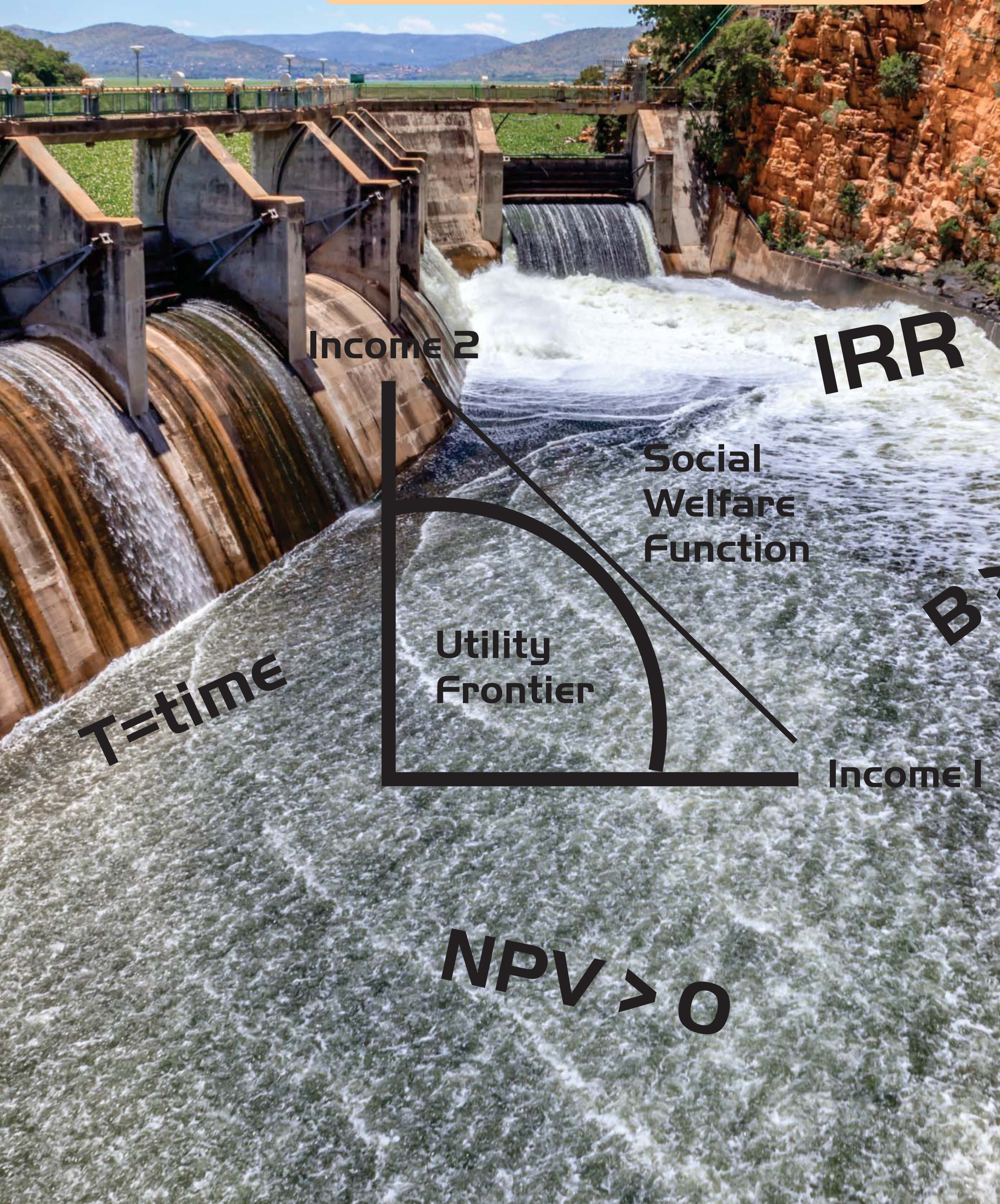
A MANUAL FOR COST-BENEFIT ANALYSIS IN SOUTH AFRICA WITH SPECIFIC REFERENCE TO WATER RESOURCE DEVELOPMENT

Mr DD Mosaka, Dr JP Botha, Mr RA Downing, Mr FX Jurgens, Dr D Mullins, Dr JK Turpie

