainties about the impacts and their magnitude. Predicted impacts of climate change in the Thames river basin include warmer and wetter winters, hotter and drier summers, and deteriorating air quality and water quality, with a greater risk of flooding in winter, and possibly drought and water shortages in summer. Changes in land use and water consumption related to changes in climate are also anticipated. More detailed information about projected climate changes and their impacts for the UK are available from the UK Climate Impacts Programme (UKCIP). Even the more moderate possible changes in weather patterns could have an indirect impact on the water environment, with changes in climate variability making it more difficult to assess the risks and pressures, the long-term effectiveness of programmes of measures, and the efficacy of sampling and monitoring regimes (defra, 2005b).

2.5.2 Pressures

This section, drawing on defra (2005b), summarises information on characteristics of water use, in terms of abstractions, discharges and morphology, and identifies the most important sectors associated with pressures in these categories.

Abstractions
In the Thames river basin, water is abstracted from water bodies to provide public water supplies and serve industry and agriculture. The main challenge in managing abstractions is meeting the demands of water users, whilst leaving enough water in the environment for ecosystem habitats. For instance, low river flows may be caused by periods of low rainfall, and may damage river ecology, but the impacts, and subsequent recovery time, can be prolonged or made worse by abstraction at critical periods. Unsustainable abstraction from groundwater can lower groundwater levels and have knock-on effects on river flows or wetlands. In the Thames river basin, abstraction is controlled by a licensing system administered by the Environment Agency, who also regulate other major influences on flows, such as inter-basin transfers of water and flow-controlling structures e.g. dams (defra, 2005b).

Abstraction and flow-related pressures are clearly linked to economic activities in the basin e.g. household and economic growth will affect the level of water demand. Therefore, these relationships can be factored into risk assessments. However, further work is needed to improve the link between abstraction and flow-related pressures and specific activities. Defra (2004a) provides information on the economic characteristics of the main activities related to these pressures. Water companies are the most important abstractors in the Thames river basin. The electricity industry is the second largest abstractor in the basin, and output in this sector is expected to continue to grow.

Discharges – point sources
In the UK, the Agency uses permits to control the amounts of substances discharged from point sources, and regularly monitors effluent discharges. Such authorised point sources are those sites that have permits to discharge at a specific place, like sewage works or industrial discharges, and operators of such sites commonly discharge effluent at a quality that is better than their permit allows, which gives them a safety margin to guard against failure of their permit conditions. However, there may also be accidental discharges of harmful substances that damage habitats and cause a loss of flora and fauna (defra, 2005b).

Since point source pressures are directly linked to economic activities in the basin, these relationships can be factored into risk assessments. For instance, household growth affects the level of sewage discharge, and economic growth affects the level of industrial discharges. However, further work is needed to improve the link between point source pressures and specific activities. Defra (2004a) provides information on the economic characteristics of the main activities related to point source pressures in the basin.

Discharges – diffuse sources
Diffuse source pressures generally arise from land use activities, both rural and urban. These are activities dispersed across a basin that have an individually minor, but collectively significant, environmental impact. Examples of diffuse pollution to surface and ground waters include the transport of nutrients and sediment from farmland, and the runoff of water contaminated with pollutants from hard surfaces in towns, or from mine workings. Diffuse pollution is often event-based i.e. associated with heavy rainfall when pollutants are flushed into watercourses. In the Thames river basin, indeed in the UK, knowledge of diffuse source impacts at a national scale is less than that for point sources, as the Agency’s surface water monitoring programme concentrating on the latter (defra, 2005b).

Since diffuse source pressures are largely associated with dispersed activities taking place in urban areas which contribute to runoff from hard surfaces, and in rural areas from the use of specific substances in agriculture (fertilisers and pesticides), links between economic activities and diffuse pollution pressures are very difficult to determine. Further work is needed to link diffuse source pressures to activities, particularly for diffuse pollution from non-agricultural activities. Defra (2004a) provides information on the economic characteristics of the main activities related to diffuse source pressures in the basin, of which population and agricultural production are important drivers.

Morphology
Physical alterations to a basin water body can cause habitat damage or loss and result in a decline or loss of species. Activities such as land reclamation, dredging, commercial fishing, and the construction of physical barriers (such as flood defences, weirs, barrages and sluices), can all damage physical habitats, alter water and sediment movements, and sometimes impede the passage of migratory fish. Using water for transport and recreation also often requires physical alteration to habitats and affects the flow of water (defra, 2005b).

Some morphological pressures can be linked to economic activities but others are more difficult, often being related to historical activities. Defra (2005a) provides information on the economic characteristics of the main activities related to morphological pressures in the Thames river basin, particularly in terms of urbanisation and shellfish harvesting. However, further work linking morphological pressures to activities is necessary.

Other pressures
Another pressure, that can result in loss of natural biodiversity and have significant economic impact, are alien species i.e. non-native organisms that establish themselves in, and subsequently disrupt, native ecosystems. Such species have been introduced into the Thames river basin by humans (deliberately or accidentally) and there is growing evidence that they can cause a major threat to native flora and fauna (defra, 2004b).

2.5.3 Baseline scenario

The baseline scenario provides a projection of "do nothing" or "business as usual" policies and trends i.e. it is a reference scenario, which includes known policy changes and other adaptations (but no others). This provides a foundation on which to develop and apply scenarios, such as programmes of measures for meeting a WFD objective e.g. water bodies at risk of not achieving good ecological status (EASG, 2004). The main pressures which are considered in development of the baseline scenario are from the water industry and agriculture, driven by policy drivers, cost drivers, environmental management and investment, industrial output projection, and water resource productivity.

3. Economic effect of change scenarios

3.1 Okavango

3.1.1 Economic Value of the Delta in the Botswana Economy

Table 3.1 summarises the direct use values of the study area. The gross output, and gross value added, or the contribution to national product are included as well as the economic resource rent generated by each use. The resource rent is calculated from the resource use enterprise models and data. Resource rent is economic rent and defined as the gross output less the costs of production plus a reasonable return to capital. It is commonly referred to an excess profit in the literature. It is used in the calculation of the value of the Ramsar site and the wetland as natural assets, as will be seen below.

In terms of direct use value, by far greatest values are those for the use of the natural resource base for tourism. The gross output associated with tourism in the Ramsar site is estimated to be Pula (P) billion, while that for agricultural activities is only P92 million, and that for natural resource harvesting and processing is only P32 million. Most of the very high tourism output is attributable to the wetland (P1 billion). Nearly all the agricultural output in the Ramsar site is attributable to the drylands in the site, and only one thirtieth P2.8 million of it is attributable to the presence of the wetland. About half (P17 million) of the natural resource harvesting and processing output is attributable to wetland.

Tourism in the Ramsar site directly contributes an estimated P400 million to the gross national product and most of this, some P363 million, is attributable to the actual wetland. Agricultural resource use, overwhelmingly dominated by livestock production in the Ramsar site contributes an estimated 43 million to the gross national product. The contribution of the wetland to this is small, being only P1.4 million. Natural resource use (harvesting and processing) in the Ramsar site contributes an estimated P29 million to the gross national product. The wetland contributes about half of this, or P15 million.

It has been we attempted to value the ecological services provided by the Ramsar site and the wetland. Only some of these indirect use values would be reflected in the conventional measures of the national economy. Thus, the value of the delta as a refuge for wildlife which is used off-site, specifically outside the Ramsar site, for tourism can be considered to contribute amounts to the gross national product that are additional to the tourism values described in Table 3.1. An estimated gross output of some P33 million in tourism value comes from trophy hunting outside the Ramsar site that would add an estimated P18 million in gross value to the national product.

The effects of other ecological service values, and the option and non-use values, associated with the delta, on the economy of Botswana are very difficult to estimate. Those that can be captured though appropriate international markets, such as carbon sequestration services, and the willingness to pay for delta preservation (option and existence values) can ultimately contribute to national income.

Table3.1. Summary of the direct economic use value of the Okavango Delta Ramsar site (P'000, 2005)

RAMSAR SITE	Direct Gross output	Direct GNP Contribution	Natural resource rent
TOURISM ACCOMMODATION	**675,360**	**327,990**	**158,450**
Lodges/Camps (non-consumptive)	445,580	209,460	102,480
Camps (trophy hunting)	103,190	56,890	29,930
Mobile & self-drive safaris	93,290	43,230	18,660
Guest houses, B&Bs, motels	19,660	12,240	4,520
Hotels	13,640	6,170	2,860
TOURISM LINKED ACTIVITIES	**440,450**	**72,980**	**33,160**
Restaurants/bars (independent)	110,180	15,930	7,710
Transport (air charter, airline, road)	105,480	17,980	8,440
Travel agents, guiding services	47,220	9,470	4,250
Shopping	166,590	24,270	11,660
Additional CBNRM income	10,980	5,330	1,100
SUBTOTAL TOURISM	**1,115,810**	**400,970**	**191,610**

CROP PRODUCTION	**9,030**	**2,770**	**320**
Crops – molapo	2,770	1,370	190
Crops – dryland	6,270	1,400	130
LIVESTOCK PRODUCTION	**83,210**	**39,760**	**950**
Livestock - cattle posts	74,560	34,370	0
Livestock - village	8,650	5,390	950
SUBTOTAL AGRICULTURE	**92,240**	**42,530**	**1,270**
NATURAL RESOURCE HARVESTING	**26,800**	**24,050**	**16,420**
Fishing	3,190	3,160	690
Firewood	9,260	8,910	7,870
Poles, withies	1,880	1,730	1,600
Timber	600	600	340
Grass	4,420	4,380	2,480
Reeds	2,460	2,330	1,380
Papyrus	30	20	10
Palm leaves	1,880	1,880	1,050
Veld foods	1,480	1,480	830
Medicines	300	290	170
Birds	920	-420	0
Other wildlife	380	-310	0
NATURAL RESOURCE PROCESSING	**4,830**	**4,740**	**680**
Craft products	2,010	1,990	280
Food products	2,530	2,530	350
Wood products	290	220	40
SUBTOTAL NATURAL RESOURCE USE	**31,630**	**28,790**	**17,090**
TOTAL RAMSAR DIRECT USE VALUES	**1,239,680**	**472,290**	**209,980**

Impact on Rural Livelihoods

In Table 3.2, the value added by use of the resources of the Ramsar site and the wetland, which accrues directly to local low-income households has been estimated. In the Ramsar site as a whole, local communities earn significant amount in profits from direct use of natural resources. Significant amounts are profits in-kind (consumed directly) while in the case of livestock, and in particular cattle post livestock, important cash profits are also earned from sales. Local low-income households earn comparable amounts through salaries and wages earned in the direct use of the delta's resource for tourism activities. Low income communities also derive income collectively through rentals and royalties from CBNRM joint ventures in the tourism sector.

Table 3.2. Estimated direct contribution of the Okavango Delta Ramsar site and wetland to the livelihoods of low income rural households in Ngamiland (P'000, 2005)

RAMSAR SITE	**Profits in-kind**	**Profits cash**	**Salaries & wages**	**Rentals & royalties**
Non-consumptive tourism services	0	0	72,800	18,990
Hunting tourism services	0	0	13,410	5,650
Tourism linked activities	0	0	5,080	0
Additional CBNRM income	0	3,180	1,320	0
SUBTOTAL TOURISM	0	3,180	92,620	24,640
Crop production	5,330	1,060	1,150	0
Livestock production	17,560	43,610	7,820	0

SUBTOTAL AGRICULTURE	22,890	44,670	8,980	0
NATURAL RESOURCE USE	21,070	7,340	150	0
TOTAL RAMSAR SITE LIVELIHOOD CONTRIBUTION	**43,950**	**55,190**	**101,750**	**24,640**

Macroeconomic Impact

The *total* economy-wide impact of the Okavango Delta is a sum of the direct plus the indirect impacts. The ratio of the total to direct impact (on sectoral output, incomes, employment or any other variable relevant for policy) is called a "multiplier" because it measures how a change (increase or decrease) in one sector's level of activity will affect the entire economy.

The Social Accounting Matrix (SAM) is an economic tool designed for economic impact analysis. The SAM expands the national accounts in the format of a table that shows the linkages among all components of an economy: production and generation of income, distribution of income, expenditures, savings and investment, and foreign trade. Several SAM models have been applied in Botswana. Using the most recent Household Income and Expenditure Survey, a new SAM for 2002/2003 was constructed for Botswana (Thurlow, 2006). This basic SAM has been expanded to analyse economic activities in the Okavango Delta for the present study.

Using the Ramsar site SAM model and the hydrological model the impact of economic activities in the Okavango Delta on the national economy was calculated. Table 3.3 shows the total impact of Okavango Delta activities on the Botswana's national income as measured by the Central Statistic Office (2006): the *direct* contribution to GNP is P475 million for the entire RAMSAR site, roughly 1.04% of the national GNP in 2005. But the *total* contribution to GNP is much higher: total income generated ranged was P1,182 million or 2.6% of the national GNP. The GNP multiplier - the indirect stimulus from Delta activities to the rest of the economy - is roughly 2.5 (slightly higher for the wetlands). That means, for every P1.00 of income generated from direct services provided to tourists or agriculture, an additional P1.50 of income will be generated because of the demand for products to produce those services, and the products households buy with their additional income.

The GNP multipliers for household agricultural and natural resource harvesting/processing activities are 2.03. This is lower than for tourism, because the household activities are mainly subsistence-based, with relatively small inputs from other sectors of the economy.

Table 3.3. The total impact of direct use of the natural resources of the Ramsar site and the wetland on the national economy (P'000, 2005)

	Direct GNP	GNP multiplier	Total GNP
RAMSAR SITE			
Tourism	400,970	2.58	1,032,870
Agriculture/natural resource use	73,600	2.03	149,340
TOTAL	**474,570**		**1,182,210**
Percent of total national GNP	**1.04%**		**2.60%**

3.2 Biobío

3.2.1 Identification of Impacts with No Climate Change

Impacts in the Livestock and Forestry Sector

Impacts on Livestock

From the analysis of the monitoring in sections and stations defined in the standard, we identified five sections with indicators that we estimate can be associated to livestock and/or dairy farming activities, in terms of current quality as well as the surface water quality in the 5 year projection. This can be seen in the following tables.

Table 3.4. Reduction Magnitude (W[1]) that can be attributed to livestock and/or dairy farming activities

Parameters	Rivers				
	Bio-Bio	Bureo		Guaqui	Rarinco
	BI-TR-33	BU-TR-11	BU-TR-12	GU-TR-10	RA-TR-10
DBO5	-9.26%				-6.79%
Ammonium			-2.1%		
Nitrite			-7.19%	-4.54%	
Fecal coliforms				-0.91%	-1.77%
Total coliforms		-12.79%			
DQO		-12.06%	-4.4%		-12.82%
Nitrate			-3.1%		
Phosphorus					
N-Total			-9.01%	-1.77%	
Reduction % in section:	-9.26%	-12.79%	-9.01%	-4.54%	-12.82%

Source: Elaboration based on the methodology expressed in chapter 3, point 3.2. Identification of Impacts, 3.2.1. Water Quality Methodology, letter i.

Secondary Standard and Soil Erosion

In the Biobío basin there is a series of soils that have higher sensitivity to erosion; these are San Esteban, Cauquenes, Colipulli. These use part of the towns of (from bigger to smaller used surface) Los Angeles, Angol, Nacimiento, Yumbel, Santa Juana, Laja, Quilaco. Totalizing a surface of 1,809,480 hectares.

Table 3.5. Reduction magnitude (W[2]) associated to erosion indicators in rivers Laja, Duqueco, Bureo, Vergara, Guaqui, Tavoleo and Rarinco

Parameters	Rivers										
	Laja		Duqueco		Bureo		Vergara		Guaqui	Tavoleo	Rarinco
	LA-TR-21	LA-TR-22	DU-TR-11	DU-TR-12	BU-TR-11	BU-TR-12	VE-TR-10	VE-TR-20	GU-TR-10	TA-TR-10	RA-TR-10
Suspended Solids		-48.5%			-29.3%		-60.55%	-28.05%	-39.5%	-47.5%	-51.8%
Dissolved Solids		-41.7%		-10.35%	-16.3%	-4.8%			-24.15%		
Chromium											
Iron				-1.0%							

Manganese		-30%				-63.9%					
Aluminum		-19.15%	-10.6%						-3.0%		
Suspended Solids Autumn	-57.2%	-63.2%		-63.8%	-28. 9%			-44. 5%	-30. 9%		
Suspended Solids Winter											
Suspended Solids Spring						-0.7%					
True Color		-5. 3%				-35.7%					
Reduction % in section (W^2)	**-57.2%**	**-63.2%**	**-10.6%**	**-63.8%**	**-28.9%**	**-63.9%**	**-60.55%**	**-44.5%**	**-39.5%**	**-47.5%**	**-51.8%**

Source: Elaboration based on the methodology expressed in chapter 3, point 3.2. Identification of Impacts, 3.2.1. Water Quality Methodology, letter j.

Management of Crops, Fertilizers and Pesticides

The examination of some parameters in the sections studied, that can be associated to evidence of contaminant debris, originated in fertilizers and pesticides, allows to observe that in sections corresponding to areas or territories with no industrial activity, there are signs on parameters that we must consider to be associated to farming activity.

Table 3.6. Reduction magnitude (W^3) associated to indicators of possible presence of fertilizers debris and chlorine products debris (AOX)

Parameters	Rivers		
	Biobío	**Vergara**	**Guaqui**
	BI-TR-31	**VE-TR-20**	**GU-TR-10**
Nitrite			-19.9%
DQO	-39.85%		
N-Total	-24.85%	-47.00%	-7.75%
AOX		-12.00%	-4.10%
Reduction % in section (W^3)	**-39.85%**	**-47.00%**	**-19.9%**

Source: Elaboration based on the methodology expressed in chapter 3, point 3.2. Identification of Impacts, 3.2.1. Water Quality Methodology.

The abatement of contaminants of diffuse source, coming from agricultural and livestock supplies has as one action course, regulation of their use and as different action course diffusion and fostering of Agricultural Best Practices.

Impacts in the Industrial Sector

Regarding the main characteristic of this sector, which makes it different from the farming and livestock sector, is that its contaminant sources can be perfectly located, because they come from industries discharging the industrial waste on localized sections of the Biobío and its affluent. Therefore, it is possible to be highly certain about what sections are mostly affected by industrial activity, using the contaminant indexes contained in the industry effluents.

Water Quality Analysis in the Sector

Table 3.7. Magnitude of the Reduction in Parameters Altered by Industrial Activity on the Biobío Basin, According to Affected Sections

Sections	DBO5		True Color		Suspended Solids		Ammonium		Manganese		Aluminum	
	A	B	A	B	A	B	A	B	A	B	A	B
BI-TR-40	L	L	L	L	-28%	-57.4%	----	----	-7.8%	-7.8%	-----	-----
BI-TR-50	-----	----	-----	-----	-32%	-20.0%	----	----	-----	-----	-----	-----
BI-TR-72	-----	----	-----	-----	-55%	-57.9%	----	----	-----	-----	-----	-----
LA-TR-21	-----	----	-----	-----	L	0.0%	----	----	-----	-----	-----	-----
LA-TR-22	-----	----	-5%	-5%	-43%	-53.7%	----	----	-28%	-30%	0.0%	-38%
VE-TR-10	-6%	L	-----	-----	-56%	-65.0%	----	----	-----	-----	-----	-----
VE-TR-20	-----	----	-----	-----	-25%	-30.6%	----	----	L	0.0%	-----	-----
GU-TR-10	-----	----	-----	-----	-47%	-31.5%	----	----	-----	-----	0.0%	L

Source: Elaborated according to monitoring tables per station of the EULA-CHILE Center

A - CURRENT SITUATION
B - PROJECTED SITUATION

- (white) Parameter with no alteration during the whole time horizon
- (green) Parameter saturated at the end of the time horizon
- (cyan) Parameter that goes from latency to saturation or vice versa
- (yellow) Parameter with saturation during the whole time horizon

3.2.2 Identification of Impacts with Climate Change

According to what is established on the methodology procedures of this study, to determine the impact of flow levels on the different parameters for water quality present in river Biobío, it is necessary to calculate the values of parameter-flow elasticity that would indicate what is the percentage variation of current and projected concentrations when the percentage point of the flow level in the section being evaluated is changed.

