THE SCOPE FOR RESOURCE ECONOMIC ANALYSIS TO SUPPORT ENVIRONMENTAL ASSESSMENT UNDER THE SOUTH AFRICAN WATER POLICY

by

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CHAPTER 1. INTRODUCTION

1.1 The Development of South Africa's Water Resources

South Africa has a long history of water resource engineering, starting with the building of Waegenaars Dam to supply water to ships passing the Cape of Good Hope in 1663 (Triebel and van Niekerk, 1994: pg 33). Over the past 50 year water resource engineering has consistently ensured that South Africa's growing agricultural, industrial and domestic demand for water has been met through the development of large regional water supply schemes. This has recently culminated in the massive Lesotho Highlands Water Project (Triebel and van Niekerk, 1994).

However, in the past decade there has been a recognition that this supply-side approach to water resource management is not sustainable, given the relatively limited water resource availability in South Africa. South Africa is a water scarce country, with an average of less than 500 mm rainfall per annum (DWAF, 1986). Furthermore, these early engineering-driven water resource developments did not take account of the fragile relationship between water resources, aquatic ecosystems and local communities.

This recognition has led to a reorientation of the approaches to water resources management in South Africa, which has been reflected in the new National Water Policy (DWAF, 1997b) and enabled through the National Water Act (Act 36 of 1998). This legislation has acknowledged the need to protect the sustainable functioning of the water resource upon which all other users depend, as well as the necessity of managing water demand. The role of environmental assessment in the planning and design of water resources development has been emphasised, in order to manage the potentially significant environmental impacts of these developments.

1.2 The Environmental Impacts of Water Resource Developments

1.2.1 Types of environmental impacts

By their nature, large water resource developments, such as impoundments, affect the social and ecological systems in which they occur (Rooseboom *et al*, 1994; Department of Water Affairs, 1986). Some of these environmental effects may be positive, but there are usually many negative consequences associated with their construction and operation (Davies *et al*, 1993).

Regional water supply is generally the main objective of large water resource developments and is directly addressed during the planning process, as it has obvious social and economic connotations. On the other hand, environmental impacts occurring in the immediate vicinity of the development or within and along the river downstream of the development, were not considered to as great a degree historically.

In the following discussion, ecological impacts are dealt with separately from social impacts, although they may be highly interrelated. In some cases, the social or ecological impacts have associated economic consequences; these are highlighted at the end of this section.

1.2.2 Ecological impacts

The ecological impacts of construction are significant and are largely related to the disturbance of the biota and habitat in river channel and riparian areas. This includes the development area itself, associated-activities such as the access roads and borrow pits, as well as downstream impacts such as sedimentation.

For the purposes of this dissertation, the ecological impacts associated with the operation of the water resource development are of greater interest, in particularly the impacts associated with regulation, storage, abstraction and (inter-basin) transfer of water. Davies *et al* (1993: pg 145) and DWA (1986: pg 6.46) highlight a number of the ecological impacts associated with impoundments. These impacts are generally negative and result in loss of habitat and species (reduced biodiversity) in the downstream aquatic and riparian environment. The following general types are cited:

- Changes in flow regime, due to regulation and abstraction, which affects the habitat and ecosystem functioning of the downstream aquatic environment.
- Changes in flood cycles which should scour rivers of deposited silt and act as ecological triggers for the development of certain aquatic species(eg. fish breeding).
- Changes in sediment loads, due to the capture of sediment in the impoundment, resulting in scouring of the river channel directly below the impoundment.
- Changes in riverine geomorphology, due to changing flow regime and reduced floods, which results in siltation and destruction of certain habitats.
- Changes in water quality, due to changing flow regimes and the release of water with poor quality from stratified, eutrophied and/or anoxic impoundments, which affects biota.

- Changes in thermal regime, both within and downstream of the impoundment, which affects the aquatic and riparian biota.
- Barriers to migration of aquatic species, particularly fish which migrate to breed.
- Introduction of alien species into catchments through inter-basin transfers.
- Creation of conditions for pests, either in the impoundment (eg. mosquitoes) or in the downstream river (eg. blackflies).

Together these factors influence the health of the aquatic ecosystem upon which all other users depend, both for water and associated natural resources.

1.2.3 Social impacts

There are both positive and negative social impacts associated with large impoundments (DWAF, 1986; Rooseboom *et al*, 1994). Apart from the direct beneficial consequences of water supply, social impacts may be associated with community disruption, culture, natural resource use, recreation or flooding.

During the construction phase the major social impacts are the relocation of people, the loss of arable land, destruction of heritage sites, and the severing of road networks. There are also other social impacts associated with the influx of construction workers, such as increases in STDs and incentives for sex workers. However, positive social consequences are also associated with the improved facilities and development that may be associated with these large construction projects, such as transfer of skills to local communities, improved roads and the development of social and commercial infrastructure.

As with the ecological systems, there are potentially significant social impacts associated with regulation, storage and abstraction of water resources (Rooseboom *et al*, 1994). Positive impacts associated with the water resource development itself include, reduced flooding of downstream settlements and opportunities for recreation around the impoundment. However, the negative impacts include:

- Reduced availability of water for downstream subsistence settlements, for domestic and small scale agricultural use.
- Adverse impacts on freshwater and coastal fisheries, due to changing ecological functioning of the river and estuary ecosystems.

- Reduction in the availability of natural resources for harvesting, such as reeds from wetlands.
- Changing the cultural significance of a river for local people, such as baptism rituals, through reduced flow regimes and sedimentation.
- Health impacts associated with the increase in disease vector habitat and resulting water related diseases, such as bilharzia, malaria, and sleeping sickness.
- Reduced aesthetics of the downstream riverine environment, due to degraded ecological functioning, which impacts on recreational opportunities and local community's quality of life.

1.2.4 Economic consequences of social and ecological impacts

Some of these social and ecological impacts have direct measurable economic consequences. The most significant of these are:

- Positive and/or negative impacts on recreation and tourism associated with the water resource development and/or degraded ecological functioning.
- Negative impacts on productivity associated with the health problems arising from the changing ecological or social environment.
- Reduction in natural resource use by local communities (eg harvesting reeds), or natural resources used by commercial enterprises (such as fisheries).
- Increased costs of treatment or implications of no treatment associated with poor water quality released from an impoundment.

1.3 Environmental Assessment of Water Resource Developments

Internationally, the importance of these environmental impacts has become apparent during the past two decades, particularly those associated with the construction phase of water resource projects. Environmental impacts were discussed for the first time at the International Commission on Large Dams (ICOLD) at their 1973 congress (DWAF, 1986).

In the past 10 years, the World Bank has issued a number of directives aimed at identifying, assessing and mitigating (or reinforcing) the negative (or positive) environmental impacts associated with large water resource developments (World Bank, 1993). These impacts are considered during the planning and design of a development, by way of an Environmental Impact Assessment (EIA), with significant input and consultation of local communities and stakeholders.

Similar developments have occurred in South Africa, with the development of Integrated Environmental Management (IEM) procedures (DEAT, 1992). EIAs have been conducted for large water resource development projects in South Africa since the early 1980's (DWA, 1986). These were formalised by DWAF into the ROIP procedure, which was required during the planning phase of any dam or weir.

During the past decade, techniques for evaluating the environmental consequences of water resources developments have been developed an applied to both large inter-basin transfers (eg. the Lesotho Highlands Water project) and smaller dams on sensitive rivers (eg. Injaka Dam on the Sabie River). Comprehensive evaluation of the costs and benefits of large water resource developments has also been conducted, such as for the Maguga Dam project (Conningarth Consultants, 1996).

More recently, the National Environmental Management Act (Act 107 of 1998) has enabled the statutory implementation of IEM in South Africa, while DEAT (1998a) outlines a strategy for its implementation. Although, the associated regulations indicating when IEM should be used have not yet been promulgated under this act, regulations requiring EIAs for water resource developments (DEAT, 1998b) were gazetted on 5 September 1997 under sections 21, 22 and 26 of the Environmental Conservation Act (1989). Since then, the DEAT and DWAF have entered into a Memorandum of Understanding about conducting EIAs during the planning and design of water resource developments.

Although, Environmental Impact Assessments are required for the construction of water resource developments, they do not necessarily minimise the environmental impacts of operation and management of these developments. Rather this is the role of the new National Water Policy (and enabling Act), which is the focus of this dissertation.

1.4 Some Different Perspectives on Water Resources Management

Water resources may be viewed from a number of different perspectives. Following Merrett (1997) this dissertation distinguishes between the engineer's perspective and the economist's perspective. However a third view is also included, namely that of the environmentalist.

The environmental perspective

There is a growing awareness that the aquatic environment is an integrated functioning ecosystem, with distinct parts and interactions. These occur within water bodies, between the water resources and the terrestrial environment in the riparian zone, and ultimately in the entire river catchment. Furthermore, the ecological health of a water resource ensures that it will continue to function sustainably to provide water for other uses. This healthy functioning includes such diverse characteristics, as low flow water supply, flood attenuation, assimilation of contaminants, and harvesting of aquatic biota. Thus, the water resource is referred to as the resource base upon which all other (human) users depend, which can be viewed as a *hydro-ecological cycle*.

In order for the continued healthy functioning of the aquatic environment there are particular ecological requirements in terms of flow regime, water quality and habitat integrity. If any of these is significantly altered or degraded, the natural functioning of the water resource may be temporarily affected, or permanently driven beyond its ability to recover (i.e. its sustainability). The sustainability of the water resource (MacKay, 1998), is generally associated with its resilience (ability to recover from a degraded state) and biological diversity (which affects the resilience).

The need for sustainability of the water resource has been recognised in the National Water Policy (DWAF, 1997b), but the policy does not indicate whether the resource should be kept in a pristine state, or may be degraded to the level at which it is just able to recover. Our limited knowledge of the water resource's ecological functioning implies that care should be taken in making these decisions (i.e. a precautionary approach), but the policy also indicates that this is dependent upon the strategic importance of the associated water use (eg. provision of domestic and industrial water) and the possibilities for management (eg. in an urban environment).

The *precautionary principle* implies erring on the side of caution and is generally adopted as a sound policy position under situations of uncertainty. These issues are fundamental to water resource engineering and the tradeoffs between acceptable risk to the ecological and social environments, versus economic development. This is a key issue associated with the economic analysis of water resource developments, and is one that this dissertation addresses.

The engineering perspective

The primary objective of water resources engineering is the development of infrastructure to regulate, capture and abstract water from aquatic systems, to meet demand at a specified level of assurance. Merrett (1997) refers to this as the *hydrosocial cycle* upon which fresh and waste water services depend. In order to do this, rivers are basically viewed and analysed as networks consisting of a series of links and nodes. Water of various volumes and qualities is assumed to flow through this network. However, the ecological nature of aquatic systems is largely ignored, and the possibility of development having an impact on the underlying system is not addressed.

It is only in the past decade (since King and Rowlston, 1991) that the requirements of the aquatic environment have been considered in water resources management in South Africa. Nevertheless, there has been some progress in the communication between scientists and engineers about the sustainable management of the water resource. In summary, even though water resources engineering and planning is based upon a systems approach, this is a system curtailed to the flow (and possibly quality) of water, but not viewing the aquatic environment as an integrated whole in line with the ecological perspective.

The economic perspective

The preceding two perspectives have viewed water in terms of its physical and ecological characteristics. However, water is also an economic resource with complex characteristics, being both a basic human need and is a critical resource for economic development. Furthermore, many of the economy's resources are used to supply water and dispose of waste water (Merrett, 1997).

A *hydro-economic cycle* reflects the flows of resources required to support the hydrosocial cycle. The economist converts these resource flows from physical to financial units, thereby giving water a value and an associated price within the economy, which have implications for the its allocation, demand and use. The hydro-economic cycle is predominantly oriented around those aspects of the water resource that people use and which have prices. It may be extended to include those environmental resources that have intrinsic value to society, but not prices (eg. biodiversity and pristine riverine environments). The economic perspective provides a possible means of integrating the engineering and the ecological approaches. The exploration of this possibility and its role in achieving the goals of environmental management, are major themes of this dissertation.

1.5 Policy Options for Water Resources Management

1.5.1 General Policy Options

Policy options may be grouped into those based on *regulation, persuasion* and *economic incentives,* as outlined in the following discussion (DEAT, 1997a; 1996; DWAF, 1997b).