FOURTH EDITION (UPDATED AND REVISED)



WATER RESEARCH COMMISSION

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A Manual for Cost-Benefit Analysis in South Africa with Specific Reference to Water Resource Development

FOURTH EDITION (UPDATED AND REVISED)

Report to the
Water Research Commission

by

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EXECUTIVE SUMMARY

This report presents the guidelines in the format of a manual for conducting cost-benefit analysis (CBA) in South Africa with specific reference to evaluating the development and management of water resources. This evaluation of projects is often a difficult task since costs and benefits do not occur only once but appear over time. Furthermore, costs and benefits are often hidden, making them hard to identify, and are also frequently difficult to measure. The same problems occur when the decision-maker has to make a choice between a number of mutually exclusive projects intended to achieve the same goal via a number of different routes. These problems are not limited to capital projects; they also occur when decisions have to be made regarding the merits of current expenditure programmes.

In 1989, the then Central Economic Advisory Services produced the original Manual for Cost-Benefit Analysis (CBA) in South Africa. The second Manual for CBA, produced in in 2001, built on a project that was commissioned by the Water Research Commission (WRC) entitled: *A Manual for Cost-Benefit Analysis with Special Reference to Water Resource Developmen*t (WRC Report No. TT 177/02). This second edition was revised and updated in 2007, and published as WRC Report No TT 305/07. A further update was undertaken in 2014 (WRC Report No. TT 598/14), which is referred to as the Third Edition.

It is vitally important that updates to this CBA manual are made from time to time so as to provide users with a set of standardised, uniform parameters that will enable decision-makers to arrive at sound conclusions and decisions. This Fourth Edition of the CBA Manual updates and expands shadow and surrogate prices to 2020 prices; and specific attention has also been given to the update of the economic value of water in the various economic sectors.

This manual is specifically aimed at the decision-maker in the public sector, but can also be used outside the public sector. To ensure that this manual provides practical guidelines for the CBA practitioners the research for the original manual was conducted in close cooperation with the research manager at the Water Research Commission, members of the Reference Group of the project, the Development Bank of Southern Africa, the Department of Water Affairs and Forestry and leading CBA practitioners. As part of the process, four major workshops were held during the course of the project, all of which provided valuable inputs to the process.

Highlights of this CBA Manual include the fact that a broad approach has been followed to incorporate the relationships that exist between CBA and other aspects of the economy. These include:

- The relationship between the principles of CBA and welfare economics;
- CBA as being one component of a range of decision-making instruments; and
- The equity and efficiency principles

As such, this manual deals specifically with the uses, limitations and basic principles of CBA in order to explain the underlying conceptual framework to the reader. It provides information for not only the analyst, but also contains insight into CBA application possibilities for decision-makers. This information is contained in the introduction and background, which forms a separate section in the document.

This manual advocates that the CBA concept needs to be widened to include the broader social costs and benefits derived from a project. Furthermore, it is also accepted that CBA is only one of several instruments for evaluating proposed projects. One of the main objectives, therefore, was to incorporate an income weighting system that provides for the recognition of some of the macroeconomic policies of the government, i.e. combating poverty and promoting regional development. The impact of income distribution on CBA is specifically addressed in this manual. The fundamental point of departure being that additional income for lower-income groups should be relatively more important than additional incomes for higher-income groups.

By using different methods for estimating the real social discount rate for South Africa, Luus and Mullins (2008) found that most of these estimates range between 8.4 and 9.6% in real terms. Based on historical per-capita income and expenditure data for South Africa, and global empirical research on pure discount rates, a Social Time Preference Rate method (STPR) of 8.35% has been determined.

Considering that the second edition of the CBA manual is already recommending a real discount rate of 8%, and that this rate is used in project evaluations in the public sector, it seems appropriate to retain 8% as the applicable discount rate for South Africa. Based on current evidence, the 8% discount rate would also be closer to the theoretically argued and calculated rates based on opportunity costs and time preferences.