Results[10] indicate there is full agreement between signs in elasticity values calculated at the three stations for each parameter, which reflect the kind of parameter-caudal ratio (inverse or directly proportional) that coincides on all sections considered in the Biobío basin, therefore, behavior pattern of parameters if there are variations in the different flow levels along the basin, is very similar. Similarly, it can be observed that some parameters did not have, in any of the three stations evaluated, statistical relationship at all, or there was no information on the data base regarding that parameter, so an elasticity value was not calculated for these cases (for Chloride, Copper, Molybdenum, Cadmium, Mercury and Phosphorus). However, there are some exceptions where it was possible to find a statistical relation between both variables for the corresponding parameter in one station, but it was not possible for others, either because they did not exist (such criterion was determined according to the statistical importance) or due to lack of information (these are the cases for parameters of Dissolved Solids, Ammonium, Nitrite, Sulphate and Lead).

[10] See table 32 of original report

Percentage Variation of Impact Flows

Once the elasticity values previously shown were obtained, these were used for the necessary percentage variation in order to be a direct impact on the alteration of the current and future condition of the concentration levels of physical-chemical parameters influencing the water quality, this is, how much is the percentage variation of the flow level for a certain parameter to go from a normal situation to a saturation zone (above the limit established in the standard) or vice versa.

3.3 Nura

This section discusses how the basin might develop if currently discussed proposals for water use are carried through. By far the most important is the proposal that following a clean up of mercury from the river bed, that water could be used for the development of the new capital city of Kazakhstan, Astana. The main features here are firstly policies that can be though of as Sustainable in that they avoid the potential for ecological catastrophe in the closed lake and wetland system, secondly is the question, following on from interpretations of the Water Framework Directive, of how appropriate economic valuation of potential ecological damage to the terminal wetlands should be included in the social price of water obtained from the River Nura.

3.3.1 When might catastrophe happen?

For a threshold that corresponds to a constant level then we can obtain results as to when this threshold will be reached by a stochastic process for water inflow. This is the 'first hitting times'. For the management of the wetlands, we would be interested in a lower boundary value that corresponds to irreversible damage in the wetlands. This is given by the expected first hitting time E(T*) which is the expected first time for a stochastic variable starting from a value of S_0 of hitting a barrier at level a with $0 < a < S_0$. This is given by :

$$E(T^*(S = a)) = \frac{1}{\frac{1}{2}\sigma^2 - \alpha}\ln\left(\frac{S_0}{a}\right) \quad if \ \alpha < \tfrac{1}{2}\sigma^2 \ ; \quad = \ \infty \quad if \ \alpha \geq \tfrac{1}{2}\sigma^2$$

The expected time falls as the variance term in the process increases in relation to the trend term. So, for a sufficiently high variance, there is a finite expected time at which the lower boundary will be reached even if there is a positive trend component. When the current water level in the wetlands is high, in relation to the threshold catastrophe level, S_0/a may be high causing there to be a long time before hitting the threshold through natural variability[11]. If S_0' is an average stock of water in the wetlands at the point with an extraction/diversion strategy in place, and this is a proportion β of that with no extraction, then expected hitting time is increased by a factor of $\ln(1/\beta)/(\sigma^2/2 - \alpha)$. For the River Nura, $\beta = 0.5$, $\sigma_N^2/2 = 0.46$ [12] and $\alpha = 0$, the expected time to reach a threshold increases by 31.5%. For a western European river, such as the Rhine, where $\exp(\sigma_R^2/2) = 1.007$ and if for the Nura, $\exp(\sigma_N^2/2) = 1.3$, then $\sigma_N^2/\sigma_R^2 = 37.6$, hence the expected time that a low level of flow on the Nura will be reached is about 38 times sooner than that for a similar threshold but for a river with western European flow characteristics.

If there was a Normal distribution for water level, then $E(T^*(S = a)) = \frac{S_0 - a}{|\alpha|} \quad if \quad \alpha < 0$;

$E(T^*(S = a)) = \infty \ if \ \alpha \geq 0$. So that the expected time to reach the threshold level, *a*, is infinite, independent on the distance between the starting point for the process, S_0, and the threshold level. Whereas for normally distributed water flow and low variance we may be able to ignore the lower

[11] We are assuming here that the water stock in the wetlands will follow a process similar to that of water flow in the river.

[12] Corresponding to mean/ median ration for the River Nura

boundary on the basis of expectations, for log-normally distributed flow with a high variance then it is essential that this boundary be taken account.

3.3.2 Uncertainty and precaution in optimal water policy

Increasing variability in river flow will change the extent to which a Precautionary Approach should be adopted, in contrast to the case where a Certainty Equivalent approach is used.
Here the amount of precautionary behaviour is calculated, depending on the degree of variability, and learning about the river basin. Learning will be important if it applies to parameters that enter in a non quadratic way, so leading to a non-linear response. The true value of δ_1 may be unknown in the planning stage and may or may not be known later. The impact of learning has no unambiguous effect on the amount of precaution. In relation to the clean up of Mercury in the Nura, there is uncertainty related to how stable the mercury is in the river, and the possibility that it will reach the wetlands and lakes and cause damage to them. There is uncertainty related to the use of the water and its consequences once the mercury has been cleaned up. There is also uncertainty related to the stability of the mercury in the technogenic silt, and whether this is moving along the river or is stationary. Suppose the decision concerns how much of the mercury silt to remove, based on the damage cost of leaving the silt where it is. This could be low because the silt stays where it currently is close to the site of its original deposition, or high, because mercury can change form, and travel down the river. Irreversibility arises because, once the mercury silt has travelled down the river, it is harder to remove. For this problem the analysis of the previous section would apply. However, a rather different structure would apply to a decision which is either to fully clean up or not clean up.

Where large uncertainties exist, and when these apply to the decision model itself, they make conventional approaches unsatisfactory, and suggest the need for ‘Robust’ or ‘Safe’ policies. The question is what the level of the decision variables should be when the model being used to determine those decisions is not known. Hansen et al. (2001) show how robust control theory justifies the use of a decision criterion which is that of max-min expected utility, where the maximization is done with respect to the decision variables, and the minimization with respect to uncertain variables in the control model. Where a decision maker is unsure about what the appropriate model is, a max-min approach is appropriate, in the sense that it leads to the same decision rules, as other rather different structures leading to model uncertainty. Using the decision problem of water allocation, and the previous log-normal distribution for water flow in the river, we can see how a robust policy might be developed.

A more general use of the interpretation of the max-min version of robustness as making the best choice in the worst possible scenario is as follows. These strategies are equivalent to the ‘safe’ strategies that have been proposed for climate change. A safe strategy would be to avoid irreversible damage to the wetland and lake system. If the state of the wetland complex is determined by a differential equation, this would mean keeping the system within the reversible part of the solution. Given the current state of knowledge of the wetland, we cannot be entirely sure where the boundary value of b and range for that corresponds to a high ecological state lies. In this situation the optimal policy is to use past experience to determine a safe region which avoided catastrophic effects.

Comparing, for the current water levels, what is the worst outcome for water level over the longest experienced dry period if that started now, with the worst outcome that there has been, for an acceptable ecological status, and the current water level giving rise to that, gives a current surplus that can be safely used and diverted away from the wetlands. By calculating this surplus for each period, a safe plan for water use can be determined, and an expected value for water use calculated. This is the equivalent here of the safe corridor proposed for Greenhouse Gas emissions. Alternatively, it is equivalent to a safe policy for a pension fund, with future commitments which give a minimum value constraint but with uncertain payouts and returns. In this context, the lake and wetland complex can be viewed as a buffer stock, and water not used but allowed to flow into the wetland corresponds to precautionary savings.

3.3.3 Consequences for the management of the basin and the mercury clean-up decision

Two contrasting versions of the appraisal of the Nura Mercury Clean-Up Project are based on the issues concerning variability. In the first case, there is little difference between mean and median flow, and flows in different years are independent of each other. These correspond to the variability of water flow being low. This is the situation that would correspond to a western European river. Here, the flow corresponds to that arising from an Arithmetic Brownian Motion. As the expected hitting time for a lower boundary to be reached is not finite, it may be concluded that damage to the wetland will be at a low level. The water level remains above that at which substantial damage occurs. Loss of water level in one period can be made up in future periods, so that the period 1 decision is replicated in future time periods. So whilst extraction may be zero in very low flow years, there is no consequence for previous years' decisions.
We represent this decision process by the following decision tree (Figure 3.1). The end decision compares the clean up cost, CC with the benefit from mercury removal BM, the benefit from water use over future periods, BW, but as damage to wetlands is unlikely, DW = 0.

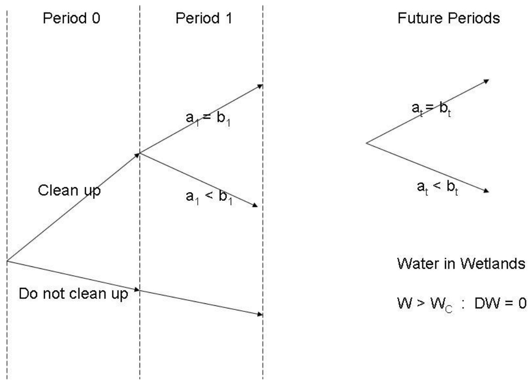

Figure 3.1. Decision tree for typical Western European River

The second extreme is one in which there is very high variability of flow, where the mean is much higher than the median, and the water level in the river and the wetlands correspond to a Geometric Brownian Motion. This generates a correlation between water levels in successive years and periods of wet and dry periods, and so is a stylised version of rivers and wetland systems such as that found on the Nura.

Here there is a finite expected time at which the critical value will be reached, depending on the amount of water removed, and the variance of the process. When this critical value is reached, there is the possibility of high damages to the wetlands, so we need a decision structure where these damages can be taken into account. This is shown in the next decision tree (Figure 3.2). The decision taken in period 0 is now based on the net benefits realised in period 3. The various levels of net benefits are shown depending on the extraction decisions taken. In period 2, the decision taken is to maximise the value of the objective (or equivalently minimise cost) based on decisions taken up to that time, and the realisation of stochastic flow into the wetlands. High variability, together with a desire for making a robust decision against parameter mistakes, can lead to the decision not to use water at all. This depends on, and interacts with, period 1 decisions. So that, as in our example, it may be desirable not to use water in period 1 because of the consequences for the period 2 choice, and ultimate damage to wetland. The clean up decision at period 0 will depend on the expected value of net benefits for the four options compared to with 0, the base level value for 'doing nothing' .

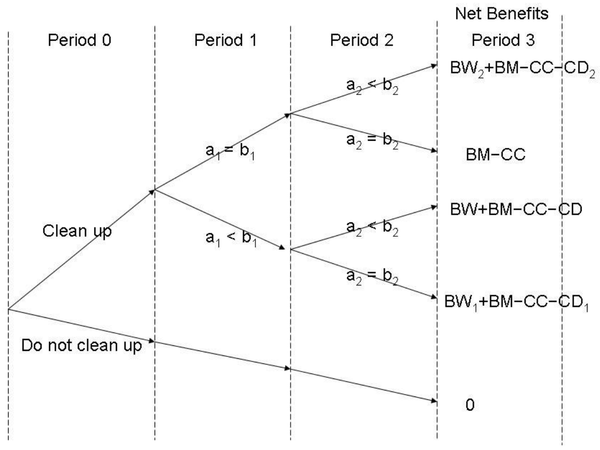

Figure 3.2. Decision tree for the River Nura

The main difference is that of increasing the chances of making zero water use for each period, because (i) we take into account damage to wetland (ii) we recognise impact of variability on water use decision and (iii) we recognise the interaction between decisions in adjacent periods caused by the irreversibility effect. This can be extended to planning over many periods. Damage to the wetlands is realised when the water level in the wetlands, or river flow, reaches a critically low level. The formal solution to this by the backward induction method is straightforward in principle. Depending on the random flow of water in the river and into the wetlands, there will be the possibility of irreversibilities where, if possible, it would be desirable to have negative water extraction in period t, but the non-negativity constraint forces extraction to be zero. This increases the benefits of water conservation in the previous period, $t - 1$. It is possible that this increase in benefit, which depends in part on river flow variability, is sufficient to cause water extraction in period $t - 1$ to be negative, if that were possible. The non negativity constraint then has a similar effect on period $t - 2$, and so on back to the start when the clean up decision is being made. Considering the value of water flowing into the wetland, when the critical damage level is reached, has an effect that cascades backwards, with the result that no extraction of water is ever undertaken. Hence, if the clean up decision hinges on the value of extracted water, clean up would no longer be economically viable.

If we neglect to take into account the variability in river flow, or we use the same decision tools as for rivers with normally distributed flow, then when the clean up decision is made, there is the possibility of overlooking the presence of the threshold level. Hence, ecological damage to the wetland is not included, and in any case because the variability term does not enter into the planned extraction levels, the irreversibility effects may not be triggered. Consequently, water would then be used in all periods and this could justify the clean up decision.

3.3.4 The social price accounting for ecological catastrophe

The potential for irreversible damage, such as has happened with the Aral Sea, is modelled by there being an absorbing barrier for the stochastic process for river flow, X. It is a state that once X(t) attains a specific value, c, then the process terminates, with possibly a terminal value/cost of k. In order to evaluate the social price it is necessary to calculate, and then differentiate expected present value. As an explicit expression is obtained for this, it is then possible to see how this social price changes as key parameters of the situation such as the variance of water flow in the river. This enables the comparison of social price of water between river basins based on the hydrological characteristics independently of socio-economic aspects. The expected present value is G(X) where

$G(X) = E\left\{\int_0^\infty f(X)e^{-\rho t}\,dt \mid X_0 = X\right\}$ and X follows GBM starting at point $X_0 = X$: $(dX)/X) = \nu.dt + \sigma.dz$. Consider a lower absorbing boundary. This affects the solution to the differential equation by introducing a boundary condition at X = c. The general solution will be

$G(X) = G_0(X) + CX^{-\gamma}$ So: $C = c^{\gamma}\left(\dfrac{K^*}{\rho} - \dfrac{c^{\lambda}}{\rho - \nu\lambda - \frac{1}{2}\sigma^2\lambda(\lambda-1)}\right)$

and all of the parameters in this expression will be known. ν and σ come from the stochastic process of flow in the river, ρ is the discount rate. However, it may be not so straightforward to calculate c and K^*, in the absence of detailed analysis of the hydrology and ecology of the wetlands.

The analysis of Dasgupta (2001) shows what the shadow price should be if the management of the economy does not follow first best principles. In this case, the concept of 'Sustainability' is particularly important in economies where first best policies are not followed, or where there is some disagreement as to what a first best policy might be. Such optimality requirements on the nature of the overall objective are also required for the usual analysis of 'Sustainability'. Where non-economic issues form a substantial part of the objective then a modified method will be required. However, it is not of a very different form, and in this case may be easier to calculate, as what is suggested is that the shadow price will be the marginal effect of increases in all forms of capital, including natural capital, on actual value of social wealth, and not the marginal effect that arises out of a full optimization problem. However, we consider two constituencies for wealth, one a national constituency as would be usual, the other an international one, which is appropriate for wetlands with Ramsar status. Also, the linear nature of wealth, means that we can consider each constituency in turn and then simply sum the resulting social prices to get an overall price, and we can also consider wealth arising from the wetlands independently of wealth elsewhere in the economy.

If the inter-temporal value function is W, which may or may not be derived from some form of optimisation, and that this results from the use of various capital stocks X_i, then the accounting price for the i'th capital stock, or resource, p_i will be given by the derivative $\partial W/\partial X_i$. In general, if the quantity variable for which we require a shadow price is y then the price that should be used is $\partial E(V)/\partial y$, where V is actual rather than optimised value. The model we have gives the expected inter-temporal value of wetland services, for any given pattern of water flow and withdrawal. This requires that we are able to derive an expression for the integral, for which a derivative can be calculated. For an important class of functions of f it is possible to do this.

Shadow price is then $\partial V/\partial X$, where $V(X) = E\left\{\int_0^\infty f(X)e^{-\rho t}\,dt \mid X_0 = X\right\}$

V has two parts. One part is local value V_1_the other is international value, V_2. Overall shadow price will be $p = \partial V_1/\partial X + \partial V_2/\partial X$. We are able to treat these as the derivatives of two separate integrals, each for a GBM with an absorbing lower barrier. It will be the same process and barrier for both integrals. There are several ways that the marginal effect for the use of water might be defined, depending on the evolution of the quantity of water withdrawal. Each specification will have a different value or the derivative, and consequently for the shadow price. Possibilities are:

1 The use of an amount of water for a very limited time period.

2. On-going scenarios for water withdrawal. In the spirit of Sustainability, one scenario is that of a constant amount of water withdrawal, and in the spirit of the Water Framework Directive, a value for the environmental-economic impact is derived, which will aid in the concept of wise use of water. This constant withdrawal amounts to a reduction in the mean of wetland size, but apart from that there is no change in the stochastic process. It corresponds to a constant downwards shift in quantity of water entering the wetland system, and so in the area of wetland, and given the simple model used, the quantity of wetland ecosystem services. This presumes

that management of water resources in the Nura River Basin is completely non-reactive to circumstances.

3. An even more drastic non-reactive scheme is to consider not just a constant amount of withdrawal, but one that is changing (increasing due to growth) over time. This amounts to a change in the parameter ν in the stochastic process.

4 A *reactive* scheme is to consider a withdrawal proportional to the difference between current and some base level (a new long run average) flow, so that water is extracted when it is plentiful, but is replenished when it is scarce. This would correspond to a scheme which converts the stochastic process of flow from one that is GBM into one which is a mean reverting, or Ornstein-Uhlenbeck, process.

3.3.5 Social price of water with reduction in mean value for process

This is the shadow price that applies when there is a constant level of withdrawal, and a reduction in the mean of wetland size. As C and γ are independent of X , so in this case, they can be regarded as constant and so $s(t)=\frac{\partial W}{\partial X}=\frac{\lambda X^{\lambda-1}}{\rho-\nu\lambda-\frac{1}{2}\sigma^2\ \lambda(\lambda-1)}-\gamma C X^{-(\gamma+1)}$:

∂W/∂X , the shadow price, falls as X increases, which confirms intuition that wetland will become more valuable the less of it that there is, where C is as above.

Calculating C also gives the economic cost of ecological loss of the Tengiz-Kurgaldzhino wetlands should a catastrophic level be reached. For the base data and parameters used, values for the social price of water, s* and for the amount deducted from expected present value due to the presence of the absorbing lower boundary that represents the possibility of ecological catastrophe for the wetland and lake system, $CX^{-\gamma}$, is given in Table 3.8 below:

Table 3.8. Social price of water

	€ Per m³ per year	**Cost of Loss of Wetland** (mn.€ 2000) = $CX^{-\gamma}$
Operating cost only	0.07	
Domestic valuation. (i.e. using Brander et al.)	0.19	44.8
International valuation (i.e. using Woodward and Wui)	0.40	603.0
Both valuations	0.59	647.8

Including value of the wetlands, including potential catastrophic loss, into the cost of water from the Nura, would then reverse the cost comparison by a significant amount. If the cost of the cheapest alternative is € 0.17 per m³ then water from the Nura is no longer substantially cheaper (€ 0.07), but more expensive if we just use domestic valuation, and substantially more expensive (up to 3.5 times) if we add on an element for the international value that leads the wetlands to have Ramsar status.