Regulatory Policy Options

Regulatory policy options are in the form of prescriptive "command and control" regulations and have traditionally been the most commonly used means of water environmental resource management. Their strength is that a focused regulation may be formulated to address a specific threat, to ensure a desired result where monitoring and enforcement processes are good. This focussed character is particularly important when risks must be avoided in the management of sensitive catchments. Regulatory policy options provide an essential platform to the water resource management system, upon which other more flexible but less assured options may be built. The requirement for IEM and EIA represents a sub-set of management tools under the regulatory options.

Flexibility should be built into the regulatory environment where possible, because regulations tend not to encourage individuals to do better than the standard, may not allow individuals to choose the least cost response, and may not consider issues of efficiency. By contrast, the absence of these weaknesses forms the primary appeal of economic management tools.

Economic Policy Options

Economic instruments are designed to influence decision making behaviour by altering the costs and/or benefits of different activities. This implies penalising activities with negative impacts and/or rewarding activities with positive or benign impacts, to ensure that resource use decisions take account of all the social and ecological (environmental) costs and benefits. Incorporating these impacts into the water price implies that water resource management becomes an integral part of decision making about production and consumption choices. This should lead to more socially optimal outcomes. It also enables individuals to be flexible in their response, thereby encouraging innovative and locally appropriate solutions. Furthermore, the administrative costs of implementing economic options are usually lower than for regulatory options, and they can generate revenue for government, which may be used to mitigate the impacts of the externalities.

Persuasive Policy Options

Regulatory controls and economic instruments provide the basis for managing water resources, but the complex administrative and legislative requirements may make it infeasible to apply these options to all problems or catchments. Influencing individuals' decision making through non-coercive and non-economic options can be particularly cost-effective and sustainable, particularly for less sensitive activities and catchments. Persuasive options are usually dependent upon the mobilisation of communities in a catchment and access to information, which results in the development of voluntary agreements between affected parties based largely on self-regulation. The IEM process involves stakeholder consultation and thus provides a mechanism to promote persuasive options.

Although a combination of regulatory, economic and persuasive options should comprise the policy framework for water resources management, those dealing with economic issues are the focus in this dissertation and are elaborated upon in the following section.

1.5.2 Economic Instruments

Economic (market based) instruments provide an important opportunity to manage impacts on water environmental resources and may be used in conjunction with regulatory options, particularly in less sensitive catchments. Some of the particular instruments which are available, include (DEAT, 1997b; Tietenberg, 1988):

- *Charges* which require individuals to pay for the full administrative and/or environmental costs of an action, such as applying for an exemption or conducting a controlled activity.
- *Taxes* applied to inputs or outputs from activities which cause water resource problems, to ensure the full social and environmental costs are included in decisions.
- *Subsidies* compensate for market distortions, encourage the movement to another pricing regime or enable economically disadvantaged groups to implement management measures, and should preferably be of a capital nature or involve training over the short-term.
- *Marketable permits* enables a legislative and institutional framework for the sale or renting of rights (permits) to use water or conduct restricted activities.

- *Environmental bonds* require a potential impactor to set aside funds (which may be refundable if certain environmental criteria are met) to mitigate impacts, remediate accidents or rehabilitate problems.
- *Extension of property rights* implies full private ownership and thereby provide an incentive to individuals to manage resources efficiently, but this must be consistent with other water resources policies.

These instruments require a supportive institutional and legal framework to function effectively, and should be used as part of a package of policy options for environmental management. Baumol and Oates (1988) demonstrate that these instruments are not effective in situations where environmental damage can occur quickly and unexpectedly. Regulatory options are more appropriate under these circumstances.

Economic instruments may be used in three general ways, usually to address market failure or distortion caused by incorrect pricing and non-optimal use of resources:

- *Pricing*: Direct alteration of price or cost levels through charges on input (eg. fertilizer or water) and/or output (eg. agricultural produce) from an activity, to incorporate the full environmental cost.
- *Fiscal means*: Indirect alteration of prices or costs through fiscal instruments which affect market functioning, such as subsidies, loans, tax depreciation or non-compliance fees.
- *Market creation*: Development and support of a market for water licences, to facilitate optimal resource allocation, since externalities are due to a "missing market".

In order to implement economically optimal policy options, valuation of environmental costs and benefits of activities which impact the water environment may be needed. However, this is often very difficult. The impacts of different economic instruments on decision making are also not well understood and they can cause potentially unforeseen market distortions resulting in further market failures.

These tools are only optimally effective in influencing decisions to reduce environmental impacts if the valuation of environmental resources and costs are correct and the market impacts can be predicted. The valuation techniques required to support the use of economic instruments are discussed in Chapter 4.

1.6 The Objectives of this Dissertation

Historically, water resource development in South Africa emphasised water supply with an engineering emphasis, through dam building, inter-basin transfers and abstraction, with little regard for the ecological consequences of these developments. In an evaluation of the ecological impacts of the Orange-Fish Transfer scheme, O'Keefe and de Moor (1988: pg 54) conclude "that when water transfer schemes are first planned, very few of the relevant aspects such as environmental and social impacts are taken into account, and decisions are often made on purely economic grounds". It was only during the past decade that environmental and social impacts of these developments were comrehensively evaluated during the planning phase of large schemes.

The National Water Act (No. 36 of 1998) has followed the more recent initiatives, and provides the framework within which the ecological, engineering and economic imperatives of water resource development can be considered. Water policy has therefore undergone significant reform, but the details of implementation have yet to be fully clarified.

This dissertation explores the possible use of economic analysis in decision making around water resources development in South Africa, both in terms of the pricing of water from these developments and the evaluation of development projects. It identifies the opportunities presented by the National Water Act (Act 38 of 1998), and evaluates the relevance and applicability of different economic approaches.

The focus of the discussion is on the appraisal of water supply projects which alter the flow regime of the water resource, particularly impoundments and abstractions. Although there is also significant scope for economic analysis to support waste (effluent) disposal, this component of water resource management has not been dealt with in this dissertation.

This dissertation will explore the possible role of environmental resource economic analysis to support water resource planning of large developments (i.e. impoundments) in South Africa. This will require answering three questions:

- Has this possibility been enabled through policy formulation in South Africa?
- Does environmental resource economics have a practical role to play in water pricing or project analysis?
- Are there appropriate and implementable resource valuation techniques for South Africa?

1.7 The Structure of this Dissertation

Chapter 2 highlights key environmental and economic issues in the new water policy. It evaluates the possibilities for economic analysis to support water resource development, and highlights the proposed approach to resource protection and financing.

Chapter 3 overviews the evolution of environmental resource economics and highlights some key issues for water resources managements. It then goes on to outline the proposed water pricing policy and strategy, with an emphasis on the way in which water pricing may be used to influence water resource development.

Chapter 4 reviews economic project appraisal and environmental valuation techniques, which may be used to assist decision making around water resources development projects, by incorporating environmental sustainability considerations. It indicates which ones may be appropriate to the particular conditions and needs of South Africa, and outlines the most appropriate approach, that is consistent with the new water policy.

Chapter 5 summarises the conclusions and presents recommendation about the use of economic analysis to support the environmental assessment of water resource development in South Africa.

CHAPTER 2. ENVIRONMENT AND ECONOMICS IN THE NEW SOUTH AFRICAN WATER POLICY

2.1 Introduction

This Chapter reviews the important elements of the new South African water resource policy, in terms of the scope for using economic analysis to support environmental assessment of water resource developments. This includes a brief review of the relevant Constitutional principles and the water law review process, a detailed discussion of the provisions in the National Water Policy and the National Water Act.

2.2 The Legislative Context

Policy development in South Africa during the past 5 years has incorporated a number of principles for sustainable development. Of particular relevance to this thesis are those that have been incorporated into the new South African *Constitution* and those that formed the basis for the water law review process. The following discussion highlights these principles.

2.2.1 The Constitution and Bill of Rights

With the signing of the new Constitution in 1996, South Africa adopted a far reaching set of guiding principles upon which all new law is and will be based. The Bill of Rights as contained in the Constitution is the cornerstone of democracy and applies to all laws. It also binds the legislature, the executive, the judiciary and all other organs of state. The State must respect, protect, promote and fulfil these rights. Those rights which are of direct importance to this dissertation include:

- The right to an *environment*, which is not harmful to peoples health and well-being, through protection of the environment, while promoting justifiable economic and social development.
- The right to pursue *economic activity*, although the practice may be regulated by law.
- The right not to be deprived of *property*, except in terms of law which may not be arbitrary, and expropriation only in the public interest and being subject to compensation.
- The right to have access to sufficient *water*, with the state taking reasonable legislation and other measures for the progressive realisation of these rights.
- The right of access to *information* held by the state, which is required to exercise other rights.

The Constitution also allows for *equality* amongst all South Africans, but makes special recognition of the need to actively promote the achievement of equality for those historically disadvantaged by unfair discrimination. Constitutional rights are, however, not all absolute and may be limited by law if the limitation is reasonable and justifiable in an open and democratic society.

Many constitutional rights are vague and require further definition for implementation; these are not dealt with further in this dissertation. Policy development has however specified the meaning of some of these rights. For example, the Water Services Act (Act 108 of 1997) defines "access to sufficient water" as being 25 litres pre capita per day within 200 metres from a household.

The Constitution also indicates that the state must take "reasonable legislative and other measures, within its available resources, to achieve the progressive realisation" of many of these rights. This places an enormous responsibility on government, albeit within its available resources. At present the interpretation of "available resources" has not been Constitutionally tested and the implications of this condition are not clear. Nevertheless, an appropriate and effective water environmental regulatory system should be developed and enforced, to ensure sustainability of South Africa's water resource. If this does not happen, then the government has not fulfilled the environmental obligations imposed on it by the Constitution and may restrict the improvement of the quality of life of all South Africa's citizens.

The National Water Policy and Act outlined below has gone a long way toward providing the enabling framework for these rights. However, it is not entirely clear how these powers should be implemented, although a great deal of work is being done currently by the DWAF to address this issue. These issues must underpin the particular policies upon which economic incentives may be used for water resources management.

It should be noted that the Constitution and National Water Policy also have many similarities with *Agenda 21* (United Nations, 1992), which is the international programme for sustainable development adopted at the Rio Earth Summit, as well as the SADC (1994) *Policy and Strategy for Environmental and Sustainable Development*. Thus the development of legislation in South Africa is consistent with international trends in environmental management underlying sustainable development.

2.2.2 Water Law Review Process

Between 1995 and 1998, there was a process of reviewing and formulating a new water law for South Africa, to bring it in line with the objectives of the new democratic government, the changing pressures on water resources in South Africa, as well as local and international trends and developments in water resources management. The distribution of a discussion document *You and Your Water Rights* (DWAF, 1995) was followed by the formulation of the *Fundamental Principles and Objectives of a new Water Law in South Africa* (DWAF, 1997a), which was accepted by Cabinet in early 1997. The principles that were particularly pertinent to this dissertation are paraphrased below (DWAF, 1997a).

Legal Aspects of Water

Principle 1

The water law shall be subject to and consistent with the Constitution

Principle 2

All water . . . is a resource common to all, the use of which shall be subject to national control.

Principle 3

There shall be no ownership of water, but only its right (for environmental and basic human needs) or an authorisation for its use.

Principle 4

The location of the water resource in relation to land shall not in itself confer preferential rights to usage. The riparian principle shall not apply.

This implies that the allocation of rights to develop and use water is ultimately the responsibility of the national government, and that no-one has an inalienable right to water.

Water Resources Management Priorities

Principle 7

The objective of managing . . . the nation's water resources is to achieve optimal, long-term environmentally sustainable social and economic benefit for society from their use.

Principle 9

The quantity, quality and reliability of water required to maintain the ecological functions upon which humans depend shall be reserved so that human use of water does not individually or cumulatively compromise the long term sustainability of aquatic and associated ecosystems.

Principle 10

The water required to meet the basic human needs . . . and the needs of the environment shall be identified as "the Reserve" and shall enjoy priority of use by right. The use of water for all other purposes shall be subject to authorisation.