The manual also advocates the need for sensitivity analysis. In most cases, a CBA is performed for future projects, and thus entails the estimation of certain key variables such as expected prices and quantities. Although it could be accepted that the decision-maker is fully aware of the fact that the projected outcome of a project cannot be interpreted in absolutely certain terms, it is important that the analyst provides the decision-maker with some idea of the degree of certainty/uncertainty that a specific project's outcome could be subjected to. In this regard, both selective and general sensitivity analysis are discussed, where a general sensitivity analysis hinges on the derivation of a probability distribution of possible outcomes.

As far as possible a practical approach is followed in this manual. This applies specifically to the guidelines for shadow and surrogate prices. In this regard the following shadow/surrogate prices are provided:

- Shadow wages for unskilled labourers per province
- Estimated annual remuneration for occupational categories in South Africa per province
- Index of projected real effective exchange rate of the Rand
- Index of projected prices for petrol and diesel
- Index of estimated relative changes in electricity prices
- Estimated time cost according to income groups
- Economic value of productive life

As mentioned above, the focus in this manual is on evaluating the development and management of water resources. In this regard, various issues relating to such evaluation are discussed, i.e. attention is given to water development and river basin management costs; and the subject of the opportunity-cost of water is also addressed. The user of this manual is further provided with a list of environmental aspects related to water development; and methodologies for calculating the economic value of water for various water usages are discussed in detail.

Researchers are assisted with the application of the guidelines contained in this manual through the provision of practical examples that appear on the website of the Water Research Commission (WRC). These examples include the Construction of a Dam, the Provision of Potable Water, Green Infrastructure projects, the construction of an Electricity Hydropower Facility, an Agro-Processing Project, a Coal Mining project, a Road Development project, a Tourism Project including a Safari lodge, electricity, potable water, roads and municipal versus irrigation water schemes.

The main subjects discussed in this manual are the following:

- Applications and limitations of CBA
- Methodology

- Criteria for project assessment
- Shadow and surrogate prices for South Africa
- Issues relating to water development
- Practical examples.

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The identification of the key role players in the study was based on the principle of relevance and the anticipated contribution to the study as determined by the associated tasks.

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ACRONYMS & ABBREVIATIONS

BCR	Benefit-Cost Ratio
CAPM	Capital Asset Pricing Model
CBA	Cost-Benefit Analysis
CGE	Computable General Equilibrium
c.i.f.	Cost-insurance freight
CVM	Contingent Valuation Method
DBSA	Development Bank of South Africa
DCF	Discount Cash Flows
DWAF	Department of Water Affairs and Forestry
ERR	Economic Rate of Return
f.o.b.	free on board
FRA	Financial Rate of Return
GDP	Gross Domestic Product
HDM	Highway Development and Management
I-O	Input-Output
IRR	Internal Rate of Return
JSE	Johannesburg Stock Exchange
LFS	Labour Force Survey
LP	Linear Programming
MCDA	Multi-criteria Decision Analysis
NPV	Net Present Value
PSA	Public Servants Association of South Africa
RAF	Road Accident Fund
RED	Roads Economic Decision
SADC	Southern African Development Community
SAM	Social Accounting Matrix
SARB	South African Reserve Bank
SARS	South African Revenue Service
SETA	Sector Education and Training Authority
SOC	Social Opportunity Cost
SPC	Shadow Price of Capital
SRTP	Social Rate of Time Preference
SSA	Statistics South Africa
STPR	Social Time Preference Rate
TCM	Travel Cost Method
UK	United Kingdom
VAT	Value Added Tax
WCD	World Commission on Dams

WfW	Working for Water
WMA	Water Management Area
WRC	Water Research Commission
WTA	Willingness to Accept
WTP	Willingness to Pay
WUA	Water Use Authority

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CHAPTER 1: INTRODUCTION AND BACKGROUND

1.1 FOURTH EDITION OF THE COST-BENEFIT ANALYSIS MANUAL IN SOUTH AFRICA

In 1989, the then Central Economic Advisory Services produced the original Manual for Cost-Benefit Analysis (CBA) in South Africa. The second Manual for CBA, produced in in 2001, built on a project that was commissioned by the Water Research Commission (WRC) entitled: A Manual for Cost-Benefit Analysis with Special Reference to Water Resource Development (WRC Report No. TT 177/02). This second edition was revised and updated in 2007, and published as WRC Report No TT 305/07. A further update was undertaken in 2014 (WRC Report No. TT 598/14), which is referred to as the Third Edition.