3.4 Norrström

The agricultural sector – Future scenarios

To start with these scenarios are created to match the expected local adjustments to the IPCC´s descriptions of the A2 and B2 scenarios. The present situation in Sweden is that all farmable land is not used for agricultural purposes i.e., a certain percentage is laid in fallow. In scenarios where it is described that 100% of farmable land is in use, this means that no farmable land is laid in fallow. It does, however, not mean that 100% of the farmable land is being used for grain production; energy crops such as Salix are regarded as an agricultural product. The underlying assumption that 100% of the farmable land will be used is based on the hypothesis that increases in the European population will imply a raise in food demand. Therefore, EU would not afford to have farmable land that is not being used. Furthermore the assumption that a warmer climate may lead to more extreme weathers such as drought and flooding in Europe would lead to a need of a higher safety marginal when it comes to food production.

Buffer zones are described as an activity that is investigated in the different scenarios. Buffer zones are, however, not considered in the base scenarios. The buffer zones are only looked upon as an additional measurement to reduce the nutrient leakage. The measurement with buffer zones means that 23% percentage of the farmable land is having buffer zones of 6 metres width. The reason why there are no buffer zones in the base scenarios is based on the difficulties to interpret how governmental policies will be in the future and also to make the differences clearer.

The reason why B2 scenario has a higher percentage of Salix than A2 is that B2 scenario is more focused on solving the environmental problems by finding local solutions. With that as a background Salix has grown in importance and the Salix production in B2 is larger than in A2 scenario. However, the primary production for the agriculture remains grain production.

In both A2 and B2 the percentage of spring sawn crops are reduced to the advantage for autumn swan crops. The underlying assumption is that warmer climate and longer growing season would give farmers more time in the autumn. Furthermore, autumn sawn crops generally give higher yield than spring sawn crop.

For the scenarios A2 and B2 as well as the varying time span i.e., in approximately 50 years or 100 years, the activities undertaken to reduce emissions of N and P to Sagån and Svartån are as follows:

3.4.1 Sagån

Except the variations in barley, hay, wheat, work out of soil as well as fallow field (see Table 3.9), the major activities for the different time spans related to the A2 scenario are as follows:

A2 in 50 years

- Approximately 100% of farmable land is in use;
- Approximately 12% of the agricultural area is being used to grow Salix;
- 5 percent of coniferous forest is replaced by deciduous forest;
- Buffer zones for 23 % of farmable land;
- Growing Season of approximately 6 months with planting at mid April and harvest at mid August.

A2 in 100 years

- Approximately 100% of farmable land is in use;
- Approximately 12% of the agricultural area is being used to grow Salix ;
- 10 percent of coniferous forest is replaced by deciduous forest;
- Buffer zones in 23 % of farmable land;
- Growing Season of approximately 6 months with planting beginning in April and harvest beginning in August.

Table 3.9. Implications of A2 scenario for Sagån

	1998-2004		50 years		100 years	
	ha	%	ha	%	ha	%
Barley (spring)	24418	66	20718	56	6659	18
Barley (winter)	0	0	2590	7	9249	25
Hay, pasture	2590	7	2590	7	2590	7
Wheat (winter)	5550	15	6659	18	6659	18
Soil work out barley	0	0	0	0	7399	20
Fallow field	4440	12	0	0	0	0
Salix	0	0	4440	12	4440	12
TOT		100		100		100

Except the variations in barley, hay, wheat as well as soil work out (see Table 3.10), the major activities for the different time spans related to the B2 scenario are as follows:

B2 in 50 years

- Approximately 100% of farmable land is in use with 7% used for hay;
- Approximately 17% of the agricultural area is being used to grow energy forest (Salix) – relative to year 1998-2004;
- 5 percent of coniferous forest is replaced by deciduous forest;
- Buffer zones in 23 % of farmable land;
- Growing Season of approximately 6 months with planting at mid April and harvest at mid August.

B2 in 100 years

- Approximately 100% of farmable land is in use;
- Approximately 17% of the agricultural area is being used to grow Salix;
- 10 percent of coniferous forest is replaced by deciduous forest;
- Buffer zones in 23 % of farmable land;
- Growing season of approximately 6 months with planting beginning in April and harvest in beginning of August.

Table 3.10. Implications of B2 scenario to Sagån

	50 years		100 years	
	ha	%	ha	%
Salix	6289	17	7769	21
Barley (spring)	18868	51	9249	25
Barley (winter)	2590	7	5919	16
Soil work out	0	0	4810	13
Hay, pasture	2590	7	2590	7
Wheat (winter)	6659	18	6659	18
Total		100		100

3.4.2 Svartån

Except the variations in barley, hay, wheat, work out of soil as well as fallow field (see Table 3.11), the major activities for the different time spans related to the A2 scenario are as follows:

A2 in 50 years

- Approximately 100 % of farmable land is in use with 0.6% used for hay;
- Approximately 7.6 % of the agricultural area is being used to grow energy forest (Salix) – relative to year 1998-2004;
- 5 percent of coniferous forest is replaced by deciduous forest;
- Buffer zones in 23 % of farmable land;
- Growing Season of approximately 6 months with planting at mid April and harvest at mid August.

A2 in 100 years

- Approximately 100% of farmable land is in use with 0.6% used for hay;
- Approximately 11.2% of the agricultural area is being used to grow Salix;
- 10 percent of coniferous forest is replaced by deciduous forest;
- Buffer zones in 23 % of farmable land;
- Growing Season of approximately 6 months with planting beginning in April and harvest beginning in August.

Table 3.11. Implications of A2 scenario to Svartån

	1998-2004		50 years		100 years	
	ha	%	ha	%	ha	%
Barley (spring)	8648	61.4	7384	52.4	2621	19
Hay	80	0.6	80	0.6	80	0.6
Grain non defined	2587	18.4	0	0	0	0
Soil work out barley	0	0	2593	18.4	2593	18.4
Wheat (winter)	1708	12	2114	15	2114	15
Barley (winter)	0	0	846	6	4281	30.4
Fallow field	1068	7.6	0	0	0	0
Salix	0	0	1068	7.6	1570	11.2
Total		100		100		100

Except the variations in barley, hay, wheat as well as soil work out (see Table 3.12), the major activities for the different time spans related to the A2 scenario are as follows:

B2 in 50 years

- Approximately 100 % of farmable land is in use with 0.6% used for hay;
- Approximately 11.3 % of the agricultural area is being used to grow Salix;
- 5 percent of coniferous forest is replaced by deciduous forest;
- Buffer zones in 23 % of farmable land;
- Growing season of approximately 6 months with planting at mid April and harvest at mid August;
- Fertiliser use as in years 1998-2004.

B2 in 100 years

- Approximately 100% of farmable land is in use with 0.6% used for hay;
- Approximately 14.9 % of the agricultural area is being used to grow Salix
- 10 percent of coniferous forest is replaced by deciduous forest;
- Buffer zones in 23 % of farmable;
- Growing season of approximately 6 months with planting beginning in April and harvest beginning in August;
- Fertiliser use as in years 1998-2004.

Table 3.12. Implications of B2 scenario to Svartån

	50 years		100 years	
	ha	%	ha	%
Barley (spring)	6860	48.7	2974	21.1
Hay, pasture	85	0.6	85	0.6
Soil work out	2593	18.4	2593	18.4
Wheat (winter)	2114	15	2114	15
Barley (winter)	846	6	4228	30
Salix	1595	11.3	2100	14.9
Total		100		100

3.5 Thames

The WFD defines all activities that have a significant impact on the status of water bodies in the basin as water uses. These include water services, predominantly the water companies who abstract water to provide public water supplies and serve industry and agriculture. Section 2.5 identified water companies as the most important abstractors in the Thames river basin. An additional component of the economic analysis of water use is, therefore, the levels of cost recovery of water services. This is concerned with water service provision, the extent to which financial, environmental and resource costs are recovered, how cost recovery is organised and the way in which key water uses contribute to the cost of water services (FWR, 2004). Information on the recovery of the costs of water services is provided in defra (2005a) and ERM and Stone & Webster (2004), and the figures included in the following section are reproduced from defra (2005b).

The principal providers of water services in the Thames river basin are licensed water and sewerage undertakers, who are private companies appointed to provide water and sewerage services in specified areas. (There are also some private water services e.g. some people may have their own water supply from a well or borehole, or may have mains water supply but not mains sewerage). Eight water companies supply around 5.5M households and 441,000 businesses with water in the Thames river basin: Northumbrian Water, Southern Water, Thames Water, Wessex Water, Mid Kent Water, South East Water, Sutton and East Surrey Water, and Three Valleys Water. They also provide sewerage services to approximately 5.3M households and 313,000 businesses. The water companies are estimated to supply 4325 ML of water per day and to collect 3171 ML of sewage per day.

3.5.1 Cost of providing water services

The cost of providing water services is usually quantified in terms of costs to the water companies. The economic analysis is complicated because the boundaries of the areas licensed to the water companies do not correspond with the boundaries of the river basin. Therefore, allocated costs and revenues for each company within the Thames river basin are based on the estimated population in the area of the basin served by company. Also considered are the various intangible costs to the environment caused by the water abstraction or effluent discharge.

Financial cost

In 2003-04, the financial costs of the water and sewerage services in the Thames river basin were £817.1M and £709.8M, respectively, equating to unit costs of £0.63 per m^3 for water supply and £0.62 per m^3 for sewerage service.

Analysis of the operational costs of the eight companies in the Thames river basin suggests that around £50.5M of their annual costs arise from diffuse pollution. These costs are mainly incurred to deal with nitrates, pesticides and other contaminants and in managing the risk from the parasite cryptosporidium (defra, 2005b).

Environmental cost
The water industry and agriculture form the two largest contributors to environmental damage caused by abstraction and water pollution, respectively, and together account for about 85% of estimated environmental damage costs. Other diffuse and point sources, such as diffuse urban pollution, landfill sites and contaminated land account for the remaining 15% of costs.

Analysis of capital and operating expenditure of the eight companies in the Thames river basin reveals that around £122M of their annual costs is associated with mitigating the environmental impacts of water services (defra, 2005b). Further work is required to improve the assessment of environmental damage costs of water use in the future.

3.5.2 Financial cost recovery

Water companies recover the costs of providing water services to households and businesses within their water service areas through revenues from these customers. Water companies in the Thames river basin provide annual details of the financial costs and revenues of the water and sewerage services in the basin to Ofwat, the economic regulator for the water industry in England and Wales for the annual "June Return" report (see References). Figures for the period 1998-2004 are shown in Tables 3.13 and 3.14 (defra, 2005b); note that the balance between costs and revenues is achieved over a 5-year time horizon in the economic regulatory regime in England and Wales, so annual total costs and revenues do not match exactly.

Table 3.13. Public water supply – cost recovery for Thames RBD (£M, 2003-04 prices)

Cost component (financial year)	98-99	99-00	00-01	01-02	02-03	03-04
Total revenues	872.7	887.7	787.1	810.3	805.6	812.2
Total financial costs (inclusive of taxes)	887.2	898.8	798.2	819.5	812.5	819.6
Cost recovery rate (%)	98	99	99	99	99	99

Source: defra, 2005b

Table 3.14. Sewerage service – cost recovery for Thames RBD (£M, 2003-04 prices)

Cost component (financial year)	98-99	99-00	00-01	01-02	02-03	03-04
Total revenues	780.9	792.4	676.9	698.4	695.8	694.0
Total financial costs (inclusive of taxes)	779.7	797.5	700.3	716.1	719.8	709.8
Cost recovery rate (%)	100	99	97	98	97	98

Source: defra, 2005b

The water companies pay abstraction and discharge fees to the Environment Agency for the water they abstract to use and the discharges they make. The Agency levies administrative charges to recover its costs of administering abstraction licences and discharge consents. The Agency also recovers part of its costs in dealing with water pollution incidents from some polluters.

3.5.3 Summary

Assessment of the cost recovery of the provision of water services by water companies, the main abstractors in the basin, in the economic analysis of water use has been done as a whole, but not yet for individual sectors i.e. households, industry, agriculture. This is one of several issues requiring further investigation (EASG, 2004). Others include developing a system for gathering cost and revenue data at a river basin level, making environmental mitigation costs more transparent, exploring the relationship between pressures and impacts and incentive pricing, investigating private water services, and providing more information on the recovery of costs by the Agency.

4. Policy solutions and costs

This section describes the efficiency of different policy instruments for the conditions in the different basins, and the economic effect of climate change and human development scenarios.

4.1 Okavango

While an understanding of the total economic value of the delta is potentially useful for lobbying for conservation support, consideration of how this value might change under different management or policy scenarios is potentially a far more useful undertaking for decision-makers. Numerous development options have been considered for this area in the past, such as irrigation schemes and water transfers out of the Okavango. Various management options have been considered which affect the location and extent of veterinary fences and wildlife management areas, or consumptive or non-consumptive use of wildlife, the density of tourism developments, etc. In addition, it would be prudent to consider the effect of matters beyond local control, namely climate change which threatens to alter rainfall patterns and flooding of the Okavango.

It should be emphasised that the present study was carried out as a brief exercise where the main emphasis was on deriving the current value of the delta through a desktop analysis. Spatial data on values are not detailed enough to allow accurate calculation of scenario impacts. Thus the values given in Tables 4.1 and 4.2 below are based on educated subjective estimates made by team members. If these outcomes are of particular interest it would be worthwhile investigating the assumptions further in a dedicated study.

The scenarios considered here were developed based on scenarios that have already been considered for the delta at one stage or another, or that would illustrate an extreme case. The proposed scenarios below were discussed in a stakeholder workshop during an early part of the study.

1. Agricultural expansion
2. Expanded protection
3. Wise use
4. Wise use plus abstraction
5. Wise use plus climate change

The planning document by Plantec *et al*. (2006) was used to guide the wise use scenarios.

4.1.1 Scenarios

Scenario 1: Agricultural Expansion

In this scenario the veterinary fence is moved back and grazing is expanded into the wetland area (Figure 4.1). Existing photographic tourism activities in and around Moremi continue and expand into a buffer area around the reserve, replacing commercial hunting to the west of the reserve. Commercial and communal hunting activities are precluded in the expanded grazing area.

Scenario 1 basically follows existing land use in the Ramsar site, but emphasises the use of the rich natural resource base of the area in zoning land for various land use activities, with emphasis on economic growth.

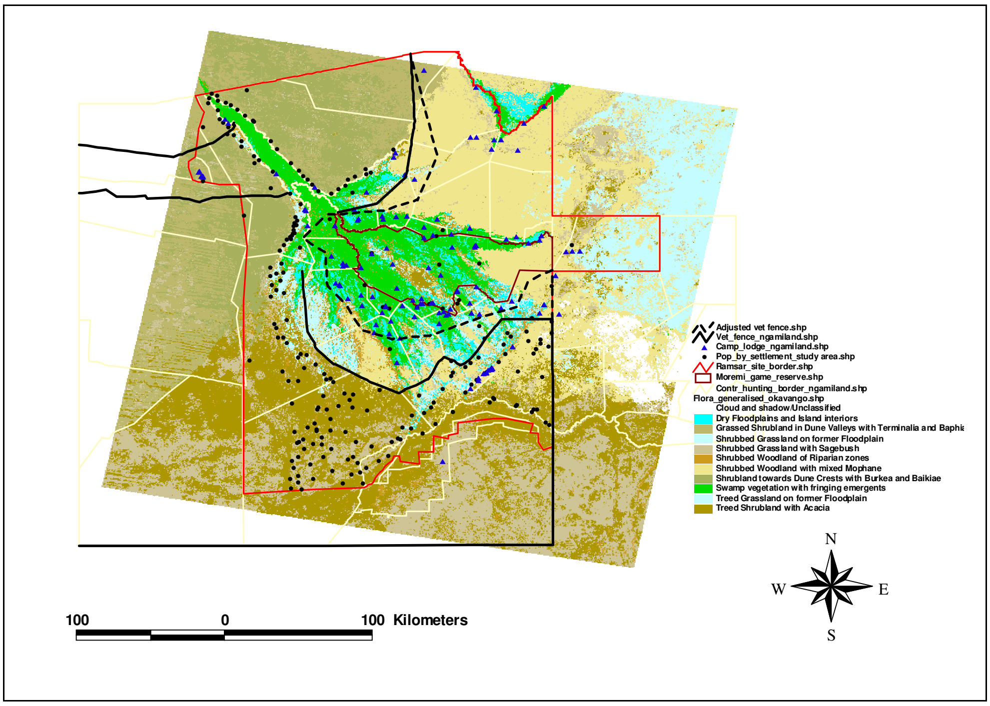

Figure 4.1. Change in position of the veterinary fences under Scenario 1. Expanded agriculture

Scenario 2: Expanded Protection

This scenario places emphasis on the conservation of the Ramsar site, with particular emphasis on the delta wetlands as the most sensitive area. The delta wetland area is proclaimed as a national park, but lodges are located both within and around the park as at present. The main difference from present is that there is no consumptive use of resources (e.g. reed collection, fishing or hunting) within the national park. Throughout the rest of the Ramsar site, use of natural resources will be controlled at sustainable levels.

Scenario 3: Wise Use

This scenario is based on the land use plan as recommended by Plantec *et al*. 2006. This is largely based on the Ramsar planning guidelines for wetland ecosystems. Emphasis is on sustainable resource use, such that utilisation is within the regeneration capacity of resources and does not alter the ecological balance of the delta. Land uses in ecologically vulnerable areas, such as molapo farming and resource harvesting, would be subject to more intensive management, monitoring and enforcement. Existing lodges continue, but new ones would only be allowed within the carrying capacity of the delta. There is emphasis on balancing the need for protection and tourism use and avoid disruption of livelihood strategies.

The main differences from present are:

- Part of the commercial and community wildlife utilisation areas are zoned for commercial and community photographic areas, in order to create a buffer around Moremi;
- The northern-most controlled hunting area is changed from undesignated to community managed photographic area;

- A tourism development area is proposed alongside the wetland below the panhandle in the Etsha area; and
- Within Moremi, tourism use is zoned into low and medium density and wilderness zone.

Scenario 4: Wise use plus upstream abstraction

This scenario is based on the wise use scenario plus upstream water resources development as described in DHI *et al*. (December 2005). The water resources developments are as follows:

- Development of ten dams for hydropower in Angola, changing the distribution of flow and altering sedimentation into the delta;
- Irrigated area of 54 500 ha in Angola and 7500 ha Namibia, creating an irrigation demand of 15 000 m^3/ha/annum;
- Abstractions of surface water in the Delta for domestic supply, livestock, small scale irrigation and construction. The modelled amount is a total abstraction of 68 000 m^3/day, as the projected demand in 2025 (current use is about 46 540 m3/day; DHI *et al*. 2005).

DHI *et al*. (2005) predicted the impacts on flow based on the above scenarios, and how these would affect the areas of five types flood area ranging from permanently flooded to rarely flooded areas (Figure 4.2). Note that the rarely flooded area includes large parts of what is woodland today. The delta wetland area can be considered as the first four areas, but it should be noted that molapos and some minor wetlands and floodplain areas are situated in the fifth zone.