These principles outline the need for sustainable development based on the continued functioning of the aquatic environment and the supply of basic human water needs. This implies that sustainable maintenance of the functioning of the aquatic ecosystem has priority over other users, whose use will be authorised for a given period of time.

Water Resources Management Approaches

Principle 13

As custodian of the nations' water resources, the National Government shall ensure that the development, apportionment, management and use of those resources is carried out using the criteria of public interest, sustainability, equity and efficiency of use in a manner which reflects its public trust obligations and the value of water to society while ensuring that basic domestic needs, the requirements of the environment and international obligations are met.

Principle 14

Water resources shall be developed, apportioned and managed in such a manner as to enable all user sectors to gain equitable access to . . . water. Conservation and other measures to manage demand shall be actively promoted as a preferred option to achieve these objectives

Principle 16

Water quality management options shall include the use of economic incentives and penalties

Principle 17

> Water resources development . . . shall be managed in a manner which is consistent with the broader national approaches to environmental management.

These principles require that decision making associated with water resources planning and operation must be based on the guiding principles of sustainability, equity and efficiency, which underlie sustainable development, and should be ensured through established methods such as Integrated Environmental Management (IEM) and Environmental Impact Assessment (EIA). Although economic instruments are only outlined for water quality management, the efficiency criterion requires that they will also be used to handle water allocation issues.

Water Institutions

Principle 23

> Responsibility for the development, apportionment and management of available water resources shall, where possible and appropriate, be delegated to a catchment or regional level

Principle 24

> Beneficiaries of the water management system shall contribute to the cost of its establishment and maintenance on an equitable basis.

These two principles provide the basis for catchment management, in terms of responsibility and funding. This also implies that the recipients of water should be responsible for the full costs of development and maintenance of water resources.

Taken together these principles provide a strong basis for sustainable development of South Africa's water resources, with the water requirements for sustainable aquatic ecological functioning and basic domestic needs having priority. They also provide an opportunity to use economic policy options and instruments to influence water resource development and use, taking account of the sometimes competing requirements and constraints of equity and efficiency. This indicates a significant departure from the previous South African water law.

2.3 The National Water Policy and its Implementation

2.3.1 Introduction

The above detailed principles were translated into the *White Paper on a new Water Policy for South Africa* (DWAF, 1997b). This provided the policy background for the National Water Act (Act No 36 of 1998), which was formulated as a framework act. The details for implementation of this policy and legislation are currently being formulated. The following discussion addresses key issues raised by the financial provisions and resource protection components of the policy.

2.3.2 Financial Provisions

Issues surrounding the economics of water use were addressed in more detail in the White Paper. Key proposals of the White Paper, which extend the Fundamental Principles in terms of economics and environmental management, include (DWAF, 1997b: pg 4):

- To promote the efficient use of water, the policy will be to charge users for the full financial cost of providing access to water, including infrastructure development and catchment management activities.
- All water use, wherever in the water cycle it occurs, will be subject to the catchment management charge, which will cover actual costs incurred.
- All water use, where ever in the water cycle it occurs, will be subject to a resource conservation charge where there are competing beneficial uses or where such use significantly affects other users.
- The use of rivers and other water resources to dispose of wastes will also be made subject to a catchment management charge . . . and a resource conservation charge . . .
- To promote equitable access to water for basic human needs, provision will also be made for some or all of these charges to be waived.

What these proposals imply is that there may be three types of charges associated with water resource use (water use and/or waste disposal). These are the infrastructure development charge (for those users who are supplied through infrastructure), the catchment management charge (for all users benefiting from water resource management at a catchment scale) and the resource conservation charge (in those catchments in which the water is a scarce resource). Through these mechanisms, water users "will have to pay a price for water that reflects the real economic cost, including the indirect costs to society and the environment for their water use" (DWAF, 1997b; pg 4-5).

The means for implementing this policy have not yet been specified, although there has been some work done on a *Pricing Strategy for Water Use Charges in terms of the National Water Act* (DWAF, 1998). The following outlines the elements of the proposed pricing strategy for water use charges.

Catchment Management Charges

Water resource management expenditure relates to the regulation, management and maintenance of the water resources in a catchment, including:

- planning and implementing catchment management strategies;
- monitoring and assessment of resource availability, quality and use;
- water quantity management;
- the evaluation and processing of water use licensing;
- water resource protection, water quality management and water pollution control; and
- water conservation and demand management.

These costs must be borne by all beneficiaries of water resource management, but only those costs associated with the activities from which they benefit. Incorporating these costs into the pricing strategy represents the internalisation of the costs of environmental management of the water resource, i.e. avoiding, mitigating or rehabilitating negative environmental impacts.

Infrastructure Charges

Infrastructure charges fund water resource development and use of water works, and include the costs of developing, operating, maintaining and improving water resources infrastructure. The development costs incorporate both the capital costs of the scheme, as well as the financial costs associated with raising the capital costs. The operating costs include the direct costs of the scheme, as well as the indirect costs which contribute to the management and operation of the water resources in the region.

The policy is to move from a funding approach, where income only matches expenditure in a particular year, to an accrual approach, which also provides for depreciation of assets and potential future disbursements. This is consistent with the Generally Accepted Accounting Practice (GAAP).

In practice, this means that water from dams with a high siltation rate will pay a higher cost, because a new source will have to be developed earlier. On the other hand, water from old dams for which the costs have been paid-off will have lower infrastructure charges, but taking account of the higher maintenance requirements and the potential need to develop additional resources to meet increasing demand.

Resource Conservation Charges

In the long-term, the pricing strategy may use economic instruments to optimise the allocation of scarce water resources between competing users in water stressed areas. This would be designed to achieve the "equitable and efficient use of water" as stated in the National Water Act, Section 56(2)(c). However, this charge is unlikely to be implemented in the short-term, due to the difficulty in estimating the marginal value for water by different users, which may differ spatially and temporally within a catchment. Furthermore, it is expected that the implementation of full financial cost recovery through the catchment management and infrastructure charges would increase the current water prices and thereby generate a shift towards higher value use of water. This would reduce the need for implementation of this economic charge in the short-term, although it may become necessary as demand increases in the longer term. The issue as to whether it would be used to "cap" demand in a catchment by increasing as demand increased, based on a fixed total water availability, or whether it would only be used to allocate water optimally until the next supply source is developed is not clear. In the later case, the resource conservation charge would not exceed the marginal cost of developing the next supply source.

Theoretically, this charge may also enable the internalisation of environmental damage costs into the pricing strategy, rather than only the mitigation costs as outlined above. This would facilitate the socially optimal use of water resources through the application of *Pigouvian taxes,* but would depend upon the reliable valuation of environmental damage costs, using the techniques discussed in Chapter 4. There is a "double dividend associated with this approach, namely the improved allocation and use of the resource, as well as the additional revenue that may be used to support environmental or social investments. However, the National Water Act states that no water user charge "may be of such a nature as to constitute the imposition of a tax, levy or duty" - Section 57(5). Unfortunately, this clause probably prevents the use of the resource conservation charge in this way, except if it can be argued that it is equivalent to the external costs generated by a user. The application of Pigouvian taxes is thus unclear for South African water resource purposes.

Many of these issues have been addressed by the water resource pricing policy (DWAF, 1997a), and are revisited during the discussion of this policy in Section 3.3.

2.3.3 Resource Protection

An important extension to the Principles is the concept of resource protection, based on the specification of clear objectives for the level of protection for each resource. This is based on a national resource protection classification system (MacKay, 1998), which will be used to group different resources (catchments) through a process of consensus-seeking among water users and stakeholders. It reflects the required level of protection and/or needs for short to medium term use. Resources requiring greater protection will demand lower risk of damage, and thus greater caution in water resource development and use. This approach facilitates the implementation of the ecological "Reserve", which represents the water required to protect the ecosystems that underpin the sustainable use of the water resources by other users (Kleynhans et al, 1998). This is based on an assessment of the ecological (Kleynhans, 1998) and socio/cultural (O'Keefe, 1998) importance and sensitivity of the water resource. Classes A to D reflect decreasing levels of protection (i.e. higher level of risk to the sustainability of the resource).

The required level of protection may be based on the social and ecological importance of the resource, as well as its possible economic value. This implies that a lower risk of damage will be accepted for an ecologically unique river or a water resource on which a community depends directly to support their basic needs and economic livelihood. Therefore, a resource economic interpretation of the value of the aquatic environment may provide additional justification to proposing a higher protection class (level of protection) for a particular water resource. This is one of the most important reasons for investigating the possibilities for incorporating the economic value of the resource into the decision making process.

In terms of a water resource development, the ecological Reserve must be accommodated in its planning and operation. In many cases, this will impose greater requirements on the development, eg. an impoundment may have to be larger to provide the water releases for the Reserve, which may mean increased costs. These costs must be borne by the other water users, and thus will increase the infrastructure charge. Therefore, the new policy allows for the internalisation of the environmental costs, in this case by including the mitigation costs within the development costs. This issue will be explored further in Chapter 4 during the discussion of valuation techniques.

CHAPTER 3. ENVIRONMENTAL RESOURCE ECONOMICS AND WATER PRICING

3.1 Introduction

Chapter 2 outlined the new policy and legislative environment of water resources management in South Africa. It indicated a significant shift in the financial provisions, with the inclusion of user charges for infrastructure and water resource management costs, as well as the possibility that water be priced to ensure "optimal beneficial use" in situations of scarcity.

This Chapter explores the resource economic approach to water pricing and interprets the new pricing policy and strategy in this light. It begins with an overview of the evolution of the field of resource economics and goes on to explore the new pricing policy.

3.2 The Evolution of Environmental Resource Economics

The early origins of environmental resource economics go back to the first half of this century with early writings by Hotelling (1931). However, the pre-1960's developmental period was relatively slow and environmental resource economics only took off substantially in the 1960's, spurred on by dissertations of the day concerned with increased levels of pollution and resource depletion, such as Rachel Carsons "Silent Spring"(1964).

According to Cropper and Oates (1992) the economic profession was ready and waiting for the environmental revolution of the 1960's. From the earlier economic theory to present time, various environmental economic paradigms have progressively developed. In some cases the more clearly definable paradigms have remained as departure points for different "schools of thought" or approaches to debating environmental valuation. In order to discuss the development of environmental economics it is important to trace back the origins within the mainstream development of economic theory.

3.2.1 Primary Economic Theories

Theorists of early political economy, such as Adam Smith (1723-1790), Thomas Malthus (1766-1834), David Ricardo (1772-1823) and John Stuart Mill (1806-1873) based much of their thought on Smith's *invisible hand.* This argued that individuals' rational self-interest could both satisfy individual wants and also serve the interests of society as a whole. The key element being the ability to operate in a freely competitive market.

The Malthusian theory postulated that a geometrically increasing population, but arithmetically increasing food production, would lead to economic despair, due to declining per capita output, land shortages and incomes of merely a subsistence level (Samuelson & Nordhaus, 1985). Samuelson & Nordhaus, (1985 p814) quote the following Malthusian statement, *Because of the law of diminishing returns applied to nature's fixed supply of land, food production tends not to keep up with populations's geometric-progression rate of growth.* The concept of diminishing returns was therefore introduced to classic economic theory, indicating a less optimistic prediction of the prospects of long-term economic growth.

David Ricardo introduced a sense of "environmental limits" by explaining rent as a function of the limited supply of good agricultural land and of the consequent diminishing returns on agricultural production. Ricardo's model introduced the concept of natural resource scarcity. J.S Mill, on the other hand, foresaw the impact of technological development counteracting the impacts of diminishing returns.

Karl Marx (1818-1883) contributed in a profound manner to economic theory through the *labour theory of value*. He believed progress was through material and technological development based on the exploitation of nature for people's use. Natural resources should be used to turn inherent value into use value. However, Marxian analysis does assert that modern capitalist systems are not able to reproduce themselves, i.e. they are not sustainable. An element of this non-sustainability is environmental destruction, and that the negative environmental impacts are worst for the poorest and most marginalised members of society.

The neoclassical theorists abandoned the labour theory of value and viewed a commodity's price as reflecting the interaction between scarcity and use value, i.e. the interaction of supply and demand determines the equilibrium price, with the preferences of individual buyers being constrained by their choices and income.