It is vitally important that updates to this CBA manual are made from time to time so as to provide users with a set of standardised, uniform parameters that will enable decision-makers to arrive at sound conclusions and decisions. This Fourth Edition of the CBA Manual updates and expands shadow and surrogate prices to 2020 prices; and specific attention has also been given to the update of the economic value of water in the various economic sectors.

It is of paramount importance that the manual integrates key aspects pertaining to ecosystem services, and a dedicated chapter has been added to this fourth edition dealing with this topic. The chapter first discusses the role of biodiversity and ecosystems, and the concept of ecosystem services. This introduction is followed by a discussion of the role of the environment in achieving water-security where key terminology and measures to address key issues are identified. The chapter then provides an overview of how economics can be applied to evaluate and address environmental problems through valuation and CBA.

As indicated above, this manual specifically addresses the Social Discount Rate in order to determine whether the 8% (real term) benchmark is still valid. In the recent past, the level of South African and global interest rates has decreased, and it was therefore necessary to review the Social Discount Rate in this Fourth Edition. As a result, the Social Discount Rate was increased to 10% (real term) in order to bring it into alignment with the Social Discount Rates being applied by Development Finance Institutions such as the World Bank and The African Development Bank.

1.2 INTERNATIONAL HISTORY OF COST BENEFIT APPLICATIONS

CBA has its roots in the middle of the nineteenth century, when economists started to link theory of consumers' surplus with the net gain of communities from government spending projects. The link between the surplus theory and the indirect third-party losses and gains from capital projects was again revived in the 1930s in the United States with the United States Flood Control Act of 1936. That CBA should start in the USA in practice is not surprising, because academic economists secured links with the US government at an earlier stage than in any other country. The earliest application of CBA in the United Kingdom was only in 1960 in respect of the M1 motorway. In 1967, the British Government officially directed its nationalised industries to adopt CBA.

The increasing interest and application of CBA in recent times can be based on two distinct factors:

- Firstly, public expenditure in the developed economies has risen substantially since World War II. Furthermore, in developing countries the need for infrastructure expenditures has increased substantially, often financed by governments of developed countries and international aid agencies – requiring some "standardised" framework and method to evaluate these huge capital projects and minimise, as far as possible, the risk of failure, and

- Secondly, such appraisal techniques were already fairly well developed in the private sector in the form of discounted cash flows (DCFs) and also allowing for identified risks and causal sensitivities. These two factors, have given impetus to the prevailing notion that the principle of efficiency should be extended to drastically increased government expenditures.

1.3 WATER-SECURITY, ECONOMIC DEVELOPMENT AND COST-BENEFIT ANALYSIS

1.3.1 Water-Security

This manual focuses on the use of CBA in evaluating potential water-security policies or projects. The United Nations defines water-security as: "the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality of water for sustaining livelihoods, human wellbeing, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters and for the preservation of ecosystems in a climate of peace and political stability" (UN-Water 2013). There are four core elements within this definition:

- People have access to safe adequate quantities of acceptable quality drinking water for sustaining livelihoods, human well-being, and socio-economic development. Water supply needs to be adequate and reliable, and typically piped to people's homes and places of work;
- Water is available for economic activities and development, energy production, industry and transport as required, and people's livelihoods are not affected by unreliable water supplies;
- Ecosystems are preserved such that they deliver water-related ecosystem services. This includes the protection of freshwater resources, and the aesthetic and recreational opportunities associated with aquatic ecosystems and human-made reservoirs; and
- Climate related water hazards, such as floods and droughts, and the risks associated with these, are effectively managed.

1.3.2 Links between Economic Growth and Water-Security

There are very clear links between economic growth and water-security, but this relationship changes over time as economies and countries become more developed. In countries with a low level of development, water is a major constraining resource where households spend a disproportionate amount of income on accessing water. When incomes increase, households and governments have greater opportunity to invest in water-security and associated infrastructure. As water-related risk decreases, investment in economic activity increases, and economies grow. With increasing wealth, there is an increased demand for services, as well as potentially more savings available for investment. Investments here are complementary to investments in education and health, reducing illness and the time-costs associated with this. This, in turn, has positive feedback on income.