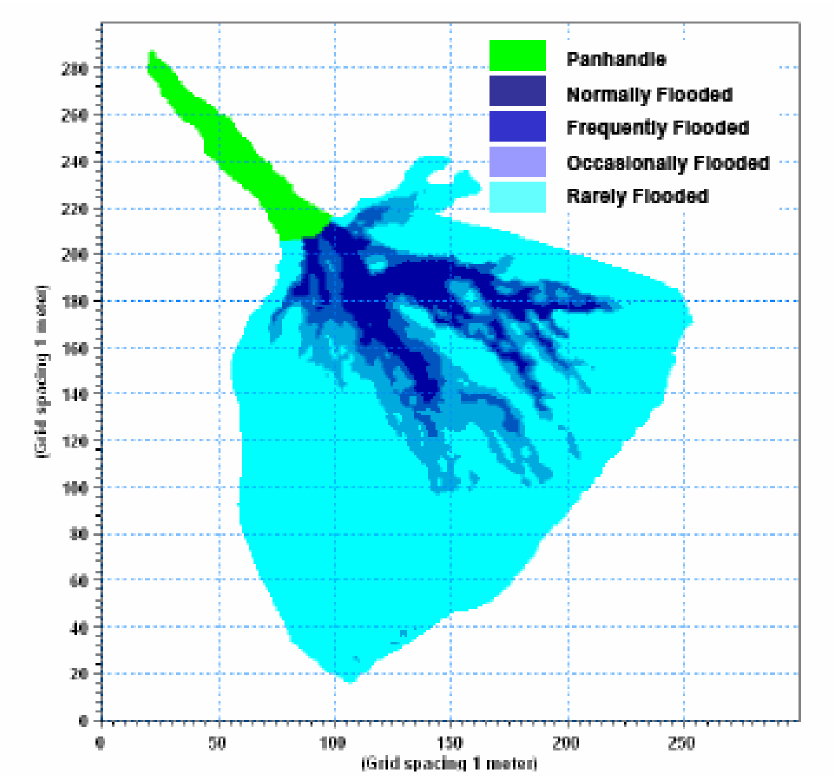

Figure 4.2 Different categories of flooding area in the Okavango Delta (DHI *et al.* 2005)

The average reduction on flooded areas predicted by DHI *et al*. (2005) was used. Under the abstraction scenario, the delta proper is reduced in area by 10%. This reduction is fairly uniform across the different flood zones.

Scenario 5: Wise use plus climate change

Climate change is likely to have an impact on the delta due to its effects on catchment and local rainfall. Several climatic models have been built to predict the impacts of climate change, but their predictions vary greatly depending on the assumptions made, among other considerations. One of the most widely accepted models is the HadCM3. DHI *et al*. (2005) used the predictions of changed precipitation and temperature under this model to modify the flows into the delta for the year 2025. The result was a highly significant change in runoff and flooding of the delta, with inflows being reduced by 38% and local precipitation by 9%. These effects are compounded by a temperature increase of 2.2°C.

Under this scenario, the delta proper is reduced in area to 65% of its current size. The more occasionally flooded areas are the most impacted, but even the Panhandle is greatly affected (Figure 4.3).

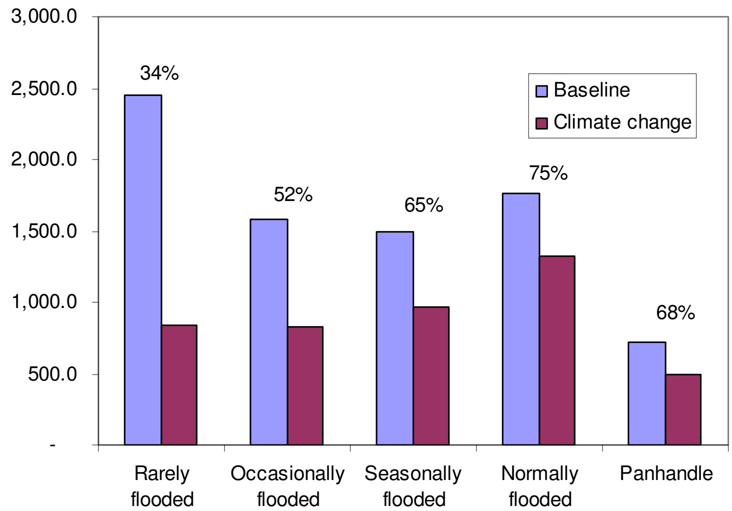

Figure 4.3. Predicted change in area for each of the types of flooding area in the Delta under a climate change scenario (based on DHI *et al.* 2005)

4.1.2 Parameters under different scenarios

The hydrological model results were used to guide estimates of the changes in various biophysical parameters under the different scenarios, in conjunction with the expected change in land use under each scenario (Table 4.1). These estimates are rough and require further investigation, but are probably sufficiently indicative to allow a reliable ranking of the scenarios.

Table 4.1. Estimated percentage relative to present for different parameters under the five scenarios

Scenario	1. Agriculture	2. Protection	3. Wise use	4. Abstraction	5. Climate ch.
External factors:	*Present*	*Present*	*Present*	*Abstraction*	*Climate change*
Land Use:	*Development*	*Protection*	*Wise use*	*Wise use*	*Wise use*
Surface water supply	100	100	100	90	68
Grazing resources	120	70	100	90	68
Area of molapos	110	97.5	100	92	34
Fish stocks	100	85	90	90	65
Wetland grass stocks	80	90	110	90	65
Reed and sedge stocks	80	90	110	90	65
Delta area mammals	80	90	110	90	65
Wetland birds	80	90	110	90	65
Wetland food plants	80	90	110	90	65
Non-consumptive tourism	100	120	120	100	80
Hunting tourism	60	0	75	70	50
Groundwater supply m^3	100	100	100	90	50
Carbon sink	100	100	100	100	110
Wildlife refuge	75	110	110	90	65
Water purification	100	100	100	95	65
Scientific/education value	90	100	100	95	80
Option value	Medium	V high	High	Medium	Low
Existence value	Medium	V high	High	Medium	Low

4.1.3 Economic implications of different scenarios

The economic implications are described in Table 4.2, in terms of expected changes in direct value added from the Ramsar Site and the wetland itself. In estimating the impacts, the proportion of different types of value that are attributable to the wetland were taken into account, as well as the extent to which the value would be affected under the different scenarios.

With no change in external factors, the most favourable scenario in terms of direct use values is the Wise Use scenario (3), This suggest that current land use plans are optimal, and more economically efficient than options which give more emphasis to conservation and agricultural expansion. It illustrates the complementary nature of current land use in the delta. The values for the Wise Use Scenario are compromised somewhat under the Abstraction scenario (4) and severely under the Climate Change (5) scenario. Indeed the values for the less desirable scenarios (1 and 2) would be similarly affected. In reality the impacts resulting from external factors in scenarios 4 and 5 impacts might be mitigated to some extent by adaptation.

The impacts of the scenarios on the indirect use values (ecological service values) estimated in this study are difficult to quantify and these values have been given ratings only. The Protection and Wise Use scenarios would appear to result in the highest values. The values would again be reduced under the effects of external factors such as abstraction and Climate Change. While non-use values such as existence value are unknown, it is reasonable to assume that they are correlated with biodiversity. Thus the Protection scenario is likely to rate highest in terms of existence value. The Climate Change scenario will have the greatest impact on this value.

Table 4.2 Estimated outcomes in terms of direct value added, or general value, attributable to the Ramsar Site and the wetland, following five different scenarios. Note that estimates are rough.

Scenario	Present	1. Agriculture	2. Protection	3. Wise use	4. Abstraction	5. Climate change
Ramsar site						
Tourism	514 100 000	471 100 000	487 920 000	**568 545 000**	481 850 000	379 030 000
Household use	70 231 769	70 532 221	57 520 039	**70 629 294**	68 297 910	63 181 679
Indirect use	High	High	V high	**V high**	Medium	Low
Existence	High	Medium	V high	**High**	Medium	Low
Wetland						
Tourism	461 520 000	431 420 000	463 524 000	**519 961 500**	438 945 000	346 641 000
Household use	18 989 980	17 936 907	8 189 818	**19 389 135**	17 753 028	14 484 703
Indirect use	High	High	V high	**V high**	Medium	Low
Existence	High	Medium	V high	**High**	Medium	Low

4.2 Biobío

4.2.1 Valuation of Impacts with No Climate Change

Valuation of Impacts in the Livestock and Forestry Sector

This section is intended to get close to the impacts indicated, coming from the diffuse contamination and which are related to the water quality standard. Estimation is performed in terms of public costs to focus resources on existing programs (Programs to foster Best Practices, System of Incentives for Recovery of Eroded Soils).

Valuation of Impacts on Livestock

Impact both action courses will have on the activities generating organic emissions of purine to zero, can be estimated as: handling of purine and development of best practices associated, which allow to make sure that emission to atmosphere is minimum or close to minimum as follows:

a) Handling of Purine

Table 4.3. Estimation of Investment and Net Flow of purine handling in groups over 100 cows in dairy farms of tows with saturation parameters that can be attributed to this activity

Town	Sections	Reduction magnitude W[1]	Dairy farms exploited	% of Exploitation 100 cows	Exploitation >100 cows	Investment of purine handling M$	Net Flow Handling of Purine M$	Investment associated to Quality Standard M$	Net Flow associated to Quality Standard M$
Los Ángeles	RA-TR-10 and GU-TR-10	12.82%	1,522	5.50%	83	-638,045	137,768	-81,797	17,662
Mulchén	BU-TR-11 and BU-TR12	12.79%	231	5.50%	12	-92,247	19,918	-11,798	2,548
Santa Bárbara	BI-TR-33	9.26%	458	3.70%	16	-122,997	26,558	-11,389	2,459
TOTAL			2,211		111*			**-104,984**	**22,669**

* Number of exploitations with more than 100 cows in towns with saturated parameters, that can be attributed to dairy activities (Los Ángeles, Mulchén, and Santa Bárbara).

Source: Elaboration with average prices ODEPA, 2003 – 2005 VAT included Forestry and Livestock Census 1997 and data from SAG Mulchén.

From the previous table, we can see that private activity, purine handling in plants with more than 100 cows, that will be generated in the most likely scenario (explained in the impact identification 3.2.1 letter a) attributed to change in practice caused by the enforcement of DS 90/2000, and therefore regulation by secondary standard, is: Investment M$ -104,948 and an Annual Net Flow of M$22,579. It is important to mention that opportunity cost for private entities that may obtain this activity, is between 3% and 6%.

a2) Development of best practices associated with purine handling

Table 4.4. Estimation of focalization cost for fostering good practices in dairy activities, through existing allowances from INDAP an CORFO (UF 12/31/05)

Associated Town	%	No of Exploitation	Annual value of allowance A.T. UF	Annual cost allowance A.T. (5%) UF	Cost associated to technical assistance allowance M$	FDI allowance	Administrative cost (5%) M$	Annual total M$	Reduction magnitude (W^3)	Total cost associated to standard
Los Ángeles		1,522								
INDAP	73.9%	1.,25	15	844	15,163	101,087	5,812	122,062	12.82%	-15,648
CORFO	26.1%	397	71.5	1,420	25,527	0	1,276	26.803		-3,436
Mulchén		231								
INDAP	73.9%	171	15	128	2,301	15,342	882	18,526	12.79%	-2.,69
CORFO	26.1%	60	71.5	216	3,874	0	194	4,068		-520
Santa Bárbara		458								
INDAP	83.0%	380	15	285	5,125	34,164	1,965	41,254	9.26%	-3,820
CORFO	17.0%	78	71.5	278	5,003	0	250	5,253		-486
TOTAL COST										**-26,279**

Source: Elaborated based on the forestry and livestock census 1997 and data from SAG Mulchén.
Value UF = 17,974.81 up to 12/31/2005.

b) Soil Erosion Control

Table 4.5. Cost attributed to Quality Standard, in sections and towns with erosion indicators

Section	Reduction magnitude (W^2)	Town	Eroded hectares (He)	Average cost per hectares M$	Total cost (He * 83.669) M$	Cost attributed to standard (C^2) M$
LA-TR-21	-57.20%	Laja	3,183	83.669	266,352	-152,353
LA-TR-22	-63.20%	Laja	1,388	83.669	116,107	-73,380
BU-TR-12	-63.90%	Mulchén	994	83.669	83,167	-53,144
VE-TR-10	-60.55%	Traiguen	0.46	83.669	38	-23
		Los Sauces	1,454	83.669	121,655	-73,662
GU-TR-10	-39.5%	Los Ángeles	630	83.669	52,711	-20,821
TA-TR-10	-47.50%	Nacimiento	7,636	83.669	638,896	-303,476
		Santa Juana	3,773	83.669	315,683	-149,949
TOTAL			**19,059**		**1,594,611**	**-826,808**

Source: Elaborated based on intersection of coverage of soil series, soil uses, towns and sections with erosion indicators in the Biobío basin and average cost, soil conservation practices Cost Table SIRSD SAG - INDAP 2005.

c) Management of Crops, Fertilizers and Pesticides

Information based on the real number of exploitations that currently have an allowance, was delivered by clerks of the institutions (INDAP, CORFO), meanwhile the value of allowances is institutional and corresponds to 15 UF for INDAP and 71.5 for CORFO per exploitation (that

Table 4.6. Estimation of annual value of allowances applied to the fostering of Best Farming Practices, through available allowances from INDAP and CORFO

Associated town	Number of Farming Exploitations	Number of Potential Exploitations to technical assistance (5% annual)	Number of real exploitations at technical assistance	Annual value of allowance (UF)	Annual cost of allowance BPA UF	Cost of Allowance in M$	Administration Cost (3%) M$	ANNUAL TOTAL M$	Red. Mag. (W^3)	Total Cost Associated to Water Quality Standard
Quilaco INDAP Exploitation <12 HRB (1)	247	12	1	15 71.	165	2,966	89	3,055	-39. 85%	-1,217
CORFO Exploitation <12 HRB (1)	20	1	0	5	72	1,285	39	1.324		-527
Negrete INDAP Exploitation <12 HRB (1)	306	15	0	15	225	4,044	121	4,166	-47.0%	-1,958
CORFO Exploitation <12 HRB (1)	89	4	1	71.5	215	3,856	116	3,971		-1,866
Los Ángeles INDAP Exploitation <12 HRB (1)	2,655	132	24	15	1,620	29,119	874	29,993	-19.9%	-5,969
CORFO Exploitation <12 HRB (1)	754	37	5	71.5	2,288	41,126	1,234	42,360		-8,429
TOTAL COST										**-19,966**

Source: Classification of Farming Exploitations of the VI National Forestry and Livestock Census according to Type of Producer and Geographical Location. ODEPA, Work Document Nº 5, January 2000.
Personal Information Mr. Ricardo García INDAP VIII Region and Mr. Fernando Castro, CORFO VIII Region.
Value UF = 17,974.81 up to 12/31/2005.

corresponds to 50% of the total value of the "Quality Fostering Instrument - Best Farming Practices" broken down in 7.5 UF for initial evaluation, plus 57.5 in implementation and finally 6.5 UF in verification process). A 3% administrative expense value is designated, which is normally incurred by these institutions, resides considering as annual attention subject 5% of each stratum. These supporting instruments currently operate on demand logic by the producers.

Valuation of Impacts in the Industrial Sector

First, impacts in the industrial sector in terms of costs are linked to investment in new technology for treatments that allow abate altered parameters for water quality. It is also possible to mention that paper pulp and paper industry assume most of the investment costs and operational costs of treatment technologies, due to high level of emissions of effluents.

Table 4.7. Flows of Annual Industrial Costs for Abatement of Altered Quality Parameters according to Sections and Treatment Systems (M$ Dec. 2005)

Parameter (Section) to be treated	Treatment System	Years				
		1	2	3	4	5
DBO5 (VE-TR-10)	Activated Sludge	83,066	2,384	------	------	------
Total Suspended Solids (BI-TR-40)	Polymer assisted clarification	99,303	101,964	104,262	106,278	108,070
Total Suspended Solids (BI-TR-50)	Polymer assisted clarification	52,069	48,322	44,762	41,358	38,087
Total Suspended Solids (BI-TR-72)	Polymer assisted clarification	18,826	19,000	19,148	19,277	19,392
Total Suspended Solids (LA-TR-22)	Polymer assisted clarification	7,909	8,081	8,226	8,350	8,459
Total Suspended Solids (VE-TR-10)	Polymer assisted clarification	28,597	29,290	29,844	30,302	30,689
Total Suspended Solids (GU-TR-10)	Polymer assisted clarification	24,743	23,164	21,756	20,480	19,310
Manganese (BI-TR-40)	Chemical Oxidation plus Chemical Precipitation	379,600	379,600	379,600	379,600	379,600
Manganese (LA-TR-22)	Chemical Oxidation plus Chemical Precipitation	74,579	74,579	75,388	75,789	76,189
Aluminum (LA-TR-22)	Chemical Precipitation	57,085	61,491	65,249	68,503	71,352
LEAD (GU-TR-10)	Chemical Precipitation	45,990	50,589	50,589	55,097	59,517
DQO (BI-TR-40)	Activated Sludge	5,906,900	5,906,900	5,906,900	5,906,900	5,906,900
DQO (BI-TR-50)	Activated Sludge	------	------	------	49,449	166,068
DQO (BI-TR-72)	Activated Sludge	632,960	632,960	632,960	632,960	632,960
DQO (LA-TR-21)	Activated Sludge	122,846	107,072	92,873	79,931	67,996
N-TOTAL (BI-TR-72)	Nitrification plus denitrification	340,989	------	------	------	------
N-TOTAL (LA-TR-21)	Nitrification plus denitrification	250,283	275,627	295,571	311,392	324,638
N-TOTAL (LA-TR-22)	Nitrification plus denitrification	62,771	92,536	116,370	136,240	153,094
N-TOTAL (GU-TR-10)	Nitrification plus denitrification	581,077	700,939	802,084	890,190	967,782
Annual Cost Flows		**8,769,593**	**8,514,499**	**8,645,582**	**8,812,097**	**9,030,102**

Source: Elaboration based on data delivered by Tables 46 to 53 contained in the original study.
* These values correspond to impact on the industrial costs due to application of DS 90

Quantification of Industrial Benefits

Benefits estimated for the industrial sector due to existing secondary standard, correspond to reduction of market losses due to probable accusations of environmental dumping from countries where products of companies operating in the basin arrive to, thus contributing to commitment of companies with social responsibility for sustainable development of our country.

Table 4.8. Estimated benefits for the industrial sector due to the decrease in the environmental dumping risks (RDA), according to section and industry, assuming a φ=5%

Involved Industry	Associated Sections	Estimated benefits per RDA (M$ annual)				
		1	2	3	4	5
Paper and paper pulp	BI-TR-40 and BI-TR-50	3,218,183	3,228,576	3,239,002	3,240,842	3,234,489
Paper and paper pulp	LA-TR-21 and LA-TR-22	4,612,235	5,389,625	6,298,043	7,290,753	8,364,251
Paper and paper pulp	VE-TR-10	52,184	50,162	48,219	46,324	44,479
Food industry	GU-TR-10	510,295	504,893	499,591	493,399	486,390
Total Benefits		**8,392,897**	**9,173,255**	**10,084,856**	**11,071,318**	**12,129,608**

Source: Elaborated based on the calculation methodology exposed in point 3.2.2 of this study and information of memories and financial statements of companies operating in the basin.