Socially optimal conditions are expressed in terms of the Pareto criterion, where "it is impossible to make any individual better off without making someone else worse off. Every competitive market equilibrium is a Pareto optimum and every Pareto optimum is a competitive equilibrium as long as a set of restrictive assumptions . . . hold true" (Pearce & Turner 1990: pg 11). Government intervention is justified where the market fails to maximise collective welfare.

That the early gloomy predictions of the classics such as Malthus were not realised, was largely due to technological advancements brought by the Industrial and Agricultural Revolutions and two World Wars. Technical innovations such as artificial fertilisers and irrigation, caused the shifting out of the production-possibility frontier. As the rate of production growth exceeded population growth, real wages increased and (as a secondary effect) population growth declined with rising standards of living. This was especially true of Western countries where the Industrial world enjoyed "an unprecedented period (1940's - 1970's) of rapid growth and rising productivity that had economies running at full steam" (William Burger, 1993 Newsweek). On the other hand Third World (Developing countries) were dealing with increased population growth rates, in places food shortages, increased rates of poverty and weak economies.

However, with increased production and growth came increased externalities. Pollution which had increased as a result of the Industrial Revolution intensified during the 1960's. Consequently environmental awareness heightened in some sections of industrialised societies, spawning new environmental ideologies; a number of these were predictably anti-economic growth (Pearce & Turner 1990). The 1970's energy crisis further prompted a rise in concern for natural resource depletion and the ominous Malthusian theory (1798) of the relationship between population growth and the economy seemed to be more real than previously believed.

3.2.2 The Development of Resource Economics

During the 1950's it appeared that economic growth driven by technological innovation could offer limitless progress. During the 1960's and 1970's the heightened environmental concerns due to increased rates of pollution, concerns for natural resources, and public outcry, indicated a need to engage the environmental arena in a more direct manner (Carson, 1966). Economic growth was outpacing the environment's ability to assimilate pollution and waste from production. This was a form of market failure, since market mechanisms were unable to internalise these environmental impacts into decisions about production and consumption. Society is bearing costs that are caused by individuals and consequently the market fails to allocate resources in a socially optimal manner.

The market's ability to solve environmental problems was re-evaluated and its failings assessed. However, the majority of economists continued to argue that economic growth remained both feasible, i.e. that growth in an economy need not run out of natural resources, and desirable, i.e. economic growth need not reduce the overall quality of life (Pearce & Turner 1990). The focus did however instead shift to the need for an efficiently functioning price system and investigation of the value of the environment. It was against this backdrop that the sub-discipline of environmental economics was born and four main branches evolved (O'Riordan and Turner, 1983), these being:

- support for a market and technological driven growth model which is environmentally damaging;
- a resource conservationist and managerial position with promotion of sustainable growth;
- resource preservationist position where nature has an intrinsic value; and
- the deep ecological perspective which promotes a minimum 'resource-take' socio-economic system.

Pigou (1877-1959) introduced what is known today as pollution charges. The Pigovian tax (charge) was promoted as a form of intervention and means of equating private and social costs based on the estimated damage. Coase (1960) contributed to the development of solving pollution cost problems by stipulating that under certain assumptions the most efficient solution to pollution damage situations was a bargaining process between polluter and sufferer. This theory was however based within the ambit of distinguishable property rights and was less effective for public goods such as clean air and fresh water. He felt that by fully extending property rights the problem of market failure would be overcome, because externalities implied "missing markets" rather than "failure".

Some economists viewed the progress critically. On the topic of environmental pollution, Ayres and Kneese in 1969 wrote that "*Despite tremendous pubic and government concern with problems such as environmental pollution, there has been a tendency in the economic literature to view externalities as exceptional cases.*" Ayres and Kneese viewed the disposal of residuals resulting from the consumption and production processes as being of economic significance and argued for their inclusion in traditional economic modelling. Baumol (1972) wrote on the taxation and control of externalities on public goods, that the application of Pigouvian taxes (or subsidies) on the generators of externalities should be sufficient to redress this.

Krutilla (1967) explored the question of natural resource valuation and the need for conservation in what was termed "*a minimum reserve to avoid potentially grossly adverse consequences for human welfare*". Arrow and Fisher (1974) discussed the issue of uncertainly and irreversibility in the natural environment and argued that the *benefits of preservation options are and can be correctly allowed for in an assessment of benefits and costs*. Krutilla and Fisher developed this theory into a model known as the Krutilla-Fisher model. In an alternative approach Bishop (1982) argued for a *safe minimum standards approach indicating that irreversibility should be avoided unless the social cost of doing so is unacceptably high*. This approach is significant as it does not rely on a single criterion for making discrete choices. It also underlies the resource protection approach adopted in the Water Policy, in which sustainability of the water resource is paramount.

Pearce and Turner (1990) use the Game Theoretic situation to demonstrate the two approaches and suggest a third which is the integration of sustainability considerations into the development-preservation decision. Game theory used by Pearce and Turner indicates on the one hand that *if development were to occur the maximum loss would be the preservation benefit and alternatively the preservation decision means the maximum loss is the development benefit*. The assumption used here is that the aim is to minimise the maximum losses, i.e. a minimax strategy. There is also the proviso used in both models that development benefits are not blindly accepted but shown to be large relative to the preservation benefits.

Using Bishop's approach, the magnitude and probability of preservation benefits is shown to be unclear and therefore consequently not directly comparable to the development benefits. Furthermore, the minimax rule does not indicate who gains and loses, both now and in the future, i.e. the issue of intergenerational equity is raised. Irreversible costs are borne by the current generation and also by all future generations *unless their preferences are different to ours* (Pearce and Turner, 1990). Due to the lack of information on the preservation benefits and the intergenerational issue, Pearce and Turner indicate that Bishop's approach argues for preservation unless the social costs of foregoing development are unacceptably high. The Krutilla-Fisher model would not have included the multiple criteria and may have resulted in a different scenario.

3.2.3 Emergence of the Concept of Sustainable Development

Pearce and Turner (1990) suggest uncertainty about the future values attached to natural environments. Intergenerational justice then implies that either the stock of natural capital or the utility from consumption of all goods (including non-natural goods) should be held constant over time. The former approach is very similar to Bishop's safe minimum standards approach. If however irreversibility is a major feature of the proposed development then the sustainability approach can not be applied and some other model should be used.

Even where the natural system is not threatened by irreversibility, natural variations and society's dependance on these resources can result in social and ecological needs not being met. This is referred to a resilience, where social and economic development can be set back by a disturbance of the natural system. In the water sector, severe drought can highlight problems with resilience, particularly where the infrastructure capital (dams etc.) is not adequate to mitigate the impacts.

The development of sustainability and consequent requirements originated with the Meadows report, but gained most influence in the Brundtland report *Our Common Future* (1987). Meadows (1972) questioned the acceptability of conventional growth objectives, strategies and policies and provided a platform for the line of thinking which led to calls for steady-state or zero growth economies. It also provided the Deep Ecologists with a firm basis for bio-economic communities modelling. The Brundtland report argued that natural resources are sufficient to meet long-term global needs without limits to growth, but highlighted the issues of inequitable resource distribution, spatial inequalities of consumption, and the relative carrying capacity of natural systems.

In summary, the key elements that need to be addressed for sustainability in economic terms are *uncertainty*, *irreversibility*, *resilience* and *intergenerational equity*. The overview of the National Water Policy in Chapter 2, indicated that these issues would be addressed through the water resource classification system and Reserve, which defines the water available for other users in terms of that left over once the need for sustainable functioning of the aquatic ecology has been ensured, at an acceptable level of risk (uncertainty).

3.2.4 Resource Economics as Applied to Water Resources

Tietenberg (1988) allocates an entire chapter to the economics of water resources. He highlights some of the key problems with current water resource management approaches and makes some recommendations about an efficient allocation system, with an emphasis on the water scarce south-western United States.

Tietenberg (1988: pg 199) states that an efficient allocation system must (1) strike a balance between competing users, and (2) handle the variability inherent in hydrological systems. Following neoclassical theory, the first issue is addressed by allocating water to maximize the total net benefit to all users. This is done by providing water such that when the last drop is allocated, the marginal net benefit is the same over all users. The second issue is most important in a year with less than average water available and should be addressed by allocating water to those users with the highest marginal net benefit associated with the available supply. This implies that those users that can most easily conserve or substitute water or that do not value it as highly (cannot use it as productively) would receive proportionately smaller allocations.

In practice, water allocation is more of an administrative process (Tietenberg, 1988), which introduces inefficiencies of the following types:

- *Restrictions on transfers*: once licences have been allocated, the legal and institutional mechanisms for trading the allocations, to enable them to gravitate to the most highly valued use, are generally not developed. If the administrative allocation system could incorporate a mechanism which enables the equalisation of marginal net benefits, this could be efficient, but this is usually not the case.
- *Large irrigation schemes*: often introduce two direct sources of inefficiency; South Africa is no exception. Firstly, they may involve substantial subsidies, which encourage inefficient use of water, and secondly the criteria governing the transfer of allocations are uncertain, which raises the costs of transfer. It should be noted that "historical" subsidies are not relevant, in that they are "sunk" costs.
- *Water pricing*: does not generally promote efficient use of water, because the prices are often too low and the tariff structure does not reflect the full costs of providing services to different users. Increasing block tariffs allow equity issues to be addressed by pricing the first portion of water at low rates, while pricing the last portion used at a higher marginal rate. This may reflect the cost of the next most expensive new water source, or may be intended to promote water conservation.

The remainder of this Chapter is an investigation of South Africa's new water policy and the associated strategy that has been proposed by the DWAF. It shows how many of the concepts and theories of resource economics have been incorporated into and enabled by this policy, although the exact mechanisms of their implementation are as yet unclear.

3.3 The South African Water Pricing Policy

3.3.1 Introduction

In a market economy, the price of goods and services should be based upon relative supply and demand, reflecting the costs of production and consumers' willingness to pay. However, market prices do not always incorporate the true costs of production or consumption, particularly in terms of environmental resources. Inefficient resource utilisation and non-optimal social welfare may thus result from mispricing, because the market does not function adequately. Policy failure and market failure are the two main causes of market malfunctioning.

Policy (or government) failure occurs when the prices of goods or services are less than the marginal financial costs of production. This occurs as a result of subsidies and incentives associated with production, including input subsidies, output price controls, output targets and exchange controls. Policy failure not only drains government's scarce financial resources, but can result in negative environmental impacts due to overuse of natural resources. For example, government subsidisation of irrigation infrastructure schemes (capital or operating costs), results in non-optimal levels of water utilisation and associated agricultural production, since prices do not reflect the actual cost of water. Another example is the subsidisation of sugar prices in South Africa, which makes the irrigation of sugar cane economically viable in sub-marginal areas with limited water availability (Mpumalanga Province, 1997).

On the other hand, even when there is no inappropriate government policy intervention, market failure may occur because the full social and environmental costs of production are not incorporated into the pricing mechanism. This occurs because neither the producers nor consumers of good or services have to consider the "externalities" associated with their actions.

An externality is present when an individual's welfare is affected by the actions of another party who does not have to take account of the former individual's utility or production functions when making decisions. Externalities are usually associated with public goods (such as air and water), where ownership is not well defined (Baumol and Oates, 1988). For example, the degradation of the ecological functioning of a river due to effluent discharge or flow reduction (resulting from water abstraction), may affect the health and well-being of present and future generations. However, this impact is not generally taken account of in the pricing of commodities associated with the effluent discharge or water abstraction. It is thus the responsibility of government as the custodian of public goods (such as the country's water resources), to manage the utilisation of those resources. This may be through direct controi and enforcement associated with environmental management, or through economic mechanisms aimed at full cost valuing of environmental resources. Section 2.3 outlined the approach to resource protection and the financial provisions adopted in the National Water Policy and Act. This section explores the water pricing policy in more detail.

In this context, efficient pricing would be the sum of the marginal financial cost and the marginal external cost of production. This means the externalities of water production are wholly internalised. This should ensure that economic decisions reflect the full social and environmental implications of economic activities, which is the central aim of economic interventions to support environmental policy. In general economic efficiency requires that economic interventions should be focused at the party causing the externality through the use of Pigouvian taxes on production or consumption. In this case the "tax" is equal to the marginal external cost.