Under these conditions, the economic value of increasing water-security increases. For example, service industry products or offerings are more valuable per unit of water compared with agriculture. Furthermore, as households and companies start to accumulate more valuable assets, they have a stronger desire to protect them, which drives the demand for and development of water-security-related infrastructure.

The positive, reinforcing benefits of water-security are clear. Nevertheless, governments need to determine the appropriate levels of investment in water-security in relation to other key priorities such as energy, healthcare and other non-water-related infrastructure development programmes. These investment decisions are formulated and established in documents relating to countries' planned development paths (Whittington *et al.,* 2013).

There are multiple and varied paths that can be followed when deciding to invest in water-related developments, but these are strongly linked to the size of the economy (as indicated by Gross Domestic Product or GDP[1]), and the financial resources that a country has access to.

Understanding the nuances and timing of where and when to invest is crucial for governments. The two dominant drivers that trigger the need for these types of infrastructure investment decisions are urbanisation and economic growth. Both accelerate the demand from the public sector for network services (piped water and sewerage infrastructure), and protective infrastructure (such as flood control). Overall, developed countries have followed similar investment paths with regards to their municipal water and sanitation construction and the supply of these services. Most have moved to piped water and sewerage networks and eventually developed sophisticated water-treatment technologies. Some countries, such as Japan, took this path quite late in their development; whilst others, such as Nepal, have not kept up with investments and have allowed the situation to go backwards, making it difficult to catch up (Whittington *et al.,* 2013).

In Africa, most cities still have a long way to go to achieving water-security, but have reached the point of prioritising this kind of investment. Some advocate following an alternative development path with non-piped water supply solutions as endpoints, rather than intermediate solutions, with networked supply as the long-term aim. Decisions to follow such a path may result in significant cost savings for governments. In addition to water-supply solutions, investing in flood prevention infrastructure and early-warning systems is also critical in that they help to reduce the risks of disruption to product supply-chains and lost labour time, and therefore shocks to the economy.

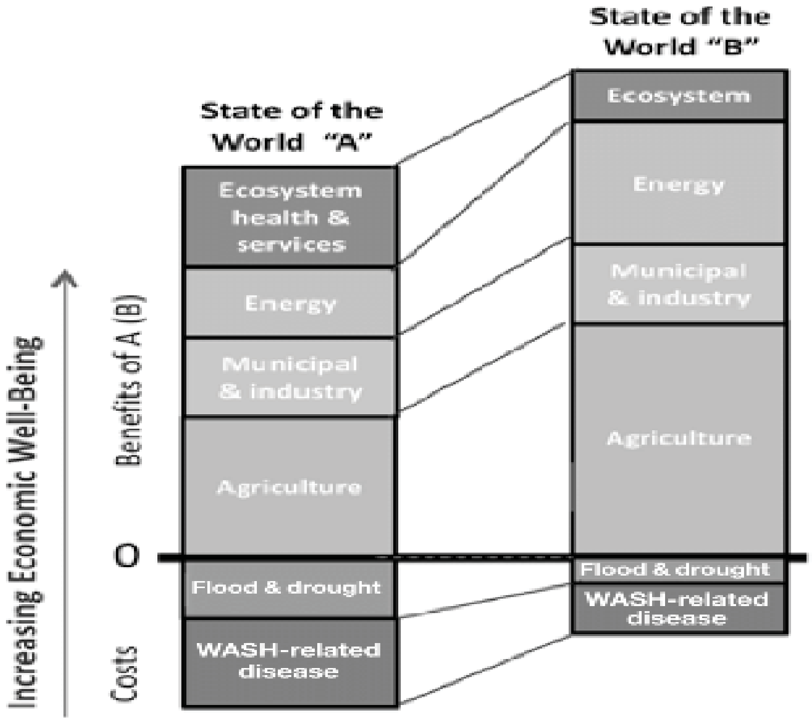
Investing in water-security is not a once-off expenditure but is an ongoing commitment. The observed experience from more developed countries indicates that expenditure on water-security continues indefinitely. For example, in England, expenditure after the initial capital investment in developing water-security infrastructure remains high, and continues to increase over time (Whittington et al., 2013). However, because of the positive linkages with development, the affordability of these investments also increases.