Cost-Benefit Evaluation of the Water Quality Standard in Biobío River

Table 4.9. Flow of social founds from the application of the water quality standard in the forestry, livestock and industrial sectors at the Biobío basin (expressed in M$)

No	ITEMS / YEAR	0	1	2	3	4	5
1	PURINE HANDLING INVESTMENT	-104,984					
2	PURINE NET FLOW		22,669	22,669	22,669	22,669	22,669
3	PROGRAM BEST DAIRY PRACTICES		-26,281	-26,281	-26,281	-26,281	-26,281
4	SOIL CONSERVATION PROGRAM		-165,362	-165,362	-165,362	-165,362	-165,362
5	PROGRAM BEST FARMING PRACTICES		-19,968	-19,968	-19,968	-19,968	-19,968
	INDUSTRIAL BENEFIT PER RDA (5%)		8,392,897	9,173,255	10,084,856	11,071,318	12,129,608
6	INDUSTRIAL ABATEMENT COST		-8,769,593	-8,514,499	-8,645,582	-8,812,097	-9,030,102
7	BENEFITS OF BEST DAIRY PRACTICES						
8	BENEFITS OF BEST FARMING PRACTICES						
9	BENEFITS OF VALUATION OF SURROUNDING LANDS						
10	BENEFITS OF RURAL TOURISM						
11	BENEFITS OF IMPROVING QUALITY OF IRRIGATION WATER						
12	BENEFITS IMPROVEMENT OF ECOLOGICAL FLOW						
13	BENEFITS OF REDUCING RISKS OF ILLNESSES						
14	BENEFITS ON ENVIRONMENTAL SERVICES						
15	COSTS OF ANNUAL MONITORING		-4,598	-4,598	-4,598	-4,598	-4,598
16	**NET FLOW**	-104,985	-570,236	465,217	1,245,734	2,065,682	2,905,966
	SOCIAL NPV (8%) M$	**4,250,860**					

Source: Elaborated based on our own data

4.2.2 Valuation of Impacts with Climate Change

Valuation of Impacts in the Livestock and Forestry Sector

Considering the methodology procedures exposed in this study to evaluate how to modify the costs associated to Water Quality Standard coming from forestry, livestock and industrial sectors, if there are changes in the different flow levels of river Biobío, the following results were obtained

Table 4.10. Estimation of Investment and Net Flow of purine handling in groups over 100 cows in dairy farms of towns with saturation parameters, that can be attributed to this activity, considering all variation scenarios in the flow level

Items of Costs and Benefits associated to Water Quality Standard	Change in Flows Scenario					
	Increases			Decreases		
	Δ+10%	Δ+20%	Δ+50%	Δ-10%	Δ-20%	Δ-50%
Investment in purine handling associated to Quality Standard	**-110,358**	**-109,326**	**-124,073**	**-95,400**	**-81,050**	**-17,186**
Net annual flows in handling of purine associated to Quality Standard	**23,829**	**23,606**	**26,790**	**20,599**	**17,500**	**3,711**

Source: Elaborated based on original methodology section in this study.

Table 4.11. Estimation of focalization cost for fostering good practices in dairy activities, through existing allowances from INDAP and CORFO (UF 12/31/05), considering all scenarios for variation in the level of flow

Items of Costs associated to Water Quality Standard	Change in Flows Scenario					
	Increases			Decreases		
	Δ+10%	Δ+20%	Δ+50%	Δ-10%	Δ-20%	Δ-50%
Total annual costs of fostering best practices in dairy farms	**-27,696**	**-27,533**	**-31,359**	**-23,823**	**-20,189**	**-4,209**

Source: Elaborated based on original methodology section in this study.

Table 4.12. Cost attributed to Quality Standard, in sections and towns with erosion indicators, considering all scenarios for variation in the flow level

Items of Costs associated to Water Quality Standard	Change in Flows Scenario					
	Increases			Decreases		
	Δ+10%	Δ+20%	Δ+50%	Δ-10%	Δ-20%	Δ-50%
Total cost per hectare with erosion index associated to Quality Standard	**-930,569**	**-1,003,186**	**-1,117,372**	**-675,111**	**-438,856**	**-66,598**

Source: Elaborated based on original methodology section in this study.

Table 4.13. Estimation of annual value of allowances applied to fostering best farming practices, through allowances available at INDAP and CORFO, considering all scenarios of variation in the flow level

Items of Costs associated to Water Quality Standard	Change in Flows Scenario					
	Increases			Decreases		
	Δ+10%	Δ+20%	Δ+50%	Δ-10%	Δ-20%	Δ-50%
Total cost of allowances to foster best farming practices	**-17,555**	**-14,741**	**-7,536**	**-21,987**	**-23,591**	**-27,938**

Source: Elaborated based on original methodology section in this study.

Valuation of Impacts in the Industrial Sector

Flow of Industrial Costs

There will be a quantification of costs of industrial abatement for different hypothetical scenarios of change in flows. In order to do this, the same hypothetical scenarios of alteration in flow levels used in the forestry and livestock sector were defined. (For more details see Appendix B section 5 of this report.)

Cost-Benefit Evaluation of the Water Quality Standard

There was an evaluation of costs and benefits results of Secondary Standard for both relevant sectors of economic activity (forestry and livestock, industrial), for different climate scenarios, including the item related to annual monitoring cost of the government to supervise compliance of the standard, that was assumed as constant. Results of the net flows obtained are shown in the following table.

Table 4.14. Net flows and Social NPV, considering the six scenarios for flow modification

Δ% Level Flow	Items / Year	0	1	2	3	4	5
+10%	Net Flows M$	-110,358	-3,661,627	-2,409,976	-1,170,406	-2,780,948	-1,922,423
+10%	Social NPV (8%) M$	-$ 9,848,475					
+20%	Net Flows M$	-109,326	-6,479,930	-5,032,304	-3,403,602	-6,927,532	-6,053,437
+20%	Social NPV (8%) M$	-$22,337,350					
+50%	Net Flows M$	-124,073	-12,640,503	-10,701,836	-8,200,917	-15,615,216	- 14,708,063
+50%	Social NPV (8%) M$	-$49,001,205					
-10%	Net Flows M$	-95,400	2,734,841	3,446,974	4,219,109	5,083,778	6,022,229
-10%	Social NPV (8%) M$	$16,576,707					
-20%	Net Flows M$	-81,050	6,204,131	6,931,824	7,786,079	8,699,328	9,629,261
-20%	Social NPV (8%) M$	$30,735,057					
-50%	Net Flows M$	-17,186	5,721,459	6,467,287	7,351,267	8,315,953	9,355,973
-50%	Social NPV (8%) M$	$29,140,782					

Source: Elaborated based on the methodology for valuation of impacts in the study.

4.3 Nura

This section develops the analysis in the previous two sections to consider how the water demands of the expanding city of Astana should be met depending on the factors that enter into the decision making process, and the type of policies that will take into account the water requirements of the wetlands. Important here is the question of timing of policy, and delaying what might be irreversible policy choices until further information is available. This is the question of how the Precautionary Principle should be applied. If there is the possibility of information arising in the future that might cause a decision maker to want to reverse, or wish that they had changed, a decision then this can be incorporated into a 'Learning Premium', or Quasi-Option Value – the value to be attributed to keeping options open. This is then the cost of using the river basin in a way that might result in irreversible, or catastrophic effects. This value is calculated for a variety of different scenarios. In order to do this it is necessary to obtain the management decisions that would be taken when there is and is not information about the uncertainties underlying the consequences of decisions.

4.3.1 Management of river basin so that river flow is a mean reverting process

This corresponds to implementation of a strategy that is Sustainable in that whilst water flow is stochastic, there is an in-built mechanism that reverts water flow to a given mean. Is this policy feasible? For the mean reverting Ornstein-Uhlenbeck process there is an equilibrium level and an in built mechanism or stabilizer, that brings the random variable back towards its mean. Such a process would be: $dx=-\theta(x-x).dt + \sigma.dz$ This process could result from, or be required by, in the terminology of the WFD, `*wise*' management. A first question is what type of management would result in this process if the underlying or natural process is :
$(dX)/X) = \nu.dt + \sigma.dw$ The resulting water flow $z = \log(Z) = y + x$ such that dz is mean reverting is given by $y = (\tilde{x}(t))^{-\theta}\left(\int a\,\tilde{x}(t)^{\theta}\,dt + C^{*}\right)$ where $a = \left(\theta\,\bar{z} - \nu + \frac{1}{2}\sigma^{2}\right)$ and $\tilde{x}(t) = e^{\int x(t)dt}$. As $\int a\,\tilde{x}(t)^{\theta}\,dt$ is increasing and unbounded in t. and, as Y is a proportion ≤ 1, and y = ln(Y) , then $-\infty < y \leq 0$,. and so if a > 0 then eventually y > 0 for any C*. This implies that Y will be > 1 and so negative quantities are taken out of the river. So control to obtain a mean reverting process is only possible indefinitely if a < 0, or
$\theta.z + (1/2)\sigma^2 < \nu$, which is not possible if $\nu = 0$ In any case, it is possible only if θ, z, or σ^2 are not large in relation to ν. So if *Sustainability* is interpreted to mean a strategy that can continue indefinitely, whilst ensuring strictly positive use, then no feasible sustainable strategy exists. One unsurprising result is that increases in σ^2 lead to increases in y. So the more variable is the flow in a river, the smaller has to be the amount of withdrawal if reversion to mean has to be maintained.

Several conclusions follow from this. The World Bank study suggests that water flow into the wetlands will be maintained at a level which will allow them to function ecologically. The rule that permits this is not a simple or straightforward one. If flow is GBM, and if maintenance corresponds to flow into the wetlands being a mean reversion process then the fraction of natural flow that should go into the wetlands is given by

$Y = e^{\left[\int_0^t \left(\frac{\tilde{x}(s)}{\tilde{x}(t)}\right)^{\theta} dt\right]^{\left(\bar{z} - \nu + \frac{1}{2}\sigma^2\right)}}$ where $x(t)=e^{\int x(s)ds}$ This is a highly non-linear function of present and past flows as well as the underlying parameters. In any case, it is not clear that a mean reversion process is desirable on either an economic or an ecological basis. One special aspect that would suggest that such a mean reversion rule would be far from optimal or desirable from a social, as opposed to ecological viewpoint, is that the amount of water extracted depends on the fluctuations in current water flow, and not on any fluctuations in demand. There are good reasons as to why these would be inversely correlated, in that periods of drought, when natural water flow is at its lowest, may be precisely the times when there is high level of user demand.

4.3.2 Effect of parameter variation

We need to ensure that results are not just because of particular parameter values. This is what we now do. However it also shows how the social price of water could vary across basins. For example, in the first case the effect of more or less variability on social price is obtained.

1) Sensitivity of shadow price to parameter values
How s* varies as variance of water flow increases can be calculated from the expression derived

earlier that : $\frac{\partial s}{\partial \sigma^2} = \frac{\partial}{\partial \sigma^2}\left(\frac{\partial W}{\partial X}\right) = \frac{\frac{1}{2}\lambda(\lambda-1)X^{\lambda}}{\left(\rho - v\lambda - \frac{1}{2}\sigma^2\lambda(\lambda-1)\right)^2} + \frac{\partial}{\partial \sigma^2}\left(CX^{-\gamma}\right)$

This, however, is clearly a complex and non-linear expression. It is not clear from the expression whether this would be positive or negative. The diagram below shows s* for different values of σ².

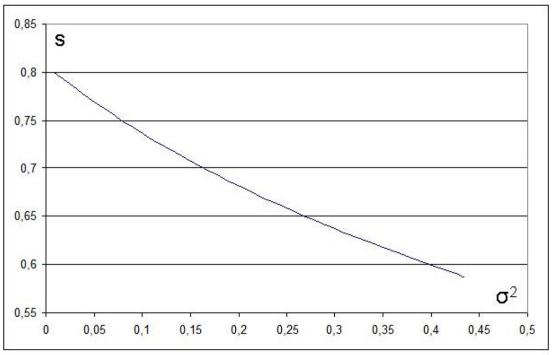

Figure 4.4. Sensitivity of shadow price s* to variance of water flow σ²

As σ² increases the shadow price s* falls. This is perhaps somewhat counter-intuitive. The reason is that as σ² increases, there are more likely high and low values for river flow, and because of the log-normal distribution, the consequences of high values will dominate low ones.

2) Sensitivity of Social Price to Variance in River Flow

As λ increases, the shadow price for water also increases, as value per ha. Loss of wetland means that loss of some more arising from increased variance, which both increase wetland area as well as decrease it according to the log-normal distribution. It is perhaps partially explained by the concavity of the valuation function $V=\alpha X^{\lambda}$. These depend on how the valuation expressions of the form $V(X,\lambda)=\alpha X^{\lambda}$ change as X and λ vary. Changing the value of λ will have two effects. It will change the overall value to be attributed to the wetlands, but also change the responsiveness of value to changes in wetland area. The first of these effects will be the same as those changes which operate in a linear scaling fashion, just the same as changing the factors that determine the level of the parameter α, such as whether bird hunting is included or excluded. So here, the focus is on the effect of the non-linear response that comes from changes in curvature of the value function, so in the above diagram both α and λ are varied together so that αX^{λ} is constant when X = 260,000 taken to the be the natural median value for wetland area. So the base value of wetland remains unchanged and the diagram shows the effect of a more non-linear response of value to area. The shadow price of water falls as the extent of diminishing returns increases (or λ falls). The reason for this is that decreasing λ reduces the marginal loss or gain in value for a given loss. Value of wetland is less area responsive and so the value loss from water diversion is not as great as it otherwise might be.

3) The effect of lowering the catastrophe level

Next, there is consideration of the level at which the absorbing barrier is set. This is a parameter that comes from the ecological analysis, and there is no economic guidance for its value. A value was chosen that seemed consistent with previous studies. However, it is clearly going to be important in the level of the shadow price. We consider, therefore drastic increases and decreases, to see if the cost comparison moving water sources away from the Nura comes from fixing the level determining catastrophe at a high level. The shadow prices reacts linearly and approaches a value of 0.75 as c approaches the initial (taken to be mean) value. For reductions in the level of the barrier c, from the value of 184550 ha., to 50,000 ha. This is one fifth of the current area. This is a drastic reduction in size, and if catastrophe is a possibility it would seem likely that it would be for reduction of area to an amount above this. For such a permissible reduction in size to 50,000 ha the shadow price to be attributed to water that does not find its way eventually into the wetlands will be above.18 euros per m³ (2000 prices). This remains well above the potential cost savings that would accrue to use of Nura water. There is initially a similar linear response, but eventually the price starts to level out and for a barrier at 50,000 ha. - that is one fifth of initial size- a value of 0.18 is reached. When international values are fully incorporated, the shadow price remains above € 0.17 even for reduction in wetland area to one fifth of its present before the occurrence of ecological catastrophe.

4) Changes in the discount rate

Finally, there is consideration of the effect of increasing the base discount rate. This is for a change in rate that applies to both valuation elements, so that for both local and global values the discount rate changes by an increment of 0.05, and for simplicity it is the base discount rate for local values that is used for the horizontal axis. The domestic discount calculated in earlier section is used. This is 20.8%, whereas for international valuations a discount rate of 5% is used. This is from the base levels of 5% for international wetland valuation, and the high value that was calculated for the domestic rate of 20% in equal .005 increments (from 0.05 and 0.2). As would be expected discounting the future more reduces the shadow price and at an exponentially declining rate, but again even so the shadow price remains above 0.15 for even very high discounting. As is expected increasing the discount rate has an exponential effect on the shadow price, although yet again it remains above € 0.15, for even very high discount rates.

5) Suppose that the growth in GDP per head and population is ignored in valuations

In part, this corresponds to ignoring issuers surrounding the Environmental Kuznets Curve for the local population. Results are that : With `EKC' social price value per $m^3$ is 0.123, and without `EKC' it is 0.024. So including, considerations of the increasing wealth and population levels will have a sixfold effect on the value per acre of wetland conservation. This is not altogether surprising given that it is equivalent to a substantial change in the effective discount rate that is being used from one which is very high at 20.8% to one much lower at 2%. The above are values for the Brander et al. meta regression which uses data from a local/regional level. The comparison with the value from the Woodward and Wui meta regression which does not and so is more of an overall global valuation is :

local valuation	0.123	global valuation	0.401

6) Calculating the price for change in trend of water diversion

For $v = 0$ then dW/dv takes the values € 17.3 / m^3 for V_1 and for V_2 € 4.5, giving a total of €21.8. This value is so high in relation to alternative water sources that no sensitivity analysis need be done.

4.3.3 The value of keeping options open

If decision-makers know that over time they are likely to get new information which will help them to resolve some of the uncertainties about the damage costs arising from water use to the Tengiz-Kurgaldzhino wetlands, then standard intuition is that this should reduce the extent to which one makes irreversible commitments in order to better exploit the information that will become available. In simple terms it pays to keep one's options open. This insight can also be viewed as a formal statement of the Precautionary Principle. This benefit, derived from keeping options open, is referred to as 'option value' or 'quasi-option value', and is an additional source of benefit to be included in any cost-benefit calculation of the net benefits of different policy choices.

A relatively simple decision model is used to calculate this. Investment can take place in two periods, representing present and future decisions, and in each period there is a good and a bad state that changes the level of water demand and the supply available from different types of water supply.

The investment plan is calculated so as to minimise expected present value of costs. However there is uncertainty about what the appropriate probability model is for the good and bad states. This is handled by their being an prior probability for which of two competing models is correct, representing the decision makers' beliefs. This is updated according as to whether a signal is received as to which of the two models might be correct. In the second period, two possibilities are considered one is that the investment decision can be made to depend on what the state of the world is at that time, in which case the decision maker is able to learn about the state. The other possibility is the decision maker has to make the investment decision before the state of world is known which corresponds to a situation where there is no learning. This allows for the cost difference between the situation in which there is learning and in which there is no learning to be calculated. This difference which we call a 'learning premium' points to answers to several interesting and important questions. The first is a direct application as to what is the value of finding out what the true state of the world is. The second type of question that this learning premium might be used to address is the extent to which a 'wait and see' policy would be worthwhile. If 'wait and see' is costly then a large learning premium may make such an approach worthwhile.

The overall objective is to choose the investment plan **x**, and the usage plan **y** to minimise the expected present value of overall costs, subject to the condition that there is sufficient capacity in place to meet demand in all states of the world. This is the requirement that the regulators impose on the water supply companies.

We take both periods 1 and 2 as lasting for 15 years. Time period 1 costs are discounted back to 2000, and time period 2 costs are discounted back to 2015, and then with the program to calculate the learning premium.

In the use of this model, an important consideration is the extent to which the environmental costs of water loss to the Tengiz-Kurgaldzhino wetlands are taken into account and whose values are included into the calculations of those values, and the corresponding calculation to be applied to the cost of the loss of wetland should ecological catastrophe occur. This is calculated from the Present Value of ecosystem services obtained before.