It is held that the incorrect economic pricing of water has led to overutilisation of South Africa's water resources and the associated degradation of the aquatic environment, and that full cost pricing should contribute to sustainability. These issues are addressed in the new water resource pricing policy for South Africa (DWAF, 1997c), which is oriented around pricing the utilisation of raw water (i.e. the water resource). This policy is based on four conceptual pricing frameworks, namely economic, social, ecological and financial. These provide the basis for "full economic pricing of water" which attempts to reflect the true value of the water resource. Thus it is a useful approach in the context of this dissertation and each of these conceptual pricing frameworks are addressed separately in the following sections.

3.3.2 Economic Pricing

The basic principle of economic pricing is to promote the efficient allocation and use of water. However, water availability is highly variable and it is often supplied under monopolistic conditions. Furthermore, water is a basic human need, and it can be argued that the constitutional right to a minimum quantity of water, requires that it should be allocated through some form of administrative system. However, the use of water can be restricted and there can be competition between users, which implies that market mechanisms may be used for water allocation.

It is therefore possible for water to be priced and allocated through a mixture of administrative and market mechanisms. In the short-term, water pricing in South Africa is likely to be performed administratively. However, whatever mechanism is adopted, the pricing of water should reflect its scarcity value, so that it is efficiently allocated. It should also be noted that economic pricing is not incompatible with equity and sustainability considerations, particularly if these are explicitly considered according to the social and ecological pricing principles outlined below.

In setting water prices according to economic principles, there are two basic charges which need to be incorporated, both of which are provided for in the National Water Policy (see Chapter 2). Firstly, the *infrastructure charge* represents the full cost of the infrastructure required to store and abstract raw water at a specified reliability (but not treatment and distribution). It should be imposed wherever water resource infrastructure must be developed, and is based on financial pricing (see section 3.3.5).

Secondly, the *resource conservation charge* reflects the relative scarcity of water in a catchment, and thus enables the pricing of water to ensure that it is allocated to those who obtain the greatest value from its use. This charge is only appropriate when demand exceeds current supply in a catchment and should represent the "market-clearing" level for competing uses in a catchment. Its estimation is more difficult under the administrative pricing approach, but the institutional and legislative conditions for the operation of water markets need to be developed over time. A possible compromise may be public auction of water rights through the water licensing process. Under the administrative approach, incremental increases in water prices until the demand is met, provides the simplest method of identifying the appropriate price level, taking consideration of the variability of supply and the required assurance of demand by different users. Alternatively, the pricing strategy states that the "economic charge may well be represented by the marginal cost of the next scheme" (DWAF, 1998: pg 14).

The economic scarcity value of water continually changes over time due to shifts in demographics, technology and economic imperatives, and thus pricing mechanisms must be flexible and responsive, which implies a market approach. On the other hand, water pricing should enable the incorporation of equity and sustainability issues, which require administrative controls into price levels. This suggests that some form of administratively managed water market (possibly public auction) is likely in the medium-term.

3.3.3 Social Pricing

South Africa's apartheid history has resulted in severe inequities in access to water between population groups, because water allocation was based on political-economic criteria and was linked to land ownership. Thus there are two considerations in the "social pricing" of water. Firstly, access to a minimum quantity of water for domestic use is a constitutional right, and thus even those who cannot afford water must be provided with a "lifeline" quantity free-of-charge (i.e lifeline subsidy). In terms of raw water pricing, this is equivalent to the basic human needs Reserve outlined in the Water Policy, which has been specified as 25 litres per capita per day (DWAF, 1998; pg 18). Water pricing can facilitate this through cross-subsidisation, this allocation being funded through the prices paid for water by other users.

Secondly, water pricing should redress the historical imbalance in access to water, by supporting disadvantaged individuals and groups (eg. emerging black farmers). The National Water Policy allows for a concessionary period during which these groups will not have to pay the full price for water. This implies subsidisation of that portion of the water allocation. However, this is a temporary measure and in the longer term, all users will be expected to pay the same price for water. The pricing strategy specifies a maximum concessionary period of 5 years as part of establishment support for newly established farmers or similar enterprises (DWAF, 1998; pg 21).

Where subsidies are used, these must be clearly targeted at disadvantaged groups and should be transparently estimated. Furthermore, the economic pricing of water should be maintained for all other users, and cognisance taken of sustainability considerations (as outlined in the next section).

3.3.4 Ecological Pricing

Water is required for natural ecosystem functioning, and it is these catchment ecosystems which are responsible for continued water availability and assimilation of contamination. The aquatic environment is the resource base upon which all other use is dependent, and thus water pricing must ensure the sustainability of this catchment ecosystem functioning, both now and for future generations. This implies that water resource development, use and contamination should not cause unacceptable or irreversible impacts for the water resource itself. There are three main issues which must be addressed by ecologically oriented water pricing, namely the impacts on:

- water quantity, as a result of water regulation, use and discharge (or transfer);
- water quality, as a result of discharge or runoff from human activity; and
- aquatic habitat, as a result of activities (including construction) in the aquatic environment.

In addition to the typical command and control measures, water pricing should reflect the economic value of the ecological resource, so that the externalities of actions are internalised by the responsible person or group. The valuation of environmental resources is the focus of Chapter 4, which outlines and evaluates various valuation techniques.

Ecologically based water pricing policies should ideally penalise negative actions, such as pollution discharge (eg. the polluter pays principle), while rewarding positive actions, such as the installation of water efficient technologies. However, the pricing system should also take account of the uncertainties in knowledge about the impacts of actions on the aquatic environment (i.e. precautionary principle). This concept is reflected in the definition of the ecological Reserve, which has a high value, but does not pay for its water requirement. Rather it determines the water available for other uses, which are priced. However, as the quantity allocated to the ecological Reserve decreases, the marginal value increases significantly, because of the increased risk of the resource becoming unsustainable. This implies a "trade-off" between ecological sustainability and water utilisation, which must be supported by scientific and economic information. The tools used to obtain this type of information are evaluated in Chapter 4.

An important element of ecological pricing is the requirement for Environmental Impact Assessment (EIA) and associated Environmental Management Plan (EMP) during the inception and planning of water resource developments. The inclusion of these costs into the financial costing of a project is one mechanism for internalising the ecological costs of development, particularly when the EMP is comprehensive and effective.

The pricing policy does not directly discuss the concept of estimating and internalising the externalities of development imposed on the water resource, but this possibility may be explored within the ecological pricing framework.

3.3.5 Financial Pricing

The historical approach in South Africa has been to supply water at its average or marginal financial cost. This leads to inequitable pricing structures, with those using the first developed (cheap) water having an advantage over those dependant on later developments, even though this may result in a higher price for the land or factory with those water rights. This is particularly apparent between economic sectors (agriculture vs. industry) and between the historically advantaged and disadvantaged populations.

The new water pricing policy for South Africa will include economic, social and ecological pricing mechanisms, as indicated above. These should be built on the financial pricing of water, otherwise water provision will not be financially sustainable. The full financial pricing of water would encompass a number of components, including the:

- capital cost of water resource infrastructure development, including depreciation and replacement costs;
- financial cost (interest) on loans;
- on-going infrastructure operation and maintenance costs; and
- cost of managing the catchment water resource, such as monitoring and licencing.

These are collapsed into two charges, an infrastructure charge and a catchment management charge. The latter may include all the costs incurred in protecting the ecological functioning of the aquatic environment, which provides the link to ecological pricing. The catchment management charge is applicable to all users of water, including land use activities which significantly intercept flow (eg. forestry and dryland agriculture) and polluters who discharge waste into the aquatic environment. The mechanisms for allocating and collecting this charge have not yet been resolved.

The unit financial cost is the full financial cost divided by the water available after the ecological and basic needs reserve. However, the financial price to different water users should reflect the differences in assurance of supply, eg. if industrial users require far higher assurance than agricultural users then they should pay a higher price.

3.3.6 Full Economic Pricing

The full economic pricing of water should take account of economic, social, ecological and financial pricing issues, in order to ensure efficiency, equity and sustainability in water use. There are three components to the water price, namely the infrastructure charge, the catchment management charge and the resource conservation charge. Obviously pricing structure will differ between catchments, depending upon the catchment characteristics, relative to water availability and demand. Nevertheless, this approach to water pricing integrates the ecological sustainability issues with the water supply issues, and thus provides a sound basis for water management. The next Chapter evaluates the use of economic analysis tools to support decision making.

CHAPTER 4. ECONOMIC ANALYSIS AND THE APPRAISAL OF WATER RESOURCE DEVELOPMENTS

4.1 Introduction

A basic economic problem facing any country is the allocation of its limited resources between a number of competing uses, so as to maximize the total net benefit to society. Resources may include capital, labour, land and other natural resources (such as water), each of which may have a different level of scarcity in a particular country. Resources may be consumed as goods, invested into infrastructure, used in sectors such as agriculture or industry, or saved for future use (if depletable). The decision implies a choice between present and future benefits, which will in turn be guided by the objectives of that particular society. Project appraisal is based on comparison of resource allocations between different projects through project analysis.

Project analysis should provide a convenient and coherent technique for evaluating allocation of limited resources between alternative projects or programmes, in a way that reflects the society's objectives. This Chapter outlines the cost-benefit approach to project analysis (which is still the most widely used decision making tool in South Africa), with some of the problems encountered in incorporating environmental factors into the analysis. The discussion then goes on to describe some of the solutions that have been proposed to address these problems and to evaluate them in the context of water environmental resource development projects in South Africa. Alternative approaches are offered briefly in Section 4.6.

4.2 Water Resource Project Analysis

Economic project appraisal requires an analytical system that allows decision makers to test whether the returns on a project exceed the costs, to rank projects in terms of their economic efficiency, and thus to choose projects that contribute to the social, political and environmental values of the country with the financial constraints (Merrett, 1997; Gittinger, 1882). In the case of a private firm, the major objective would be to maximize net income or profit (along with diversifying activities and reducing risk), based on a *financial analysis* of the project.

Being a part of governmental resource allocation, water resource project analysis is based on economic rather than financial analysis. These approaches are similar in form, in that they assess the "profit" of an investment. However, where financial analysis assesses the monetary profit to the project-operating entity, the social profit of economic analysis reflects the effect of the project on the fundamental objectives of the society or economy. The differences are reflected in the definition and valuation of costs and benefits. For example, payment for water by the operators of an irrigation project is interpreted as a financial cost to a project and as a revenue to the dam owner, while it is only interpreted as an economic cost if its use implies a sacrifice elsewhere in the society (which includes the potential impact on the aquatic ecology, recreation, industry or domestic users). Conversely, if the impact of saline irrigation return flow on the aquatic environment had an indirect negative impact on the fundamental social objectives, it would have an economic cost, but not a financial cost.

Thus, economic and financial costs are not necessarily similar nor do they always coincide, except where resource pricing reflects its true economic value due to efficient market functioning or policy intervention (i.e. the incorporation of externalities and removal of subsidies). The same may be said about financial and economic benefits. Economic costs and benefits are thus estimated by "shadow prices" (see below), which may differ from the market prices usually appropriate for financial analysis.

For society as a whole as represented by the government (as is generally the case when evaluating water resource development projects), two possible objectives are to increase national income (growth) and to redistribute that income between sectors or even generations (equity), which implies *economic analysis* of the project. These two primary objectives may be presented in a number of ways (eg. contribution towards gross geographic product, employment creation or the reduction of poverty), which are not necessarily valued equally by the society. Nevertheless, which ever way the selected objectives of a water resources development project analysis are represented or weighted, they provide the standard against which costs and benefits are defined. A cost is anything that reduces an objective, and a benefit is anything that contributes to meeting an objective. The first test (necessary, but not sufficient) is do the benefits exceed the costs? If so, the project can be acceptable; if not it should be rejected.

Project analysis involves selecting a principle objective for the analysis, but which may include other connected objectives. Gittinger (1982) identifies income (growth) maximization as the single most important project level objective for developing countries, because it parallels increased Gross Domestic Product (GDP) which is often the most important objective of economic policy at a macro level. In South Africa, this is the primary objective of the GEAR, although it also has strong employment creation and redistributional (equity) elements.