1.3.3 The Purpose of Economic Analysis within a Water-Security Context

Whilst water-security is fundamental for achieving economic growth, the benefits derived are varied and far reaching, making them difficult to quantify and to value. Despite this, there is a clear need to better understand the economic impacts of achieving, or failing to achieve, water-security, as well as what the right level of economic investment is in the pursuit thereof. Economic valuation can help us to prioritise and scale investments, and guide the choice, design and sequencing of investments.

Investigating the potential benefits of investing in water-security usually involves some kind of analysis of the potential costs and benefits of one-or-more sets of interventions, compared with a business-as-usual scenario. Such an analysis would take into account the potential implications of better water-security across a range of sectors, as illustrated in Figure 1.1 below. In this example, benefits are expected across multiple sectors, and risks are reduced, but there is a negative impact on ecosystems, possibly because of the increased abstraction of fresh water. In other cases, there may be a positive impact on ecosystems, i.e. as a result of a reduction in pollution of downstream areas.

[1] GDP is the total monetary or market value of all the finished goods and services produced within a country's borders in a specific time period. As a broad measure of overall domestic production, it functions as a comprehensive scorecard of a given country's economic health. Investopedia.



Sector/Water Event	Description of Change in Economic Well-Being as a result of the policy intervention	Direction of Change in Economic Well-Being from A → B
Ecosystem health and services	Benefits provided by ecosystems decline → loss	- -
Energy	Benefits provided by hydropower increase → gain	+++
Municipal & industry	No change in water to municipalities and industry increases benefits → neutral	0
Agriculture	Increased water for irrigation schemes → gain	++
Flood & drought	Greater water control reduces costs of floods and droughts → gain	+
Wash-related diseases	Improved water quality and sanitation reduces health costs (losses) → gain	++
Total economic value of policy intervention = ∑ sector changes		

Figure 1.1: The Economic (Sectoral) Implications of Investing in Water-Security Infrastructure

Source: Whittington et al. (2013).

1.3.4 Valuation Context is Important

The valuation context refers to the situation in which individuals (and households) and governments find themselves. It relates to the degree to which basic needs are being met (i.e. is there sufficient access to drinking water), or whether people are relatively well-off and water-secure. This is because water has a diminishing marginal utility, i.e. after basic survival needs are met, the next use of water adds slightly less value per unit, and so on.

This context-specific hierarchy of need, ranging from essential needs that must be met to less and non-essential water uses, directly influences valuation. The value of additional units of water is also highly dependent on availability at a particular time and place. Context also determines how we prioritise, initiate and scale investments at regional and national levels. Returns (benefits) on investments (in water-security infrastructure) are known to be very sensitive to location and context, and how costs and benefits change as economies grow needs to be considered.

At the national level, governments need to work towards having a fuller systemic understanding of the development context, particularly as this relates to water-security and the economic costs and benefits of different developments, and who they benefit. Furthermore, they need to understand the costs of delaying projects and costs of inaction of investment decisions.

Opportunity costs, positive and negative externalities (i.e. wastewater discharge), and the potential positive impact on different sectors of the economy, needs to be evaluated. National water-security problems and solutions are likely to involve multiple different sectors of the economy and possibly even neighbouring countries. Governments need to manage and resolve water allocation conflicts between sectors of the economy, and between geographic regions.

1.3.5 Environmental Considerations

Water-security needs to be addressed on multiple fronts. Investments are needed in the development and maintenance of a range of infrastructure, and the design of these structures also needs to be considered, including their environmental impacts and the impact this has on society. This is particularly important in developing countries where poor people depend more directly on the environment and natural resources than other groups in society. These people are usually the first to suffer when ecosystems become degraded, or resources become scarce.

If not properly considered, the environmental and social impacts of such structures can have significant long-term implications for achieving economic growth through the degradation and loss of ecosystems and the goods and services that they provide. Many of the environmental impacts are manageable if adequate measures are taken at both the planning and implementation stage of such developments. Therefore, incorporating environmental costs and benefits into such decision making is essential.