Table 4.15. Different variable costs for Nura water

Values Used	Per m^3 per year	Per m^3 per 15 year period
Operating cost only	0.07	0.76
Including env.cost domestic valuation	0.19	2.10
Including env.cost international valuation	0.40	4.37
Including env.cost both valuations	0.59	6.47

Table 4.16. Different Valuations for loss of Wetlands

Values Used	Loss of Wetland = $CX^{-\gamma}$	$e^{14\rho} CX^{-\gamma}$
domestic valuation	44.8	90.2
international valuation	603.0	1214.2
Including both valuations	1304.5	1304.4

As with other values, Quasi-Option value depends on whose valuation it is, and for what purpose it will be used. There are several possibilities for this and consequently base cases that might be of interest. These will depend on the underlying objectives. The main differences would be the extent to which the environmental costs of water loss to the Tengiz-Kurgaldzhino wetlands are taken into account and whose values are included into the calculations of those values, and the corresponding calculation to be applied to the cost of the loss of wetland should ecological catastrophe occur. Parameter values used and their sources are:

Table 4.17. Data and Sources for 'Learning Premium' Calculations

	Nura Stage 1	Nura Stage 2	Vyacheslav existing	IK canal extension	Leakage + Metering
Capacity good (Mill m^3/yr.)	45 World Bank p.41	45 World Bank p.41	54 (allowing for pipe leakage) Source: vB-H	27 Source: vB-H p.19	20 Source: vB-H p.19
Capacity bad (Million m^3/yr.)	33 Source: vB-H p.1	33 Source: vB-H p.1	36 (allowing for pipe leakage) Source: vB-H	27 Source: vB-H p.19	20 Source: vB-H p.19
Capital cost good state Mn € (2000 prices)	50.51 Source: vB-H p.24	0 Investment already made in stage 1	0 Already existing capacity	28 Source: vB-H p.24	10.8 Source: vB-H p.24
Extra Cost in period 2 bad state M € (2000 prices)	0	Use value of C^* from GBM model $= e^{14\rho} CX^{-\gamma}$	0	0	0
Operating cost good state €/m^3 (2000 prices)	0.7 WB p.39 (+ s^*) s^* taken from GBM model	0.7 WB p.39 (+ s^*) s^* taken from GBM model	1.03 WB p.39	2.64 WB p.39	1.99 JG p 41
Operating cost bad state €/m^3 (2000 prices)	0.7 WB (+ s^*) s^* taken from GBM model	0.7 WB p.39 (+ s^*) s^* taken from GBM model	1.03 WB p.39	2.64 WB p.39	1.99 JG p 41

JG – Jacobs Gibb(2004) vol. 4; WB – World Bank (2003); vB-H – van Beukering and Hirsch (2000); GBM – Geometric Brownian Motion Model.

The following cases were considered:

Case A: This is a baseline case. It excludes the environmental costs of water taken from the Nura and uses Domestic Values only for wetland loss. Demand in the "bad state" for period 2 is taken to be high.

Case B: low value of λ is low, so that value varies less with size

Case C: This uses the higher catastrophe cost that derives from value to the international community.

Case D: This sets the cost of water from Nura at the social price just in the bad state. In this case Nura stage 1 is only used in period 2 when there is higher demand. The effect on Nura stage 2 is unchanged in that it is used in good state, period 2 only. Instead there is more reliance on the IK canal extension. Leakage reduction and metering is always used in this case.

Case E: This uses a smaller increase in demand in the bad state for period 2. This lower level of demand in that state means that the IK canal extension is not used at all either in the good or bad state.

Case F: This uses a higher probability of getting the signal that the model with the higher probability of the bad state is more likely.

Case G: This is when no account at all taken of possible ecological damage to the wetlands. Nura water is the cheapest option once the investment is made. The variable cost savings outweigh the extra investment cost over Vyacheslav reservoir, and do that option is only used in period 2, and when there is learning in the bad state. This case can be thought of as being that suggested by the World Bank (2003) report, where Nura water is suggested to replace 90% of all other sources.

Case H: This is the same as before, but with a higher level of period 2 bad state demand. The

difference between this and the previous case concerns whether metering and leakage control is used. This fills the shortfall in supply in period 2. Here the IK canal extension is never used.
Case I: This increases the extent to which the social cost is taken account of. This case applies the social cost to just the period 2 bad state, but with a relatively likely good state.
Case J1: Now the social cost of water is taken account of to the bad state in both periods. It applies just to the variable cost.
Case J2 makes the good state even more likely and brings in Nura I water in period 1 in the learning case. Learning is important when it brings the decision problem close to one of certainty.
Case K1: This increases the extent to which the social cost is included by using a higher catastrophe cost for loss of the wetlands. This has effect of removing Nura stage II from the options used except for when there is learning and the good state results. In this case, supply from the Nura is replaced by supply from the IK canal extension, although this is for period 2 when demand increases.
Case K2: If probabilities increase towards 1 then Nura II is used to replace IK canal extension. These two cases can then be thought to be at a cusp where the cost decision is balanced between the two, and whether Nura II or IK extension should be used will depend on the probabilities and what is known about them. Information here is valuable as is indicated by the magnitude of the learning premium.
Case L: This extends the situations in which the social cost of Nura water is included in its variable cost for all situations except for stage I good state. This now excludes all use of Nura stage II.
Case M: This is a situation in which the two models do have very different probabilities.

We now look at how the usage plan varies for various combinations of possibilities:

Table 4.18. Simulation results part I

	Nura 1			Nura 2			Ishim			I-K Canal			Management		
Case	**1**	**2g**	**2b**	**1**	**2g**	**2b**	**1**	**2g**	**2b**	**1**	**2g**	**2b**	**1**	**2g**	**2b**
Al	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1
Anl	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1
Bl	1	1	1	0	1	0	1	1	1	0	0	1	0	0	1
Bnl	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1
Cl	1	1	1	0	1	0	1	1	1	0	0	1	0	0	1
Cnl	1	1	1	0	0	0	1	1	1	0	1	1	0	1	1
Dl	0	1	1	0	1	0	1	1	1	0	0	1	1	1	1
Dnl	0	1	1	0	0	0	1	1	1	0	1	1	1	1	1
El	0	1	1	0	1	0	1	1	1	0	0	0	1	1	1
Enl	0	1	1	0	0	0	1	1	1	0	0	0	1	1	1
Fl	0	0	1	0	0	0	1	1	1	0	1	1	1	1	1
Fnl	0	1	1	0	0	0	1	1	1	0	1	1	1	1	1
Gl	1	1	1	1	1	1	0	0	1	0	0	0	0	0	0
Gnl	1	1	1	1	1	1	0	1	1	0	0	0	0	0	0
Hl	1	1	1	1	1	1	0	0	1	0	0	0	0	0	1
Hnl	1	1	1	1	1	1	0	1	1	0	0	0	0	1	1
Il	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1
Inl	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1
Jl-1	0	1	1	0	1	1	1	1	1	0	0	0	1	1	1
Jnl-1	0	1	1	0	1	1	1	1	1	0	0	0	1	1	1
Jl-2	0	1	1	0	1	1	1	1	1	0	0	0	1	1	1
Jnl-2	0	1	1	0	1	1	1	1	1	0	0	0	1	1	1
Kl-1	0	1	1	0	1	0	1	1	1	0	0	1	1	1	1
Knl-1	0	1	1	0	0	0	1	1	1	0	1	1	1	1	1
Kl-2	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1
Knl-2	0	1	1	0	1	1	1	1	1	0	0	0	1	1	1
Ll	0	1	1	0	0	0	1	1	1	0	0	1	1	1	1

Lnl	0	1	1	0	0	0	1	1	1	0	1	1	1	1	1
Ml	1	1	1	0	1	0	1	1	1	0	0	1	0	0	1
Mnl	1	1	1	0	0	0	1	1	1	0	1	1	0	1	1

Table 4.19. Simulation results part II

Case	Cost with learning	Cost with no learning	Exp. Prob. State g	Option Value	Learning Premium (%)
A	148.1	151.8	0.69	3.4	2.2
B	183.0	189.2	0.33	6.2	3.3
C	183,0	189.2	0.33	6.2	4.5
D	214.5	221.4	0.33	6.9	3.1
E	176.0	178.5	0.33	2.5	1.4
F	227.1	238.7	0.15	11.6	4.9
G	132.3	132.3	0.15	0	0
H	146.8	150.3	0.15	3.5	2.3
I	150.6	154.0	0.66	3.4	2.2
J1	171.6	171.6	0.66	0	0
J2	149.4	152.8	0.81	3.4	2.1
K1	174.0	188.0	0.66	14.0	7.5
K2	155.7	171.1	0.81	15.4	9.0
L	179.1	188.0	0.66	8.9	4.7
M	162.3	178.9	0.56	16.6	9.3

It is possible to produce very many different simulations and cases. There are many variables and parameters for which different values could be chosen, or would be of interest. There are more of these parameters, than there are variables as outcomes. And so any desired result for the supply options chosen could be generated by judicious specification of parameters and supply and demand forecasts. However, several general conclusions emerge. If no account is taken of the environmental-economic costs of River Nura water use arising from wetland damage then that will be fully used and replace existing sources. If only limited consideration of such costs is applied overall, then such use goes to zero and other options are preferable. For in-between cases where low valuations are used then there is a variety of possibilities depending on the probabilities of good and bad states, the probability of receiving a particular the signal, and how that signal updates probabilities. However, quite what option replaces another when these change is unclear, and there are no definite statements that one option is a direct substitute for another. This is a strong justification for the use of Integrated Water Management. It is not always possible to consider just a choice between two options. All supply options should be considered, and a cost-benefit appraisal of just one or two may not be desirable if a wider view were possible.

For most cases, the magnitude of the Learning Premium is of the order of 4%. This is a relatively low figure looked at in itself. It arises because of the similarity of economic costs of different options – but it is those cases that are of interest because where there is substantial difference then decisions are clear. In these case though even a small Learning Premium will be sufficient to overturn decisions.

4.4 Norrström

Benefits and costs of policy measures

4.4.1 Activities reducing leaching of P and N

-Barley (spring): Barley production in itself does not lead to a direct decrease in nutrient leakage. The leakage reduction in a barley production is mainly due to eventual changes in the

cultivation system such as, reduced tillage or a better adjusted fertilization. Reduced tillage can have a reducing effect on the P erosion during the autumn. It also increases the humus content in the soil, thus increases the potential nutrient uptake and a higher crop yield thereby resulting in a lower nutrient leakage;
-*Hay, pasture:* Hay cultivation is known as a low leaking cropping system. It has a positive effect on the soil nutrient content by acting as N trap and thereby working as a fertilizer when it is cultivated into the soil;
-*Soil work out:* Here the conditions are the same as for spring barley;
-*Wheat, barley (winter):* When it comes to winter wheat and winter barley the same conditions regarding the positive effects apply for both. It is more a question of autumn crops versus spring crops. Autumn crops have the positive effect that there is a nutrient uptake already during the first autumn months and in the spring they have a head start and can start assimilating nutrients earlier in the year. Furthermore, in normal conditions autumn cropping results in a higher crop yield;
-*Salix:* Salix cultivation has a known low leakage of nutrients. The reasons are partly implied by lower fertilization and partly by a much longer growing period. Salix is a perennial crop and it takes around five years before harvest. This means that during a five year period the soil stands covered and the soil are not bare which has a big effect on the leakage. A perennial crop also has a more developed root system than an annual crop which decreases the leakage. An increase in Salix production means that lesser land is used for grain production thereby leading to a lower leakage;
-*Buffer zones:* Buffer zones lower the leakage from arable land due to many reasons. The filter strip in itself means that the area of arable land is reduced and no fertilizers are used on that area. The grass on the filter strip also acts as a filter for particular P that derives from surface runoff. The grass root system also sucks up a lot of the nitrate rich water and a part of it goes away due to denitrification;
-*Deciduous and coniferous forest:* There are no significant differences between deciduous and coniferous forest regarding nutrient leakage. The higher level of deciduous forest that is taken into account in the scenarios is due to a warmer climate and changes in forestry policy to a more diverse forestry.

4.4.2 The benefits of reduced emissions of N and P

Estimating the benefits of clean water depends upon several variables that describe the attributes of the resource and its uses. A water body might be used for recreational activities (such as fishing, boating, swimming, hunting, bird watching), for commercial purposes (such as industrial water supply, irrigation, municipal drinking water, and fish harvesting), or for both. Where recreational activities are created or enhanced due to water quality improvements, the public will benefit in the form of increased recreational opportunities.[13]

To estimate the benefits of clean water several methods may be used. The most used methods are related to stated preferences including the contingent valuation method and the choice experiment method. The other methods are related to revealed preferences and include methods such as travel cost and hedonic prices.

However, in the evaluation of benefits being the result of eutrophication reduction the benefit transfer method will be used. The use of the method depends on lack of resources to conduct a specific study related to eutrophication in the watershed of Sagån and Svartån.

In Sweden, for instance, several studies have been conducted with regard to water pollution. In Sandström (1996) the travel cost method was used to estimate the benefits of reduced

[13] http://www.epa.gov/waterscience/econ/appendc.html

eutrophication on the seas around Sweden. The consumer surplus from a 50% reduction of the nutrient load was estimated to range between 240 million SEK and 540 million SEK depending on the models used. In Soutukorva (2001) recreational values from a reduction of the nutrient concentrations in the Stockholm archipelago was estimated by application of the travel cost method. The aggregated consumer surplus of the two counties Stockholm and Uppsala was estimated to range between 59 million SEK for the year 1998 when time was not valued and 110 million SEK for the year 1999 when value of time was included. In Söderqvist (1996) the contingent valuation method was applied to estimate the benefits from a reduced eutrophication of the Baltic Sea. The total national willingness to pay amounted to 21816 million SEK, based on the assumption of zero WTP for all other groups than non-protesters. In Söderqvist and Scharin (2000), the contingent valuation method was applied to estimate the benefits of a reduced eutrophication in the Stockholm archipelago. The mean willingness to pay per adult resident in the counties of Stockholm and Uppsala was estimated to SEK 436-725 per year. The study concerned a sight depth in the inner and central parts of the archipelago to increase on average by about 1 meter in 10 years.

In estimating the benefits of reduced eutrophication in Sagån and Svartån watershed, the estimates of Söderqvist and Scharin (2000) are adapted to the studied area. This is because Söderqvist et al relate not only to eutrophication but to the studied area as well.

In the calculations of the present value of the benefits, the aggregation is made over:
-The adult population of Sala, Norberg and Västerås i.e., 127830 inhabitants,
-The adult population of Stockholm and Uppsala i.e., 1431700 inhabitants.

The objective of making estimations for the 2 populations is based on the fact that Sagån and Svartån watershed populations may act as altruists and express their willingness to pay to reduce the emissions of N and P to the water courses leading to lower eutrophication of Lake Mälaren as well as the Stockholm archipelago. The use of the adult population of Stockholm and Uppsala is based on the study of Söderqvist et al where these populations express their willingness to pay to decrease eutrophication to Stockholm archipelago. However, although the willingness to pay in Söderqvist et al only apply for 10 years we use this value for the whole period considered in the Sagån and Svartån watershed. Furthermore, since the present value includes the values in the coming 100 years and since we ignore the preferences of the coming populations we assume the status quo to be true in the future. When it comes to discounting interest rate of 4 % is used.

The net present value of benefits, defined here as the sum of discounted benefits over the related period, is shown in Table 4.20. Since the population of Stockholm and Uppsala counties is almost 10 times higher than the population in Sagån and Svartån watershed, the present value of benefits is almost 10 times higher as well.

Table 4.20. Net present value of benefits (million Euro$_{2005}$)

Benefits	50 years		100 years	
	A2	B2	A2	B2
Sagån, Svartån	163	163	184	184
Stockholm, Uppsala	1827	1827	2062	2062

4.4.3 Instruments in use to reduce N and P

In Sweden the sum of leaching of N from farmable land is 56000 ton. This leaching should decrease by 10000 tonnes i.e., 18% until year 2020 compared to the year 1995. The intensive agricultural sector in Sweden in general and in the municipalities of Norberg, Sala and Västerås in particular implies the use of fertilizers being the main source of eutrophication. Being aware on this fact, the authorities have been taking different measures for mitigation. In order to reduce N in agriculture, the charge on phosphorus and N has been changed since its introduction. Initially, the charge was 30 öre/kg (0.033 Euro) for N and 60 öre/kg (0.066 Euro) for P. The charges increased by 100% in 1998. In 1994 the charge on P was replaced by a charge of 30 SEK/g (3.33 Euro) cadmium exceeding 50 gramme /tonne phosphorus. During the same year the charge on N in fertilizers increased to 1.80 SEK/kg (0.2 Euro). At the same time the charge on cadmium in fertilizers changed to 30 SEK/g (3.33 Euro) for cadmium content exceeding 5 gramme/tonne. Since 1995 the charge was called a tax.[14] Yet, while the cost to reduce N leaching by one kilogram is estimated to SEK 200 (22.22 Euro) (Swedish EPA 2004) it seems that there is a need for higher taxes. As concerns phosphorus its use has increased somewhat since the reduction of its charge. Hence, the use of P was sensible to the charge.

However, since fertilizer demand is less sensible to increase in prices, other complementary programmes/ measures have been planned for the agricultural sector in order to reach the environmental goals (for more details on institutions in Norrström see WP3). These programmes/ measures such as the project "Greppa Näringen" take the form of increased information to the farmers related to:

-optimisation of fertilisers relative to crop needs;
-the use of economically and environmentally sustainable production methods;
-adaptation of livestock feeding associated to N and P content in fodder;
-construction and conservation of buffer zones adjacent to lakes and water courses.

These programmes/measures to promote awareness of environmental issues have been in place since 1986. These programmes include individual services, field and farm courses and demonstration sites. Training and demonstration projects have also been introduced – co-funded by the EU – as part of measures under the *Agri-environment Regulation (No. 2078/92)* and the *Rural Development Regulation (No. 1257/99)*.[15]

When it comes to eutrophication in general the sources are several as discussed above. In the case of households, the use of water per se does not lead to eutrophication; many types of household items might be contributing to eutrophication since many detergents contain P and lawn fertilizer contains N. However, finding instruments to decrease these chemicals is not an easy task and information to household may be the best instrument. On the other hand demand of water in Sweden in general and in the municipalities of Norberg, Sala and Västerås in particular is less price elastic. However, an increase in the price of water would generate some revenues that may be used for the management of water resources.

As concerns single houses, water treatment systems, although there are signs of improvements, the problem remains and depends mainly on the proportion of non-approved water treatment facilities. The proportion of approved treatment facilities in Sweden in general and Västmanland municipality in particular is in the range of 5-100 per cent with an average of 59 percent. In the municipality of Västmanland including Norberg, Sala and Västerås, the rate of non-approved facilities is lower, i.e., 50 percent (Swedish EPA).[16] Therefore, there is a need for increased approved treatment systems and the Swedish authorities are planning to investigate measures that can be taken. According to the Swedish EPA, the measures may take the form of incitements, subsidies or regulations.

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[14] Swedish EPA (2006).

[15] http://www.oecd.org/dataoecd/25/46/18987100.pdf#search=%22ECOTEC%20agriculture%20chemicals%20sweden%22

[16] Kunskapsläget om enskilda avlopp i Sveriges kommuner naturvårdsverket rapport 5415 (2004).

On the other hand, there is also the problem of urban run-off water that may include oils, heavy metals as well as different nutrients. These waters do not often end up in sewage treatment works but rather directly in watercourses.

4.4.4 Policy instruments and costs

There are no simple measures to counteract eutrophication depending on the variety of the sources. In the annex 9 of the EU_WFD it is recommended that the setting up of economic instruments, should be based on the polluter-pays principle in order to insure incentive pricing to water savings and "adequate" cost recovery.[17] However, the definition indicated by article 9 of the WFD, for example, does not include environmental costs.[18]

As discussed above the sources of eutrophication to Mälaren that are based on transport of N and P from Sagån and Svartån are several and are dominated by the agricultural sector. In general, two principle ways exist in the control of pollution from rural catchments:[19]

1. Adoption of "Best Environmental Practices" by optimization of fertilizer use, crop rotation, and soil cultivation methods in a manner that maintains the nutrient equilibrium in the soil;
2. Using various mitigation measures as buffering ecosystems (*e.g.*, riparian buffer strips and buffer zones, natural and constructed wetlands, hedgerows, shelterbelts) to intercept and transform nutrient fluxes from agricultural lands to water.