Assuming GDP growth as the primary objective, the analytical criterion is the income a project contributes to a society. The analysis includes evaluation of alternative projects or alternative forms of a project to inform the selection of the best option. The income-generating potential, as well as other social objectives of the project, are judged and recommendations are made. Anything that reduces national income is perceived as a cost and anything that increases national income is a benefit (Gittinger 1982). In this context, the objective to increase the sum of all final goods and services, anything that directly reduces the total final goods and services is a cost, and anything that directly increases them is clearly a benefit. This includes all negative or positive externalities caused by the project. Costs are defined relative to the opportunity cost of a resource, which is the benefit foregone (in terms of the fundamental objectives) by using that resource in the project rather than in the best available alternative investment.

Although project analysis seems to be divorced from the fundamental social and economic objectives and use of resources in other projects, the definition of costs and benefits imply that these factors play a major role in whether a project should be accepted of rejected. One way in which this can happen is through the use of subjective weights. Different costs and benefits may be weighted to reflect the relative importance that society allocates to them, i.e. if poverty reduction is a priority, project income accrued to the poor could be weighted more heavily in the project analysis than income to more affluent segments of the society.

Project analysis is a comparative and iterative process. Economic costs and benefits are based on the "with" and "without" options (which is not the same as the "before" and "after" case). The difference between with and without is the incremental net benefit arising from the project investment. The before-and-after comparison fails to account for changes in production that would occur anyway (or through the reallocation of resources) without the project, which would thus lead to an erroneous statement of the benefit attributable to the project investment (Gittinger, 1982 p47).

Even without reallocation of resources without the project, a change in output can take place in two situations. The most common is when production in the area is already growing, if only slowly, and would continue to grow during the life of the project. In this case only the incremental increase is calculated to show additional growth of output as a result of the project. Secondly, a change in output can also occur without the project if production would actually fall in the absence of new investment.

The project analysis process is iterative which means that at all stages, synthesis of the data needs to be re-examined as new data is brought to light. This is comparable with the procedures of integrated environmental management (IEM), which is the term adopted in South African for the procedure designed to ensure that the environmental impacts and consequences of developments are taken into account (DEAT, 1992). It is a positive and interactive approach to gathering and analysing data, and presenting it in a form that is conducive to informed decision making when embarking on developments (Preston *et al*, 1992).

Similarly to the IEM procedure, project analysis depends upon the evaluation of alternatives, including the "do nothing" option. This is probably the most important feature of comprehensive project appraisal (and IEM) throughout the project cycle, from sectoral development policy and programme formulation, through project identification to appraisal. Detailed project analysis is usually performed on a few alternatives, once others have been rejected. For economic project analysis to provide a valuable contribution to resource allocation, the policy environment, approach and associated criteria for early selection or rejection of proposed projects should be consistent with the philosophy of project analysis (i.e. the reflection of social objectives and the use of economic costs and benefits). This ensures that the types and design of projects for comparison under by detailed project analysis is comprehensive and appropriate. Otherwise application of project analysis at this late stage is only cosmetic.

For project evaluation Stauth (1983) has recommended three criteria for evaluating the acceptance or rejection of a project. They are: firstly, the *efficiency criterion*, which briefly is where someone is made better off without anyone else being made worse off (Pareto optimality) or where acceptable compensation is available to the losers and the gainers are still better off. Secondly, the *equity criterion*, which concerns the improvement of the distribution of social well-being and also includes compensating losers in order for the distribution of income to remain the same or improved. Finally, the *intergenerational criterion*, which concerns actions that are acceptable with future generations in other words, prospects for improvements in future well-being are not diminished (i.e. sustainability).

In judging the acceptability of a proposal in terms of these criteria, costs and benefits must be measured. If benefits are found to exceed costs, the action is efficient; if costs and benefits will be distributed fairly over the population, the action is equitable; if costs do not exceed benefits for future generations, the action has positive intergenerational effects (Stauth, 1983 p99).

4.3 Social Cost-Benefit Analysis

4.3.1 The Approach

Social cost-benefit analysis (SCBA) is the most commonly used methodology for project appraisal. It is a pragmatic realisation of the theory of welfare economics (Smith, 1987). The basic approach is that an investment in a project should be considered only if its benefits exceed its costs. Furthermore, the best resource allocation between a number of projects is associated with the one that provides the greatest net benefit. Benefits and costs are defined to include any welfare gain and loss which occurs because of the expenditure on the project (Pearce, 1983), as discussed above.

The total benefit from an investment in a project (j) is equivalent to the difference between the economic costs and benefits associated with that project, weighted according to the fundamental social objectives underlying the project appraisal. The Net Benefit of project (j) is the difference between the total benefit of the project (j) and the social benefit of an alternative or baseline project (k), which may include the "do nothing" option.

$$\text{Net Benefits}_j = (\text{Benefit}_j - \text{Cost}_j) - (\text{Benefit}_k - \text{Cost}_k)$$

If a proposed resource use has a net benefit, it is efficient; if it has a higher net benefit than an alternative resource use, it is more efficient than the alternative (Stauth and Baskind, 1992 p35). According to Stauth and Baskind (1992, p34) in order for cost-benefit to accomplish a satisfactory evaluation the following must comply:

- all costs and benefits must be identified and explicit judgements made as to their relative value;
- the efficiency, equity and intergenerational criteria must be systematically applied; and
- all concerned parties must find the method of evaluation acceptable.

The six steps to social cost-benefit analysis are (Dohan 1977, Stauth 1983):

1. Definition of alternatives including the "do nothing" alternative.
2. Identification of costs and benefits associated with each alternative.
3. Calculating the economic value of costs and benefits, by estimating *shadow prices.*
4. Describing qualitative effects which cannot meaningfully be quantified.
5. Calculating present value equivalents, by *discounting* the value of future costs and benefits.
6. Choosing the alternative with the highest net benefit.

Two other tasks that may be included are, the inclusion of weights (reflecting different objectives) into the analysis, and performing sensitivity analysis.

The concepts of shadow pricing and discounting are central to the economic analysis of water resource projects and are therefore discussed in greater detail in the following two sections, with particular emphasis on the implications for valuation of the environmental consequences of projects.

4.3.2 Shadow Pricing

As has been highlighted above, project analysis depends upon an economic interpretation of resource costs and benefits. Shadow prices represent the "economic values" of resources and impacts in terms of the fundamental social and economic objectives, which are not necessarily the same as financial prices (Squire and van der Tak, 1975). This difference between the financial and shadow prices of traded goods and services may be due to policy failure or market distortion (including the impacts of subsidies and taxes).

Shadow prices are the prices one would encounter in a perfectly competitive world free of taxes and subsidies. They ultimately reflect the interaction between the fundamental objectives of society and the resources available to achieve them. Thus, scarce resources (those for which the demand is high relative to the availability, because many alternatives are competing for that resource) have high shadow prices, because the potential benefit sacrificed by not using that resource in the next best option (i.e. the opportunity cost) tends to be high. Conversely, resources with a large supply have low shadow prices, because the demand for most alternative uses may be easily satisfied, thus there is little benefit foregone in using the resource. Although financial prices in functioning markets tend to reflect this scarcity, controlled or imperfect markets (particularly in developing countries) tend to have price distortions, particularly in markets for labour, capital and foreign exchange (and in some cases agriculture). Fortunately for the purposes of project appraisal, South African markets are becoming more liberalised and the market prices are beginning to reflect the economic value of traded resources.

On the other hand, non-traded environmental resources require valuation, in order that they may be incorporated as costs or benefits within the project analysis. Thus, shadow pricing of environmental (eg. natural and social) resources may be necessary, not because of distorted markets, but because of the lack of a formal market. Under these circumstances, shadow pricing depends upon individual's, community's and society's "willingness to pay" or "willingness to accept compensation" for environmental impacts. Techniques aimed valuing environmental resource impacts are discussed in section 4.4.

Finally, shadow pricing may also be used to address political and social constraints on the economy, as well as the traditional resource constraints (Squire and van der Tak, 1975). This is particularly important in cases where the fundamental objectives cannot be met through traditional monetary or financial policy. Under these conditions, the estimation of shadow prices may be weighted so that the project appraisal process directly addresses these fundamental social objectives. For example, even if the government is not able to ensure the level of redistribution (equity objective) required, then project appraisal may be used to allocate investment into those projects which will emphasis this objective, by valuing (shadow pricing) costs and benefits affecting to lower income groups more highly than those of affluent groups. However, these values have to be justifiable; they are not "swing weights".

Similarly, placing high shadow prices on vulnerable or threatened ecological resources would tend to exclude projects with significant negative impacts on these resources, during the project appraisal process. This is particularly important under conditions of uncertainty, where the true or future value of environmental resources are not well understood. This implies an economic approach to the "precautionary principle", and provides a potentially powerful means of environmental resource management, without requiring the allocation of extensive administrative and regulatory resources to traditional "command and control" approaches. However, this implies that all projects should be evaluated with consistent shadow pricing.

4.3.3 Discounting

An underlying assumption of project analysis is that the value of investment or consumption in the future is less than in the present (Tietenberg, 1988). This implies that future project costs and benefits are "discounted" during the analysis in order to provide equivalent *present day values*, which are then compared between projects as Net Present Values (NPV). There are two basic reasons for discounting.

Firstly, capital which is invested now will have a higher value in the future (even corrected for inflation), due to the productivity of capital. This implies that income or capital accrued in the present is worth more than that accrued in the future; this is reflected in the interest rate on capital. As with other resources, the marginal interest rate of capital should reflect the rate of return on the marginal project which may be funded with the available capital resources in the country.

Secondly, people tend to prefer benefits (or consumption) in the present rather than at some future time (positive time preference). Because project analysis is based upon the economic concept of preferences (willingness to pay/accept compensation), this time preference requires that future benefits and costs be discounted. For water resource project analysis, it may be appropriate to consider the time preference of society as opposed to a collection of individuals, because society is likely to have a lower discount rate since society's view of time is less bounded by mortality than is an individual's. This issue highlights the needs of future generations, which is particularly pertinent when dealing with environmental resources.

The focus on Net Present Value means that project appraisal may be too largely concerned with present needs, and may not address the issues of sustainability and intergenerational equity. Because discount rates reduce future costs or benefits, negative impacts on environmental resources and potential (unknown) future benefits from these resources are largely ignored. The project appraisal process then tends to select projects which accrue benefits in the short-term and impose costs in the long-term, leaving it to future generations to solve the resulting environmental problems. This problem is compounded when the true value of environmental resources are unknown, and are thus omitted or underestimated.

Two approaches may be adopted to redress the problem of discounting (and thereby negating) future environmental costs and benefits during water resource project analysis. The first is to place constraints on projects, such as obliging them to reflect some concept of intergenerational sustainability, eg. requiring the survival of certain key species which are necessary (or sufficient) for aquatic ecosystem functioning. At one level, this is the aim of the Instream Flow Requirements (IFR) process. Once these conditions are achieved, typical project analysis using the conventional discount rate would be applied to identify the most appropriate projects.

The alternative is to modify the conventional discount rate to reflect the needs of future generations. However, the estimation of appropriate discount rates then becomes arbitrary and is largely based on arguments that the productivity of capital rate is ethically or practically consistent with sustainability criteria. Nevertheless, if discount rates above about 2% are used (eg. the usual rates of between 3% and 9%), the costs of long-term environmental impacts (such as global warming or species extinction) tend to be ignored. Thus, in the context of uncertainty (and likely economic resistance to lower discount rates), it is more appropriate to place constraints on projects, rather than directly address the discount rate problem (Pearce, 1993).

4.4 Environmental Economic Valuation Techniques

4.4.1 Introduction

The previous section has indicated the relationship between economic analysis and project appraisal, while the relationship between water resources policy and economic analysis was outlined in Chapters 2 and 3. These represent the two sides of economic valuation of environmental resources to guide decision making at the micro and macro economic levels, based on an evaluation of the true costs associated with environmental resource use or degradation. The total economic value of an environmental resource (eg. riverine ecosystem) may consist of:

- *Direct use values* associated with direct use of a resource, such as recreation;
- *Indirect use values* associated with ecosystem functioning, such as watching documentaries on the ecological functioning of a river;
- *Option use values* associated with potential future direct of indirect use of the resource, such as maintaining the riverine functioning for future tourism opportunities; and
- *Existence values* associated with the knowledge that the resource exists and will continue to exist for future generations, independent of current or future use.