1.3.6 Water-Security Cost-Benefit Analysis

1.3.6.1 Rationale

At the early stages of investment in urban water-security projects, governments are typically faced with a long list of needs, as well as a significant geographic area and population to consider. Comparative analysis of the alternatives is an effective way of determining value and prioritising between different investment strategies and approaches (McKinney, 2003).

CBA is a decision support tool that evaluates the range of costs and benefits of an intervention (or suite of interventions), through the provision of an accounting framework that prescribes what factors need to be considered (costs and benefits), and how to measure and aggregate them. It enables the comparison of different projects or policies in terms of their net-benefits over a specified period of time. Critical measures in making these comparisons include the calculation of the Net Present Value (NPV) of an investment, which is the sum of benefits and costs over time, but with future costs down-weighted using a discount rate (or rate-of-return on an investment) that indicates how well the investment might perform relative to alternative investment options at a known interest rate.

1.4 THE SOUTH AFRICAN EXPERIENCE

The economic and political experiences in South Africa over the past three decades or so do not differ materially from the international situation discussed above. The main difference between South Africa and other developing countries is to be found in the added pressures that the apartheid policy placed on scarce national resources.

Since the 1970s, government expenditure calculated as a percentage of Gross Domestic Product (GDP) rose constantly, reaching high levels of 30%. Due to direct and indirect international economic sanctions, over time, the need for economic self-sufficiency and security forced the South African government to channel a disproportionate amount of resources for government use. This led to large budget deficits, high inflation and declining GDP growth.

The need for some kind of framework and method to evaluate spending priorities on a more rational and systematic basis arose. With the help of the then Office of the Prime Minister’s Economic Advisor, the concept and practice of CBA was steadily promoted for use in state departments with the backing of the Finance Department. In order to facilitate consistency and comparability, the decision was made to compile a manual for CBA. Hence the publication of the first Cost-Benefit Analysis Manual in August 1989 for restricted use in the public sector.

1.5 MAIN FEATURES OF THE COST-BENEFIT ANALYSIS MANUAL

This fourth edition of the CBA manual is again aimed at the decision-maker in the public sector; but can also be used outside of the public sector. Where the public sector planner usually works with concepts and criteria that frequently do not fall under the rigours of the market system, use has to be made of proxies and other substitutes to simulate the workings of the market system in its “perfect” format. This is not easy because the evaluation of projects is often a difficult task since costs and benefits do not occur only once but appear over time in the future.

Furthermore, costs and benefits are often hidden, making them difficult to identify, and they are also frequently difficult to measure. The same problems occur when the decision-maker has to make a choice between a number of mutually-exclusive projects that are intended to achieve the same goal via a number of different routes. These problems are not limited to capital projects; they also occur when decisions have to be made regarding the merits of current expenditure programmes.

The following examples of proposed projects, in a much-abbreviated form, illustrate the difficult tasks facing the decision-maker when applying the principles of CBA.

(i) The Construction of a New Road (Transport)

A new road is proposed. The road will be of benefit to certain landowners/tenants and road users – in the form of savings in vehicle maintenance costs and time – whilst being to the detriment of other landowners or tenants. The construction costs are a further burden to the community. The road will mean air and noise pollution for some, but there is the likelihood that accidents and therefore injuries and deaths will decline. The authority concerned must consider these diverse consequences and decide whether to build the road.

(ii) Flood-Control Irrigation Project (Agriculture)

Consideration is being given to the building of a dam in an area where periodic rains cause great flood damage. The dam can be used for irrigation purposes and will relieve periodic water shortages in neighbouring areas. Besides the high financial cost of constructing the dam, there is a possibility that the proposed dam may silt up rapidly. In addition, a bird sanctuary housing red data species will be flooded once the dam is completed and filled with water. Once again, the decision-maker must consider all the advantages and disadvantages before making a decision.

(iii) A Large-Scale Inoculation Programme (Health)

A large-scale inoculation programme against anthrax is planned. The vaccine is expensive and there are additional costs connected to the remuneration of the medical personnel and the distribution of the vaccine. The programme should reduce mortality, morbidity and the loss of working time. Not only will those inoculated benefit, but also the rest of the community as a whole, because of the reduced risk of infection. However, there is a small risk of serious side-effects after inoculation which may lead to death. The decision-maker must weigh up the potential benefits against the cost and decide whether the programme should be adopted and on what scale.