However, in this study the analysis of costs is based on a combination of way 1 and way 2 including mainly crop rotation and soil cultivation methods in a manner that maintains the nutrient equilibrium in the soil as well as buffer zones. These costs are also a combination of operation, maintenance as well as capital cost. However, in performing an economic assessment dealing with the agricultural sector, the response changes would be those related to both costs of production and the quality of a product. The change in costs implies a supply response, while the change in quality implies a demand response that is related to changing the consumer willingness to pay and the welfare derived from the consumption of a given quality of a crop. In this study, only costs related to the measures are considered. Impacts of the measures and the implied results on the product prices, product quantities as well as the consumer's response to these changes are not considered. This is because we assume that the Sagån and Svartån regions are too small to impact on prices although their costs may change i.e., the region is similar to the rest of the country. They are price taker and cannot influence the prices.

Table 4.21 shows the annual average costs per hectare related to production of different crops e.g., barley as well as Salix. Forest is not considered since there are no significant differences between deciduous and coniferous forest regarding nutrient leakage

Table 4.21. Production costs for different crops ($Euro_{2005}$ ha/year)[20]

Barley (spring)	Wheat (winter)	Barley (spring)	Hay	Salix	Buffer zones
389	633	500	417	333	47

[17] This European directive is the first one to recommend the implementation of economic principles.
[18] http://www.eeb.org/publication/2001/Review%20Water%20Pricing%202001.pdf
[19] http://www.biotechnology.uni-koeln.de/inco2-dev/common/contribs/36_kuuse.pdf#search=%22cost%20phosphorus%20sweden%20agriculture%22
[20] Salix: http://www.agrobransle.se/salix/odla/kalkyl/skane
Crops: http://ex-epsilon.slu.se/archive/00000674/01/2005_04.pdf
Buffer zones
http://www.greppa.nu/download/18.8aeb74fa563c6d2d7fff1562/Goda+r%C3%A5d_katalog.pdf

The undertaken measures in the agricultural sector to reduce emissions of N and P to Sagån and Svartån would lead to different reductions depending on whether the time considered is approximately 50 years or 100 years. The reduction in emissions is also dependant on whether the considered scenario is A2 or B2.

However, the annual average costs for a farmer may be considerable.[21] In the case of Sagån and Svartån and the A2 scenario for the coming 50 years for instance, the average annual cost in the first year for a farmer in the municipalities of Sala, Norberg and Västerås would be 1037 Euro. For the A2 in the coming 100 years the average annual cost would be 511 Euro. In the case of the B2 scenarios and the coming 50 years and 100 years, the average annual cost in the first year by a farmer in the municipalities of Sala, Norberg and Västerås would be 2093 and 1229 Euro respectively. The variation in costs depends mainly on the level of replacement of other crops by Salix.

Sagån

In the case of Sagån Table 4.22 brings together the emissions reductions of P and N relative to the average for years 1998-2004. The emission reductions are estimated for two scenarios using the SWAT model. In 2050-56_base, this scenario is a baseline scenario where accounts are only taken to climate change for that period. In 2050-56_A2 the emissions reductions are based both on climate change and the managements undertaken within the agricultural sector to reduce emissions of P and N. Hence, as shown emissions reductions of P in the baseline scenarios although no measures are undertaken they are considerable i.e., minus 46% after approximately 50 years and minus 57 % after approximately 100 years. These reductions are mainly a result of adaptation to climate change. For the reductions of N these are lower and depend on adaptation to climate change as well.

In order to comply with environmental goals, the managements undertaken under the A2 scenario lead to a reduction of 22% of P compared to baseline scenario where no measures are undertaken for the period 2050-56. For leaching of N to Sagån the reduction is estimated to 24% for the period 2050-56. For the period 2090-96 management in the agricultural sector would lead to reductions of P and N that are equivalent to 17% and 25%, respectively.

Table 4.22. Sagån: emissions reduction to watercourse relative to 1998-2004 (relative to baseline), all sources

	A2 scenario		B2 scenario	
Scenario	P%	N%	P %	N %
2050-56_base	-46	-12	-46	-9
2050-56	-68 **(-22)**	-36 **(-24)**	-68 **(-23)**	-35 **(-26)**
2090-96_base	-57	-9	-61	-9
2090-96	-74 **(-17)**	-34 **(-25)**	-76 **(-15)**	-38 **(-29)**

When it comes to B2 scenario emission reductions of P and N to Sagån are reduced in the baseline scenario by 46% and 9%, respectively, for the period 2050-56 as shown in Table 4.22. For the A2 scenario, the decrease in emissions of P and N are 68% and 35%, respectively. Furthermore, management undertaken under the B2 scenario imply a reduction of P and N equivalent to 23% and 26%, respectively, when comparing this scenario to the baseline scenario. For the period 2090-96 reduction of emissions of P and N relative to the baseline are estimated to 15% and 29%, respectively.

[21] The total number of farmers in the 3 municipalities is 1950.

Svartån

As concerns Svartån, the emissions reductions for both P and N are shown in Table 4.23. Similar to the case of Sagån the emission reductions are lower for the baseline scenario where no management is considered.

Table 4.23. Svartån emissions reduction to watercourse relative to 1998-2004 (relative to baseline), all sources

	A2 scenario		B2 scenario	
Scenario	P %	N %	P %	N %
2050-56_base	-43	-21	-48	-18
2050-56	-54 **(-11)**	-34 **(-13)**	-60 **(-12)**	-39 **(-21)**
2090-96_base	-59	-20	-59	-23
2090-96	-75 **(-16)**	-41 **(-21)**	-75 **(-16)**	-46 **(-23**)

For the B2 scenario the emissions reductions are in general higher than the A2 scenario depending mainly on the increased Salix production.

4.4.5 Cost effectiveness

In order to reduce emissions of P and N, the costs are relative to the source of emission as well as to the measures being used. The figure below compares costs to reduce P between different emissions sources in the lake Glan located in Östgöterland. Reduction measures are most cost effective in agriculture followed by sewage treatment works and urban run-off. The abatement costs to reduce P are less cost effective when it comes to household sewage and irrigation.

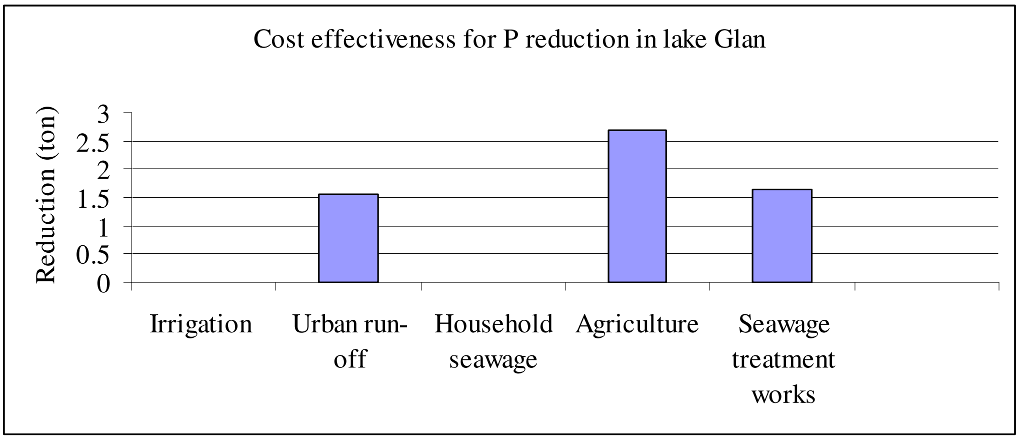

Figure 4.5. Cost effectiveness for phosphorus reduction in Lake Glan
Source: Naturvårdsverket (2003).
Note: The figure shows a summary of results based on a least cost analysis to estimate total costs related to measures that are needed to reach the proposed environmental quality norms of 25µg/l total phosphorus in Lake Glan in year 2015. The yearly cost to reach a phosphorus reduction of 6 ton is estimated to 12 millions SEK (1.33 million Euro). The results show that it is within 3 areas i.e., urban run-off, agriculture and sewage treatment works that it is cost-effective to reach 6 ton reduction.

Concerning reduction of N, costs are relative to sources as well. In Sweden, Elofsson et al (2003) have studied measures and costs to reduce emissions of N both at the source and to the cost. The costs at the source are shown in Table 4.24 where these are similar for industry and sewage treatment works i.e., 6 Euro. The costs to reduce emissions from cars by way of catalytic system are almost double i.e., 11 Euro.

Table 4.24. Average costs to reduce emissions of N ($Euro_{2005}$)

Source	Euro/kg
Industry	6
Sewage treatment works	6
Catalytic system	11

Source: adapted from Elofsson et al (2003)

However, when measures to reduce emission of P for instance are undertaken, these are often followed by a reduction of N as well. As shown in Table 4.25, the middle column shows costs where no additional positive effect is considered. In the right column the cost for the measure has been reduced by the positive simultaneous effect of N reduction. Hence, based on the side effect of the measures to reduce P the costs to reduce N are similar.

Table 4.25. Costs to reduce emissions of P and N

Measure	Euro kg^{-1} P Only P	Euro kg^{-1} P Including N-reduced
Improved arrangement of the size, shape and placement of the fields	0	0
Grass on the strips of land left at the end of a furrow in a field in order to facilitate the turning of the plough	0	0
Energy forest	0	0
Wastewater treatment with vegetation filter	67	33
Ponds to a moderate extent	133	67
Ponds to a greater extent	278	133

Source: Adapted from NV (2003).
Note: The calculation has been carried out for an ecological dairy-farm in Sweden.

In the case of Sagån and Svartån the costs to reduce both N and P for all scenarios are shown in Table 4.26. Based on the discussion of Table 19 where costs to reduce N for instance are half of total cost, the costs to reduce emissions of P and N in A2 scenario would be 5 Euro, respectively, in the case of Sagån for the period 2050-56. These costs are lower than the cost to reduce N from industry or sewage works or using catalytic system shown in Table 18. Similarly, the costs to reduce emissions of both N and P are in general lower for the period 2090-96.

Table 4.26. Average costs to reduce emissions of N and P to Sagån and Svartån ($Euro_{2005}$/kg)

Time span	Sagån		Svartån	
	A2 scenario	B2 scenario	A2 scenario	B2 scenario
2050-56	10	30	35	21
2090-98	2	5	23	44

When it comes to the B2 scenario, the costs to reduce emissions in Sagån are higher for the period 2050-56. For the B2 scenario the costs are higher in the case of Sagån in the period 2050-56. For the period 2090-96 costs in Svartån are higher.

These variations in costs between scenarios depend mainly on the level of replacement of other crops by Salix. Since production costs of Salix are lower than those of other crops, the overall implication in the different scenarios is lower average costs for the scenarios where more Salix have replaced the production of other crops.

Net present value of costs

Based on the implications of the scenarios A2 and B2 as well as the costs in Table 4.21 the sum of discounted costs i.e., the net present values of costs for the approximately coming 50 years and 100 years are shown in Table 4.27 where the used interest rate is 4%. As shown the net present values of costs for both scenarios are higher for the coming 50 years. The low present values of the coming 100 for both scenarios depend on the fact that more Salix is produced during this period.

Table 4.27. Net present value of costs (million $Euro_{2005}$)

	2050-56		2090-96	
Scenario	**A2**	**B2**	**A2**	**B2**
Costs	44	88	24	58

4.4.6 Cost benefit analysis

In this cost benefit analysis (CBA) there are other relevant effects related to the implementation of management but which are not considered. As discussed above, these effects may take the form of product price increase as well as the effect on employment. Unfortunately, depending both on lack of data and on limited resources to analyze these issues, these cost are not captured in the analysis. However, when it comes to employment in general, changes may be based on policies, projects or programs and should be included into a CBA. Since the effect of adaptation to climate change as well as management of the agricultural sector would have some impacts on cost and thereby on prices, it is probable that it will imply some unemployment. On the other hand, compliance with environmental goals may stimulate innovation inducing cost reduction where the outcome would be higher employment. Hence, there are two different hypotheses. The first one believes on increasing costs, higher prices, lower competitiveness and increasing unemployment. The other hypothesis supports the opposite outcomes. However, the assumption in this study is related to no effect, which implies that these issues are not considered. This assumption is supported by the findings in Johannesson et al (2000) where its found that in countries where the polluter sectors are relatively small e.g., Sweden, reduction of N emissions has marginal structural effects on other sectors. Further, in Morgenstern et al (2002) it is found that flexibility of labor market would absorb this effect of increasing costs.

As shown in Table 4.28, the difference between the discounted benefits and the discounted costs, i.e., the net present value is shown for both the populations of Stockholm_Uppsala and those of Sagån and Svartån i.e., populations of Norberg, Sala and Västerås, as well. Similar to the case of benefits, where these are almost ten times higher for the Stockholm_Uppsala population, the net present value when considering this population is almost ten times higher as well. However, in both cases the net present value is positive implying that the CBA passes the test meaning that the management programmes included in the scenarios would be efficient.

Table 4.28. The net present value (million $Euro_{2005}$)

	Time span (year)	Stockholm, Uppsala	Sagån, Svartån
A2 scenario	50	1784	119
	100	2039	159
B2 scenario	50	1739	74
	100	2004	125

When considering other covariates such as Salix production that may be changed in order to make a sensitivity analysis, the outcomes would depend on whether the population of

Stockholm_Uppsala or the populations of Sagån_Svartån are used. Since the affected populations are those of Stockholm_Uppsala that really expressed their willingness to pay to reduce eutrophication, a change in other covariates would not lead to negative net present value. Therefore, management in the agricultural sector based on adoption of "Best Environmental Practices" and using various mitigation measures would lead to higher benefits including compliance with the environmental objectives for the Sagån and Svartån watershed. However, although management of the agricultural sector would lead to high reductions in emissions of N and P, measures with impacts on other sources of eutrophication such as households would imply lower eutrophication and the realization of the objective of zero eutrophication.

4.5 Thames

The analyses summarised in this report reveal that a large number of activities contribute towards multiple pressures in the Thames river basin, putting many water bodies in the basin at risk of not achieving the good ecological status required by the WFD. Information on costs and benefits, including environmental costs and benefits, is needed to inform the design of cost-effective programmes of measures and river basin management plans, and the consideration of other environmental objectives (defra, 2005b). In many cases, there will be more than one measure or programme of measures which could be used to meet a WFD objective, and also more than one delivery mechanism for implementing it (defra, 2006). A cost-effectiveness analysis enables judgements to be made about the most cost-effective combination of measures which could be implemented in order to assess whether programmes of measures are disproportionately expensive and to ensure that the least cost is incurred for maximum effect (defra, 2005a).

4.5.1 Cost-effectiveness analysis

An approach to the assessment of cost-effectiveness presented by RPA (2004), suitable for UK-wide application, is being developed as part of a collaborative research programme into a practical method to build cost-effectiveness into the river basin planning process (defra, 2005a). The methodology comprises (RPA, 2004):

- Screening - overview of the likely pressures and impacts, and an initial assessment of the technical feasibility of measures;
- Costs - estimation of the costs of the measures in qualitative, quantitative and monetary terms;
- Effectiveness - prediction of the potential effectiveness of the measures across the pressures;
- Cost-effectiveness - assessment of the cost-effectiveness of the measures in order that they can be compared and combined into a programme of measures designed to meet good status.

It is recommended that the first screening of measures takes place at the national level, to identify those measures which appear most cost-effective nationally, and is then repeated at water body level, taking into account those measures to be applied at the national level and adding further measures addressing water body specific issues (RPA, 2004). This facility for application at a range of scales is a key advantage of the methodology.

The outputs of the cost-effectiveness analysis assessment for each measure or programme of measures will comprise (RPA, 2004):

- Predictions of effectiveness in relation to individual pressures and required good ecological status;
- Estimates of the associated financial and economic costs;

- A summary of the uncertainties surrounding the estimates of effectiveness and costs;
- An indication of the cost-effectiveness of the individual measures, and of the combined programmes of measures.

Ideally, numerical indicators of cost-effectiveness are required to facilitate decision-making processes.

4.5.2 Assessment of disproportionate costs

A comparison of the cost-effectiveness of different programmes of measures should enable the most cost-effective programme to meet a WFD objective to be identified. However, this is not the only relevant consideration, as selecting the most cost-effective measures will not necessarily lead to an acceptable apportionment of costs and benefits between the different water users or sectors (defra, 2006). The economic analysis provides information to determine whether a proposed measure is found to be disproportionately expensive. The assessment of disproportionate costs is done at a sectoral/water user level and is based on a comparison of costs and benefits, whilst accounting for uncertainty and qualitative information. The methodology will comprise (RPA, 2004):

- Assessment of whether the costs significantly outweigh the benefits, taking into account qualitative, quantitative and monetary data;
- Consideration of the financial costs to individual water users within a sector and the degree to which these may damage the viability of those users, including an assessment of the distribution of costs between consumers, producers and suppliers;
- Compilation of information on the total financial and economic costs borne by the water user/sector and how much these are, both as a proportion of total compliance costs and as their relative contribution to the failure to meet good ecological status. The sectoral differences in the relative contribution determine the degree to which a particular sector (or water user within that sector) bears a disproportionate share of the costs relative to their contribution to the problem.
- Investigation into the incidence of costs and benefits.

Disproportionate costs assessments and decisions would also be informed by the “polluter pays” principle and fairness assessments.

4.5.3 Summary

The cost-effectiveness analysis methodology developed by RPA (2004) has revealed several issues requiring further investigation. The following activities are scheduled to be carried out over the period 2004-2010 (defra, 2005a):

- Improved identification of the relevant water uses, drivers and pressures related to the economic analyses, and their role in the decision-making for programmes of measures;
- Improved assessment of costs and economic impacts for each of the options affecting the major sectors that will need to be appraised in river basin management plans;
- Improved identification of environmental damage concerns in the case of each option;
- Improved assessment of cost recovery and incentive pricing, cost-effectiveness and disproportionate costs, and refinement of data needs to support these analyses;
- Development of guidance on benefits assessment;
- Improved assessment of the environmental benefits of river basin management plans.

These activities will fall under a programme for work for taking forward the economic analyses supporting the implementation of the WFD (defra, 2005a), in collaboration with a wide range of stakeholders, called the UK Collaborative Research Programme on River Basin Management

Planning Economics (CRP).

4.5.4 Thames Water case study

Thames Water is the principal provider of water services in the Thames river basin. With forecasts of increasing water demands in an already water-stressed basin, and recent water shortages in the southern UK during the 2006 drought (events that may increase in severity and frequency with the potential impacts of climate change), a major project has been to predict how much water the company's customers will need over the next 25 years, and plan how to provide it. The London area and the Swindon-Oxford area are at particular risk of "running out" of water, with an extra 280 ML per day and extra 60 ML per day, respectively, needed in 2030 (Thames Water, 2006). Drawing up and choosing between the various possible solutions has enabled many of the principles of, and methods developed for, the economic analysis for the WFD to be used to give a comprehensive review of the overall sustainability of the options available. The approach implemented is based on the current industry best practice least economic cost approach (including environmental and social costs), but has been developed to allow more explicit consideration of cost, risk and environmental and social impacts (Thames Water, 2006). The method involves:

- Identification of a long list of measures for saving or supplying water (e.g. fixing leaks, demand management approaches, development of new resources, reusing wastewater, intra and inter-basin transfers);
- Screening of the long list and rejection of impractical measures;
- Development of the remaining measures into schemes that could be planned and implemented, in order to make a reasonable assessment of their costs, benefits, risks and impacts; each measure could, of course, be implemented in several ways, each with its own associated costs, etc;
- Ranking of the schemes following on the basis of their costs, benefits, risks and impacts;
- Ranking of the measures according the UK Government's recommended twin-track approach i.e. priority being given to reducing demand and leakage before and new supply schemes are developed;
- Comparison of the different schemes, again using cost, benefit, risk and impact indicators, to identify which schemes or combinations of schemes perform best overall;
- Decisions on the most suitable programme of measures.