The first three types are *use values*, which may provide financial returns through current or future utilisation of the resource (Pearce *et al*, 1993). Existence values are *non-use values* and thus cannot be accrued as financial gains from the resource, but reflect ethical and inter-generational moral desires or beliefs.

There are two basic approaches to valuation of environmental resources. The first are based upon questioning people in order that they indicate the value they place on resources and may be used to determine both direct and indirect values, and are referred to as *direct* techniques. The second are based on evaluation of conventional or other proxy markets which indicate the satisfaction people gain from environmental resources and may only be used to determine direct values, and are referred to as *indirect* techniques.

A number of the most common techniques are described in the remainder of this section, with an indication of their assumptions, validity and applicability to water resource assessment in South Africa based on Pearce *et al* (1993; 1990) and Coker and Richards (1995). It should be noted that each one of these methods is only likely to estimate a part of the total economic value to society, because they usually focus on a particular type of value, and that a combination of approaches may provide a more complete picture.

4.4.2 Dose-Response Functions

This theoretically sound indirect valuation approach is based on statistically relating a cause (dose) with its environmental effect (response) and then estimating the economic value of this effect, based on real prices without taxes or subsidies. In application, the dose-response method may indicate the environmental effect of an activity, while another valuation technique may be used to estimate the economic value of that effect. The difficulty remains in developing accurate response functions with limited data, which increases the cost of applying this approach. Furthermore, non-use values cannot be measured.

This approach is typically used for pollution valuation, where the relationship between dose (eg. level of pollution discharge to a water resource) and response (eg. change in fish stock) is known. However, the economic impact of certain ecological changes (such as fish populations) caused by alteration in the hydrological regime due to a water resource development may also be estimated. This possibility has been facilitated by recent developments in rule-based modelling of ecological impacts in the Kruger National Park Rivers Research Programme, although the difficulty remains in estimating the value of the ecology. This is quite important for the dose-response method, which cannot reflect non-use values.

4.4.3 Replacement Cost

This indirect valuation approach provides the value of an environmental standard or development constraint, based on an estimate of the cost of rehabilitating a degraded environment. This is done through first estimating the likely damage to the environment (ecology) without the standard or development constraint, and then estimating the cost of restoring the environment to its original state, or at least replacing the key functions which impact on users of the environmental resource. This approach cannot be used to estimate non-use values and is only valid where environmental guidelines, standards or requirements must be met.

This approach may be used for partially estimating the economic value of instream flow and quality requirements associated with resource-directed management outlined in the water environmental quality policy. Replacement of the flow regulation, flood attenuation and quality assimilation functions of wetlands, the riparian zone and aquatic habitat, may be estimated by the market prices of engineering structures and treatment processes that would be needed to replace these functions. This approach therefore provides part of an economic justification for the environmental requirements placed on water resource developments to ensure the continued functioning of the resource base upon which other users are dependent.

4.4.4 Household Production Functions

The previous two approaches are based on information (prices) from conventional markets. The household production function and hedonic pricing (see below) approaches make use of information from derived markets, which implicitly reflect the use of environmental resources within a service or product, which therefore act as a proxy for the environmental resource. There are three approaches which reflect household decisions about environmental resource use, but none are able to estimate non-use values.

Travel Cost

This approach is generally used to value environmental resources associated with a recreational site or the valuation of time involved in obtaining a resource (eg. collecting water). It is based on a detailed survey of people travelling, the cost of travel, the characteristics of the site visited and alternative destinations, which are then statistically analysed to indicate the cost of travel. Difficulties are faced by the method due to multi-purpose trips and alternative sites and the generally extensive (and expensive) survey required, as well as the limited ability to evaluate a change in a site's characteristics. Despite these problems, this technique is widely used to evaluate eco-tourism benefits and public responses to these facilities. This approach does provide a means of estimating the value of an existing recreational water resource, but not its change in value if it were degraded due to a water resource development. On the other hand it provides a means of evaluating the benefit of a water resource development, such as a recreational impoundment.

Random Utility

This approach can also be used to estimate the value of recreational site characteristics or time associated with resource collection. In this approach, the characteristics of alternative recreational sites or environmental resource (eg. water) sources are assumed to determine the choice between alternatives, and that this may be represented as a household utility function. Identification of these functions is based on surveyed data about resource utilisation (including trips), site or source characteristics, and household socio-economic characteristics, which can be expensive. The approach provides an indication of the relative value of various alternatives, but not the total value of a given alternative, nor the possible impact of a change in characteristics. This approach may be used to value the relative recreational benefit of different water resources (eg. river systems), but not its total benefit or possible lost benefit due to degradation after a water resource development.

Avertive Behaviour

This approach is based on estimating the measures households will undertake to mitigate an environmental impact and then estimating these at market prices. The validity of this approach is based on the measures (actions) only being for mitigation of the negative environmental impacts. The validity of this assumption and the expense of collecting adequate data, except for small localised studies, makes this approach difficult to apply. However, this approach may be applicable to estimating the value of good quality water (eg. through the use of household water filters), but this is not particularly relevant in the context of water resource developments evaluation.

4.4.5 Hedonic Pricing

Hedonic pricing is based on attributing marginal differences in property prices (willingness-to-pay) to different environmental factors, and thereby estimate the value of those factors. Property prices paid by households should reflect the potential impact that environmental factors, such as risk of flooding, water supply and aesthetic view, have on the price of different properties. However, this approach assumes that households (or individuals) are aware of the positive and negative environmental attributes and/or impacts (risks) and that the property market is well developed and functioning. Data must be collected on market prices of houses with similar and different characteristics over time, and then implicit prices are evaluated through statistical regression analysis.

This approach is time consuming and costly, but can provide information about the value people place on aesthetic or recreational aspects of water resources. It is also not able to reflect non-use values. However, it is a form of "revealed preference", and is appealing to economists as it is based on real market data.

4.4.6 Contingent Valuation and Ranking

These direct valuation methods provide a means for estimating both use and non-use values, as opposed to the above methods which evaluate use values. They are based on surveys of people in order to directly evaluate their preferences in terms of environmental resource quality and/or degradation.

Contingent Valuation

This approach is based on structured questionnaires which aim to evaluate people's willingness-to-pay (WTP) or willingness-to-accept-compensation (WTAC) for changes in environmental resource quality (associated with any environmental impact). This provides an indication of people's general preferences and thus society's mean valuation of the resource, based on statistical analysis of the results. Difficulties are faced by the hypothetical nature of the survey and thus the results may overestimate (people are not actually required to pay) or underestimate (people may believe someone else will pay) the true values. This bias may be corrected by comparison with average true values, where these are available. The approach is generally expensive and time consuming, but can provide an indication of the value society places on aquatic environmental resources. This is appropriate, because non-use values represent a large portion of the total value associated with a pristine catchment, and are likely to increase as more catchments are degraded.

Contingent Ranking

This approach asks people to rank different alternatives reflecting environmental resource quality or impacts, including some from actual markets (which allow "anchor" prices to be estimated). This may be applied to evaluating the value of aquatic environments (or degradation), but has not been widely applied.

4.5 Criticisms of Project Analysis and Economic Valuation Techniques

4.5.1 The Social Cost-Benefit Analysis Approach

SCBA does not claim to produce morally correct decisions (Pearce, 1983). It is only likely to produce the morally correct solution if the preferences of individuals or society are the morally correct way of decision making. It is often the role of government to intervene to discover who the concerned individuals are who make up the particular society. Value judgements are beyond the realm of cost-benefit and since money, with its many pitfalls is used as the measuring rod, it is rightly so.

Peoples preferences are however, displayed through transactions made in the market. People's wants and preferences are expressed in the goods and services bought daily. Moral issues surrounding the desirability or appropriateness cannot be imposed on wants as cultural and other factors play a role in differentiating between people. Also often people's wants and people's morals do not correspond (Pearce 1983). Nonetheless, markets remain the means by which preferences can be expressed and for this reason cost-benefit remains the pragmatic solution to weighing-up project alternatives.

Cost-benefit is an attractive methodology for use by resource economists, but in practice it is often difficult and complicated. There are fundamentally two criticisms of benefit estimation.

Firstly, putting monetary values on "things" that are not normally valued in the market, is problematic and often impossible, despite the techniques mentioned in the previous section. The result may be that some costs and benefits are unpriced in the final accounting. This can lead to irreversible or irreplaceable losses. In such cases, compensation however meaningful to individuals cannot lessen the loss to society. This seriously complicates the valuation of the associated cost.

Secondly, cost-benefit is not able to easily address the issue of intergenerational equity. Cost-benefit's incorporation of equity concerns has not found a truly satisfactory way to compare and trade off distributional effects (either intra-generational or intergenerational) with efficiency effects (Stauth and Baskind, 1992 p35). For example, when comparing the trade-offs of alternative resource use, a proposed use may be accepted even though it only passes one of Stauth's three evaluating criteria.

The option demand or, the premium people are prepared to pay to preserve options for use in the future, may not be taken into account. Option demand is calculated by the amount individuals are willing to pay for preservation or willing to be compensated for in the event of development. Where there is irreversible damage this option is obviously negated and conventional cost-benefit is less able to account for it. Application of option demand becomes necessary when irreversibility, significantly large changes or uniqueness (no substitutes) are characteristics of a development. For example, the development of a dam in the upper Olifants River (Western Cape) complies with the first two characteristics. The availability of a substitute is dubious, as although there are other potential alternative sites, for example smaller dams on tributaries, the substitution of water storage in the Olifants River valley is not easily overcome. Dohan (1977, p168) identifies four reasons for individuals willing to pay for future options. These are:

- shifts in tastes and preferences of future generations;
- uncertainty about future benefits and costs as viewed from the present generation; and therefore
- the possibility of obtaining more information or making better decisions; and
- the desire to exercise an option in the future, for which they do not have resources at the present.

Finally, many aspects of society's well-being cannot be valued in economic terms, for example, appreciation of life itself, good health and good government. These aspects enter the realms of rights and freedoms and are not easily measured through revealed preferences in markets.

Discounting, which is at the heart of cost-benefit, is criticized by environmentalists due to the emphasis on present values which gives little weight to future costs. The central concern of cost-benefit analysis is that of present day economic efficiency of a project for today's society, with economic efficiency implying greater net benefits. The result of this practise is less incentive for present day conservation or even environmental resource management. Very few areas are therefore set aside, untouched by developments purely for conservation purposes. Stauth (1983, p102-103) considers discounting the future a reasonable practice for people today, if the following are true:

- satisfaction today is preferred over the possibility of receiving the same satisfaction tomorrow;
- resources can be converted into capital goods thereby increasing their stock of resources over time; or
- the expectation that people will be better off tomorrow, in which case satisfaction today would mean more now than in the future due to the decreasing marginal utility of income.

The emphasis is therefore on the efficiency of present users and usage and does not incorporate a futures perspective. In order to solve this problem Stauth advises that the focus of resource allocation should be moved from an efficiency problem to a distributional problem. Demonstration of resource inefficiency might not be required if it is shown that efficiency benefits do not outweigh the great costs imposed on certain social groups today or in the future (equity and intergenerational criterion respectively) (Stauth 1983, p103).

4.5.2 Economic Valuation Techniques

Criticisms of the economic valuation techniques (presented in section 4.4) include those that question the underlying validity of economic valuation of environmental resources, as well as those that accept the basic premise of economic valuation, while questioning the accuracy of the estimates (Merrett, 1997). The former are associated with ecological arguments based upon beliefs that all ecosystems and their biota have an inalienable right to exist and thus should be conserved (or protected), whether this imposes significant costs on society, or even if this means that social structures and priorities must be revised.

Allied to this approach is the argument that economic valuation cannot reflect the true value of environmental resources, due to lack of knowledge and understanding about ecological functioning. This has been formulated as the "precautionary principle", which implies that no action should be taken when there is a risk of irreversible environmental damage and/or inadequate information. Although application of the precautionary principle is often promoted from the perspective of "ecosystem rights", this approach implicitly allocates an infinite value to ecological resources (compared with other costs or benefits) under conditions of uncertainty, because sustainability depends upon ensuring resilience (no irreversible change) in ecological systems. A counter-argument has been proposed that limited knowledge does not imply that valuation is inappropriate, based on the existence of economic valuation techniques which incorporate uncertainty (risk) in decision making.