The preferred solutions under further consideration in both risk areas (Thames Water, 2006) include metering properties on change of occupancy, enhanced water efficiency (old and new technology), water saving from new build designs, leakage reduction (proactive, seeking out leaks, rather then reactive), groundwater development, aquifer recharge, and a dual function reservoir (water supply and environmental flow support). In the London area, additional proposals include desalination in the Thames estuary and indirect use of treated wastewater. These proposals are obviously at an early stage. However, the iterative nature of river basin management planning and the requirement to consult widely with stakeholders at every stage means that it is necessary to start any such process well in advance.

5. Summary and conclusions

5.1 Okavango

Direct use values associated with the Okavango Delta Ramsar site include those generated by non-consumptive tourism, hunting tourism, household livestock production, household crop production, and household harvesting and processing of natural resource products. The values are overwhelmingly dominated by those generated by tourism, which takes place in the central zone, and which contributes P401 million annually to the GNP. Eighty percent of the tourism direct value is from non-consumptive activities. Ninety percent of tourism is attributable to the actual wetland within the Ramsar site. Agricultural pursuits take place mainly in the northern, western and southern zones, and contribute P42 million annually to the GNP. Ninety three percent of this is from livestock, and only 3% of it is derived from the wetland itself. Household harvesting and processing of natural resources also takes place in the north west and south, and contributes P29 million annually to GNP. Fifty three percent of this derived from the wetland.

The Ramsar site contributes to livelihoods of its people through profits (both cash and in-kind) from agricultural and natural resource use, through wages and salaries in the tourism sector and from rentals and royalties in the tourism sector. Poor households in the study area benefit from profits amounting to P99 million, from wages and salaries amounting to P102 million, and from rentals and royalties amounting to an estimated P25 million. The wetland contributes less than 3% of profits, but nearly all the wages and royalty benefits. Of the direct contribution made to the national GNP by the Ramsar site (P472 million per annum) 31% accrues to low income elements of society. In the total (both direct and indirect) contribution made to the national GNP by the Ramsar site, this figure is lower, being some 18%.

The likely effect of future land use options on direct use values were examined for three options. These involved the currently proposed land use plan, a second option with emphasis on the expansion of agricultural lands, and a third option with emphasis on protection of the natural assets of the delta. The currently proposed use plan, which gives emphasis to complementary land use and wise use of the resources, emerged as the most economically efficient. This plan thus appears optimal for the Ramsar site. The likely effects of external factors, involving water extraction plans and climate change predictions were tested in two further scenarios. These factors, particularly climate change, will reduce the size and value of the Ramsar site considerably. Attention should be given in planning to any possible ways of ameliorating these effects.

5.2 Biobío

By relating the economic effects caused by hypothetical variations of changes in hydrological regimes in the Biobío basin, we can see the existence of important impacts. The social NPV indicator shows a negative and inverse ratio for increments in flow level, because as the flow increases the social NPV becomes more negative, and a positive and direct ratio for flow decreases, because the social NPV progressively increases as the flow level decreases. This leads to conclusions related to the regional incorporation of a better integrated management of this water resource on the regulatory scale, because this would allow the implementation of policies and key actions leading to prevent negative economic impacts when there are negative climate scenarios.

Also, to achieve progress in the integrated management of water resources, it is fundamental to determine a clearer administration regarding the functions and responsibilities for institutions taking part in the administration of water resources, a more efficient and effective administration is required that is able to integrate all participants, without producing double functions or controversy when taking decisions, when these decisions depend on several institutions, therefore it is relevant that strategic management is in charge of only one functional unit responsible for delegating the corresponding responsibilities to other entities, and through a systemic approach with continuous feedback, expedite information flow both ways.

A policy about water resources must clearly propose protection and conservation of different river ecosystems in the country, to ensure maintenance of biodiversity of different ecosystems and resource quality. This requirement is a key objective to achieve maintenance of hydrological basins, as well as sustainability of nature and development, especially since strong economic impacts of hypothetical climate changes in the Biobío basin were discovered in this study.

5.3 Nura

Acknowledging the skewed and autocorrelated stochastic process that underlies flow in the Nura, and the potential for irreversible, or catastrophic damage to the wetlands makes a substantial difference to decisions that should be made. For example, it can lead to an extreme version of the Precautionary Principle that nothing should be done to take water out of the river before more information is available. This conclusion depends on cost and benefit parameters for the basin. In particular it requires that a Social or "shadow" price for water be calculated. This was the marginal effect of water flow on the expected present value of ecosystem services from the wetland. The following stages were necessary:

1. Calculation of appropriate discount rates that will be used by national agencies and that should be used taking into account international conservation. It was found that there was a wide divergence between the discount rates applicable to a rapidly growing transition economy taking into consideration the growing population and income levels, and those more appropriate for an international conservation agency.
2. Valuations for the wetlands. These will differ between those applicable nationally, depending on local parameters and variables, and those applicable internationally, where considerations of Ramsar status would be included.
3. Recognition that water flow is highly variable with long periods of successive droughts. This was modelled as a Geometric Brownian Motion stochastic process, and the presence of potential eco-system catastrophe as an absorbing lower barrier at which wetland value goes to zero. Including the social price makes the use of Nura water uneconomic.
4. The calculation of the social price enabled a calculation of the economic cost of ecological catastrophe for the wetland system, and this enabled an "option value", to be calculated which represents the value to be obtained from keeping options open.
5. Such values are usually included as components of overall value but very rarely calculated. A discrete model was developed that enabled this. One stage was to derive the cost minimising choice of water supply option for Astana. If the social price is fully included, then Nura water is never used, if it is not included it is always used, and where there is only partial recognition the small changes in parameters will lead to any of the available options being chosen.

A Social Price of 0.5 euros per m^3 (2000 prices) was obtained and when this is added to the operating cost, the conclusion of the World Bank Study that 90% of projected Astana water demand could possibly be met from diverting water from the River Nura with a cost of $0.07/$m^3$ compared to the cheapest alternative of $ 0.17/m^3, would be reversed if environmental costs are included in both prices.

5.4 Norrström

The study is limited to the Svartån and Sagån watersheds within the Norrström water basin where the agricultural sector is the biggest emitter of nutrients leading to eutrophication of Lake Mälaren as well as the Stockholm archipelago. Hence the study is limited to eutrophication and it is not related to water pricing or water scarcity.

The results from different scenarios, i.e. the A2 and B2 scenarios for the periods 2050-56 as well as 2090-96, show that the assumed management in the agricultural sector to comply with the regional goals is cost effective and ranges between 2 and 44 Euro being the average costs to reduce emissions of N and P. However, the average annual costs for a farmer may be considerable. These costs range between 511 Euro in the A2 scenario for the coming 100 years and 2093 Euro in the B2 scenario for the coming 50 years. The variation in costs depends mainly on the level of replacement of other crops by Salix.

When it comes to cost benefit analysis the general finding is that the discounted benefits for both the coming 50 years and the coming 100 years are much higher than the discounted costs for the respective period. When considering the population of Sagån and Svartån for instance, the net present value for the A2 scenario and the coming 50 years is estimated at 119 Euro.

There are, however, a number of uncertainties in this analysis. There are uncertainties related to the results in each scenario that are based on the assumptions included in the SWAT model. Other uncertainties are related to the estimation of benefits for the coming years. Yet, the implications of the assumptions in the A2 and B2 scenarios on the socio-economic issues would be marginal based on the fact that where the polluter sectors are relatively small, e.g. Sweden, reduction of N emissions has marginal structural effects on other sectors.

5.5 Thames

Supporting documents on the economic analyses have been prepared for the Thames river basin (defra, 2005a; 2005b), providing an overview of the socio-economic importance and dynamics of water uses in the basin, and summarising work to identify driving forces and pressures and establish a baseline scenario including forecasts of population, households, output and employment. Population and households in the basin are expected to grow at rates of 0.7% and 1% per annum, respectively. This growth has implications for public water supply abstractions and sewage discharges; indeed, the most important abstractors in the basin are water companies. The electricity industry is the second largest abstractor and output in this sector is expected to grow. The transport sector, one source of diffuse pollution, makes up an important part of the basin's economy and is also expected to grow. However, the agricultural sector, which is another source of diffuse pollution, is expected to decline. The forecasts are based on a hybrid approach involving projections of current trends (adjusted for known developments in the drivers), available models, expert opinion and stakeholders, and could be improved as more information on sector-specific parameters relating to likely future trends becomes available (defra, 2005a).

By assessing the major trends of socio-economic drivers and the evolution of present water management issues, the results identify what issues will be more and less important in the future and inform the process for developing programmes of measures and river basin management plans. The next stages include assessment, in consultation with stakeholders, of the costs and economic impacts for each of the different sectors for which control options will need to be appraised in the management plans. River basin planning is necessarily an iterative process entailing the identification of objectives (e.g. good ecological status), the consideration of possible measures to meet those objectives, consideration of the technical feasibility, costs and benefits of achieving those objectives and, as a result, reassessment of the original objectives and consideration of alternative objectives (defra, 2006). This periodic reassessment, as information is continually improved and identified gaps in the knowledge base are filled, will enable all stakeholders in the Thames river basin to take a more holistic and integrated approach to water management in the future.

6. References

Note that references for the Nura study are given in Appendix A.

Andersson, J. (2005): Reduced soil preparation – a case study. Sveriges lantbruksuniversitet, Institutionen för Jordbrukets biosystem och teknologi Alnarp.

Cambridge University. 2004. Business as Usual Projections of Agricultural Outputs Final Report. Published by the Environment Agency. (http://www.environmentagency.gov.uk/commondata/103599/busiasusualwfd_854912.doc)

Campbell, A.C. & von Richter, W. 1976. The Okavango delta and tourism. pp 245-248 in: Proceedings of the symposium on the Okavango delta and its future utilisation, Gaberone, Botswana, Aug 30 – Sep 2, 1976. Published by the Botswana Society.

Department for Environment, Food and Rural Affairs (defra). 2006. River Basin Planning Guidance. Crown copyright 2006. (http://www.defra.gov.uk/environment/water/wfd/pdf/riverbasinguidance.pdf)

Department for Environment, Food and Rural Affairs (defra). 2005a. Article 5 economic analysis of water use supporting document: Thames River Basin District. Crown copyright 2005. (http://www.defra.gov.uk/environment/water/wfd/economics/pdf/thamesecon.pdf)

Department for Environment, Food and Rural Affairs (defra). 2005b. Summary report of the characterisation, impacts and economic analyses required by Article 5: Thames River Basin District. Crown copyright 2005. (http://www.defra.gov.uk/environment/water/wfd/pdf/thamestext.pdf)

DHI *et al*. (December 2005). Okavango Delta Management Plan. Hydrology and Water Resources; Analysis of Water Resources scenarios.

Elofsson, K., Gren, I-M.(2003): Kostnadseffektivitet i svenskmiljöpolitik för Östersjön - en utvärdering. Specialstudier Nr. 3. Utgiven av Konjunkturinstitutet.

EASG (Economic Steering Group and the Economic Advisory Stakeholder Group). 2004. Economic Analysis for the Water Framework Directive Progress Report from the Economics Steering Group and Economic Advisory Stakeholder Group (England and Wales) for the External Review of the River Basin Characterisation/Article 5 outputs. Published by the Department for Environment, Food and Rural Affairs (defra). (http://www.defra.gov.uk/Environment/water/wfd/economics/pdf/easgprogrep.pdf)

European Commission (EC). 2004. Information Sheet on the methodology to prepare a baseline scenario. Common Implementation Strategy for the Water Framework Directive (2000/60/EC), produced by Working Group 2B, Drafting Group EC01. (http://forum.europa.eu.int/Public/irc/env/wfd/library?l=/framework_directive/thematic_documents/economic_issues/information_economic/i-baseline_scenario/_EN_1.0_&a=d)

European Commission (EC). 2003. Economics and the Environment: The Implementation Challenge of the Water Framework Directive. Common Implementation Strategy for the Water Framework Directive (2000/60/EC): Guidance Note 1, produced by Working Group 2.6 WATECO. Luxembourg Office for Official Publications of the European Communities. (http://forum.europa.eu.int/Public/irc/env/wfd/library?l=/framework_directive/guidance_documents/guidancesnos1seconomicss/_EN_1.0_&a=d)

Environmental Resources Management (ERM). 2004. Economic Importance and Dynamics of Water Use Relevant for River Basin Characterisation(England and Wales) Final Report. Published by the Department for Environment, Food and Rural Affairs (defra). (http://www.defra.gov.uk/environment/water/wfd/economics/pdf/usereport.pdf)

Environmental Resources Management (ERM) and Stone & Webster. 2004. Assessing Current Levels of Cost Recovery and Incentive Pricing Final Report. Published by the Department for Environment, Food and Rural Affairs (defra).

(http://www.defra.gov.uk/environment/water/wfd/economics/pdf/cripreport.pdf)

Foundation for Water Research (FWR). 2004. The EC Water Framework Directive: An Introductory Guide. Foundation for Water Research, Marlow, Bucks, UK. (http://www.fwr.org)

Grippa näringen (2004): Godaråd och värdefulla ideer. Åtgärdskatalog 2004.

IPPC (2001). Intergovernmental Panel on Climate Change - Third Assessment Report (IPCC TAR 2001) "Climate Change 2001: Impacts, Adaptation, and Vulnerability. Cambridge University Press.

Jacobsen, T., A.MacDonald and H.Enggrob, 2005. ODMP Hydrology and water resources: integrated hydrologicval model. DWA and DANIDA.

Johannesson, Å. & Randås, P. (2000): The Effects of Implementing Markets for Emission Permits Nationally Versus Regionally. *In: Managing a sea – the ecological economics of the Baltic*. Gren, I-M., Turner, K. and Wulff, F. (red.), Earthscan Publications Ltd., London.

Lantmännen Agroenergi (2007): Kalkyl för Salixodling i jämförelse med träda 2007 (utan gårdsstöd) Skåne och Halland.

Mason, C. (2002): Biology of freshwater pollution, Education Limited.

Mendelsohn, J.M. & El Obeid, S, 2004 . Okavango River: the flow of a lifeline. Comprehensive analysis and compilation of information on the Okavango River Basin in Angola, Namibia and Botswana. Published by Struik, Cape Town.

Morgenstern, R., Pizer, W., Shih, J.-S., 2002. Jobs versus the environment: an industry level perspective. Journal of Environmental Economics and Management. No 43.

Mosepele, K. 2005. Trends in fisheries development and fish utilisation in the Okavango Delta. Work package 4 of: Water and ecosystem resources in regional development: balancing societal needs and wants and natural resource system sustainability in international river basis. Harry Oppenheimer Okavango Research Centre, University of Botswana.

Naturvårdsverket (2003): Åtgärds- och konsekvensanalys för införandet av miljökvalitetsnormer förfosfor i sjöar. Underlagsrapport (1) till Miljökvalitetsnormer för fosfor i sjöar – redovisning av ett regeringsuppdrag (NV rapport 5288).

Ofwat (http://www.ofwat.gov.uk/aptrix/ofwat/publish.nsf/Content/junereturn)

Plantec Africa, MTK Planning Solutions and Lesedi Consulting, 2006. Okavango Delta RAMSAR Site land use and land management plan (2005-2029). Prepared for the Tawana land Board.

Risk and Policy Analysts (RPA). 2004. CEA and Developing a Methodology for Assessing Disproportionate Costs Final Report. Published by the Department for Environment, Food and Rural Affairs (defra). (http://www.defra.gov.uk/environment/water/wfd/economics/pdf/ceafrreport.pdf)

Sandström, Mikael (1996), "Recreational benefits from improved water quality: A random utility model of Swedish seaside recreation". Working Paper No 121, Working Paper Series in Economics and Finance, Stockholm School of Economics.

Scudder, T., Manley, R.E., Coley, R.W., Davis, R.K., Green, J., Howard, G.W., Lawry, S.W., Martz, D., Rogers, P.P., Taylor, A.R.D., Turner, S.D., White, G.F., Wright, E.P. 1993. The IUCN Review of the SOIWDP. IUCN Wetlands Programme.

Skog Forsk (2001): Resultat no 17.

SMEC, WLPU and Swedish Geological Int, 1991. Botswana National Water Master Plan: final report vol. 1. Report to the Department of Water Affairs.

Söderqvist, Tore (1996), "Contingent Valuation of a Less Eutrophicated Baltic Sea". Beijer Discussion Paper Series No. 88, The Beijer International Institute of Ecological Economics, The Royal Swedish Academy of Sciences, Stockholm.

Söderqvist, Tore and Henrik Scharin (2000), "The regional willingness to pay for reduced eutrophication in the Stockholm archipelago". Beijer Discussion Papers Series No. 128, The Beijer International Institute of Ecological Economics, The Royal Swedish Academy of Sciences, Stockholm.

Soutukorva, Åsa (2001), "The value of improved water quality – A random utility model of recreation in the Stockholm archipelago". Beijer Discussion Papers Series No. 135, The

Beijer International Institute of Ecological Economics, The Royal Swedish Academy of Sciences, Stockholm.

Statistics Sweden (2005).

Statistics Sweden (1999): Water accounts; Physical and monetary data connected to abstraction, use and discharge of water in the Swedish NAMEA.

Swedish EPA (2006): Eutrophication of Swedish Seas. Final report no 5509.

Tawana Land Board 2006. Okavango Delta Ramsar Site Land Use and Land Management Plan (2005 – 2029). Final report. Prepared by Plantec Africa in association with MTK Planning Solutions and Lesedi Consulting Engineers.

Thames Water. 2006. The Upper Thames Major Resource Development (UTMRD). Stage 1 - Needs and Alternatives Report. (http://www.thameswater.co.uk/en_gb/Downloads/PDFs/UTMRD_Stage_1_N_and_A_Report-reduce.pdf)

Thurlow, J. 2006. A 2002/03 social accounting matrix for Botswana. International Food Policy Research Institute, Washington, DC, USA.

U.S. Environmental Protection Agency (2006): Water quality standards. (http://www.epa.gov/waterscience/econ/appendc.html)

Vattenvårdsförbund (2004): Mälaren en sjö för miljoner, Miljömål för Mälaren.

Wolski, P., Murray-Hudson, M., Savenije, H., & Gumbricht, T. 2005 Modelling of the hydrology of the Okavango Delta. Water and Ecosystem Resources for Regional Development. Harry Oppenheimer Okavango Research Centre, University of Botswana.

7. Annex

Appendix A

The following papers that have been produced from the project work in the **Nura case study** are appended as a pdf file in Appendix A:

1. Alan Ingham, Lyudmila Yakovleva and Mikhail Ilyushchenko, "The Effect of Uncertainty and Variability on the Economic Appraisal of the Nura Clean up Project in Central Kazakhstan", International Journal of Ecological Economics & Statistics (IJEES), ISSN 0973-1385, Volume 5, Number S06, Summer 2006, http://ceser.res.in/ijees/cont/ijees-s06-cont.html

2. Alan Ingham and Lyudmila Yakovleva, "Calculating the Shadow Price for River Water when there is a Possibility of Ecological Catastrophe: An Application to the River Nura." Accepted for presentation at the 9th biennial conference of the International Society for Ecological Economics in Delhi in December 2006.

3. Alan Ingham, "Calculating Quasi-Option Value for the Wetland Ecosystem: Learning about the Effects of Reduced Water Inflow". In draft form.

Appendix B

Annexes to the report produced for the **Biobío basin** are collated in Appendix B, Section 1 – 5.