These arguments have largely been addressed in the context of the aquatic environment in South Africa. The fundamental principles indicate that the "quantity, quality and reliability of water required to maintain the ecological functions upon which humans depend shall be reserved" and "shall enjoy priority use by right". This indicates acceptance of the argument that some of the water resource should be reserved for environmental requirements (i.e. is infinitely valued). However, this portion is only interpreted as the basic quantity, quality and reliability required to maintain ecological functioning for human use, rather than a more strict "ecological rights" argument. Allocation of water resources above this basic (minimum) level, in order to improve the functioning of the aquatic ecosystem, is likely to be based on the value to society of maintaining a higher level of environmental health relative to other potential uses of water; or conversely the cost to society of the aquatic environmental degradation associated with utilisation of the water resource for other purposes.

The Instream Flow Requirements (IFR) approaches should provide the basic scientific information about the consequences of water resource developments, as well as an estimate of the Ecological Reserve. However, the classification of an aquatic environment into higher sensitivity classes (with associated controls on water resource development or use) may need to be supported, either implicitly or explicitly by valuation of that resource relative to other potential uses, particularly if there is stakeholder opposition to this classification. This raises the second group of critiques about environmental valuation, namely the robustness of the environmental valuation techniques.

These criticisms are of the following general types:

- basing the valuation on human preferences, which may be ill-informed;
- the interests of future generations may not be well represented; and
- the true value of the resource may not be captured if non-use or indirect use values are omitted.

4.6 Incorporating Other Criteria with Economic Analysis

4.6.1 Dual Analysis

The preceding discussion has called into question the appropriateness of attempting to value all environmental impacts and incorporate them into a social cost-benefit analysis (SCBA), particularly for those impacts that do not have easily quantifiable use values. An alternative approach called dual analysis (Merritt, 1997), combines SCBA with Environmental Impact Assessment (EIA). The SCBA is conducted to evaluate the economic viability of the project, including the valuation of environmental impacts where possible. An EIA is conducted at the same time, to identify and evaluate the importance and severity of environmental consequences that do not have an easily quantified price.

The evaluation of alternative projects is then done using information from both the SCBA and the EIA. However, because these two techniques provide non-commensurable information, even though this may be quantitative estimates of the impacts, the onus is on the decision maker to select the preferred alternative. This requires a value judgement by the decision maker about the relative importance of the economic and environmental consequences.

The resource protection approach proposed by the National Water Policy is consistent with dual analysis, in that the Reserve is defined through a form of EIA, i.e. the water resource classification and IFR, and then the viability of a project that provides for this requirement is evaluated. The evaluation process explicitly compares the social benefit of increasing the level of protection (resource class) with the economic costs of this level of protection. The latter is equivalent to a mitigation cost, while the former must be implicitly based upon a perceived damage cost associated with not protecting the water resource. Unfortunately, it will not be clear how to make these trade-offs, if the damage costs are not known. The decision must be based on information about the environmental impacts, such as species loss or changing aesthetic quality.

4.6.2 Multi Criteria Decision Analysis

The dual analysis approach raises the question of how to select from a group of alternatives under the situation where there are competing and non-commensurable objectives, such as maximising growth of GDP versus minimising loss of biodiversity. The techniques associated with Multi Criteria Decision Analysis (MCDA) attempt to guide decision makers in finding solutions which take account of conflicting goals and objectives. These techniques have been widely applied for purposes of water resources planning (Stewart *et al*, 1993; Loucks *et al*, 1981) and enable non-economic environmental and social impacts to be explicitly incorporated into decision making.

MCDA developed out of the shortcomings of the single objective optimisation techniques, which are based on the optimisation of a single objective function subject to a set of constraints, such as SCBA. On the other hand, MCDA techniques are based on the concept of *satisficing*, where the focus is on finding solutions that are acceptable across a number of objectives (Goicoechea *et al*, 1982; Loucks *et al*, 1981). Stewart (1992) and Stewart *et al* (1993) provide a review of the general MCDA approaches.

Utility and value function approaches are based on the combination of marginal utility functions for each criterion into a global utility function of some assumed form, which can then be assessed for the various alternatives. The difficulty of this approach is to determine or reveal the marginal utility functions, either explicitly or implicitly, and to weight their relative importance, particularly where the decision makers may be resistant to clear statements about politically sensitive issues.

Multi-attribute utility or value theory (MAUT or MAVT) has developed more transparent procedures whereby the different decision criteria are individually valued by the decision maker(s) and then relative weights are assigned to the different criteria. These procedures have been incorporated into decision support tools to assist conflict resolution and decision making.

Goal programming approaches are based upon the decision maker specifying levels for criteria below which they would not accept an alternative or above which there is relatively little additional benefit. The approach is then to search for alternatives which are closest to achieving the specified levels, usually be minimising the underachievement. This may be an iterative process whereby the goals are reevaluated based on the results of the search. This is a widely used approach for MCDA, because the process is relatively transparent and simple to apply.

MCDA provides a set of techniques to implement the resource protection policy of the new water law in South Africa, whereby the social benefits of increased protection (higher resource class) must be weighed against the possible increased costs associated with this higher level of protection. This is implicitly what the National Water Policy is referring to in a "process of consensus-seeking among water users and other stakeholders" for deciding the level of protection for a water resource (DWAF, 1997b: pg 19). There has certainly been a shift from an "expert driven" SCBA type approach, towards an interested and affected party (IAAP) centred decision approach by DWAF over the past few years.

Although this may not be a formal MCDA, it has similar aims that are achieved through a process of consultation and negotiation. This is supported by the economic information from the SCBA and the environmental impact information from the IFR and EIA processes. Toward this end, the evolving approach to estimating the water resource class and Reserve, is based on a process of quantifying and ranking identified impacts of a proposed water resource development.

CHAPTER 5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The aim of this dissertation was to explore the possible role of environmental resource economic analysis to support water resource planning in South Africa. This had three main components:

- To establish whether such as role has been enabled through policy formulation in South Africa.
- To ascertain whether economics has a practical role to play in water pricing or project analysis.
- To confirm that appropriate and implementable resource valuation techniques are available in South Africa?

Chapter 3 outlined the policy and legislative environment in South Africa, with respect to water resource management. The need for management and protection of the aquatic environment is highlighted in the South African Constitution, the Reconstruction and Development Programme (RDP) and the new National Water Policy. Furthermore, the use of economic instruments in pricing and regulation, and the need of integrated assessment as a means of ensuring this, is referred to in the National Water Policy (DWAF, 1997b) and the National Water Act (Act 36 of 1998).

The integrating nature of a resource economics perspective was also outlined in Chapter 3. It illustrated the concept that resource economics provides a means of incorporating social and environmental costs, together with scarcity-based economic valuation and traditional financial costing, in the pricing of water.

South African policy has recognised and enabled the use of environmental resource economic analysis to support the planning and management of water resource development. At present these concepts have not been implemented or tested in South Africa and current thinking seems to indicate that these approaches are only likely to be implemented in the medium to long term.

The regulatory approach to environmental management has been largely adopted in South Africa, albeit with a significant consultation component. The water resource classification system and definition of the Reserve provides the framework for all water resources development and management. However, the determination of the water resource class must be developed through a process of consultation with all stakeholders in a catchment, supported by technical specialists and information.

In particular, Instream Flow Requirements (IFR's) and Environmental Impact Assessments (EIA's) provide the scientific information upon which to base engineering development decisions, particularly in terms of the minimum requirements for sustainability of the aquatic environment. However, they do not easily provide information about the relative trade-offs between higher levels of resource protection and possible further water resource development. Providing this information is the focus of resource economics, whether this is to support water pricing and allocation policy at a catchment or regional level, or for evaluation of the full costs and benefits of individual water resource projects.

Therefore, environmental resource economics may have a role in both water resource pricing policy and project appraisal, but its implementation depends upon the availability of appropriate valuation techniques, except in terms of qualitative evaluation of alternatives. Chapter 4 reviewed project appraisal and environmental resource valuation techniques, indicating that these are available and have been applied internationally, including in developing countries. However, the draw-back is that most valuation techniques that provide information about the full (use) value of a resource are expensive and require considerable time to apply. Furthermore, there is limited experience with these techniques in South Africa, although some work has been done which may support the dose-response function and replacement cost approaches.

5.2 Recommendations

In conclusion, the value of economic resource analysis has been recognised at a policy level in South Africa. There are some techniques available for environmental resource valuation to support pricing policy and project appraisal. However, the application of these techniques should be further explored in South Africa, in order to evaluate their appropriateness to conditions in this country. The problems of consistent methodology, considerable expense and limited information all indicate that the application of these techniques in a practical (rather than theoretical) manner, to inform decision making, is not feasible in the short to medium term.

The possibility of valuing the full social and environmental costs and benefits of water resource utilisation should be explored in terms of its incorporation into water pricing at a catchment or regional scale. Although this is in line with the proposed water pricing policy, its implementation is likely to be delayed. Fortunately this will allow time for debate about the incorporation of these costs into the catchment management or resource conservation charge, particularly as this introduces the concept of Pigouvian taxes, which the National Water Act otherwise seems to preclude.

Cost benefit analysis has been used for water resources planning in South Africa for many years. However, the environmental and social damage costs are not easily incorporated into such analyses, largely due to the problems identified above. An alternative approach, which is provided for in the new water law, is based on the internalisation of the costs required to mitigate the environmental impacts, particularly in terms of the requirements of the Reserve and resource quality objectives. These in turn are derived through a process of stakeholder consultation resulting in the definition of the water resource management class (desired state of a river), which is implicitly a multi-criteria decision making process.

This approach would then inform the water pricing associated with that development. This may be viewed as an internalisation of the costs of protecting the environment and is the most appropriate approach under current conditions and information availability in South Africa. It is based on the concept of internalising regulated mitigation costs, that have been consulted, rather than an attempt to quantify and internalise fairly esoteric damage costs. This is particularly appropriate for non-use values associated with the environmental impacts. On the other hand, environmental impacts that have direct economic value, such as downstream fisheries, can be more easily quantified and should be explicitly incorporated into the SCBA.

Dual analysis is also provided for under the water law. This implies decision making through SCBA together with an EIA of the proposed development. All major water resource developments require EIAs, both in terms of the National Water Act (Act 36 of 1998) and the National Environmental Protection Act (Act 107 of 1998). The EIA has particular relevance when a killer issue is identified that implies that the alternative should not be implemented.

Alternatively, the EIA has a major role to play in assessing alternatives for which the economic viability of the project is marginal. Significant negative environmental impacts would indicate that these projects would not be viable if the environmental costs were incorporated.

5.3 Summary

In summary, environmental resource valuation techniques have a potential role in South Africa, but this still needs to be evaluated through application on a case study basis. Resource economic analysis should be viewed as a support tool for the water resource classification process, similarly to IFRs, particularly where water resource development pressures are competing with environmental resource protection needs. This information may provide motivation for protection of the aquatic environment at levels higher than the minimum required for sustainability of the resource (i.e. definition of a higher management class). This dissertation has confirmed the importance for EIAs and IFRs to be part of project appraisal and decision making.

The application of these approaches is important if the environmental consequences of water resource development and utilisation are to be incorporated into decisions at an individual water user level (through full cost pricing) and/or a project level (through social cost-benefit analysis). This is the longer term vision outlined by the new water policy and legislation, but the appropriate ways of implementing needs considerable further work.

These issues are particularly relevant in South Africa, which is a water scarce country, and where the pressures for development may outweigh the arguments for resource sustainability if adequate information is not available.

On the one hand, South Africa is a developing country with limited human and financial resources to apply the available resource economic analysis techniques. On the other hand, South Africa is dependant upon a limited water resource base for economic and social development, and therefore it is critical to protect this resource base against over-exploitation. This means securing the ecological integrity of the country's water resources, which would be supported by the information that these techniques provide. However, at our current levels of understanding and available resources it is not realistic to quantify all environmental impacts as prices, because the information needed to support these techniques is not available. Nevertheless, it is of fundamental importance that this information is incorporated into the decision making process, through dual analysis supported by multi-criteria decision analysis techniques.

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