(iv) Natural Resource Development Restoration

The Working for Water Program (WFW) was a multi-departmental initiative co-ordinated through the Department of Water Affairs & Forestry (DWAF) since 1995. The main aim of WfW is to eradicate invading alien plants from rivers, mountain catchments and other natural areas to improve runoff, conserve biodiversity and improve the productive potential of the land.

Although the initial emphasis of WfW was on water conservation, it has a significant environmental, economic and socio-economic impact felt mainly by very poor rural communities. In many cases, it contributes a significant proportion of the cash income of those communities and has the potential to provide members of the communities with opportunities for investment.

To maximise and to identify the various projects in the WfW Program it is necessary to develop a better understanding of the full economic impact of these projects. Currently the WfW program resides within the Department of Environment, Forestry and Fisheries (DEFF) A CBA model has been developed to calculate the economic costs and benefits at a project or quaternary catchment level. To capture the cost and the benefits of a specific project on a structured way the model has been developed in various components:

- Clearing of alien plants;
- Use of natural vegetation;
- Development of small secondary industries;
- Additional water supply and costs;
- Veld fire management; and
- Training to improve the quality of life, including improved earning potential for the local communities.

The above projects differ widely in terms of objectives but demonstrate the important principle that every project provides benefits for the community, or some groups in the community; but, at the same time, involves disadvantages or costs for the community, or some groups in the community. It is the task of the decision-maker in the public sector to weigh up the benefits against the costs in order to decide whether a project will have a net benefit for the relevant community. The CBA method (also known as benefit-cost analysis) provides a logical framework and other means by which projects such as those above can be evaluated, thereby serving as an aid in the decision-making process.

1.6 STRUCTURE OF THE COST-BENEFIT ANALYSIS MANUAL

The compilers of the CBA Manual do not claim that it is the ultimate authority on CBA in South Africa. It should be noted that both the theory and the evaluation systems are in the process of evolutionary development and, as such, are subject to further refinement. Notwithstanding this evolutionary process, the structure is sufficiently developed to enable one to look sceptically upon anyone who wishes to deviate from the basic principles of CBA.

Recent international and local experience has shown that criticism of CBA is only admissible if it can be demonstrated that alternative prescriptive procedures are in some way superior – which in reality could not yet be proven. As a result, any person or institution wishing to use alternative approaches or variations should bear the burden of proof and persuasion for any deviations made.

This is the basic point of departure pertaining to this fourth edition of the CBA Manual. However, it is accepted that in many situations in the world, and also in South Africa, the scope of CBA probably needs to be widened somewhat to include the broader social costs and benefits derived from a project.

As a result of demand from users of previous editions of this manual, it was decided that a greater emphasis would be placed on a more in-depth description and evaluation of the basic economic theory and principles underlying CBA. Chapter 2 of this manual presents the theory of CBA as a sub-section of general classical economic theory in more detail, including the fact that CBA has some shortcomings. A specific section of Chapter 2 is devoted to other possible project evaluation methods such as multi-criteria analysis for decision making (MCDA).

In addition, Chapter 3 discusses how the “standard” cost-benefit practices and procedures contained in this manual can be extended to include, for example, the income-distribution and welfare effects of a specific project. This chapter also demonstrates how the advent of modern analytical models, such as the Input-Output, Social Accounting Matrices (SAMs) and Computable General Equilibrium (CGE) models can be used in support of CBA.

An important aim of this CBA Manual is to provide the decision-maker with practical guidelines and procedures for applying the CBA methodology. Based on experience with CBA analysis over the past 20 years by various development agencies such as the Development Bank of Southern Africa, the Sector Education and Training Authority (SETA) programs of the Department of Labour, and the experiences of the Department of Water and Sanitation (DWS) and the WRC, the proposed standard procedures for the application of CBA are given in Chapter 5. These proposed steps and procedures are of a generic nature and will have a general applicability to all kinds of projects (capital and recurrent).

Another aim of this manual is to provide the user with an extensive and up to date data-bank of shadow and surrogate prices in South Africa, which is presented in Chapter 6, with a baseline year of 2020.

Having regard for the fact that, over the past number of years, CBA has found extensive applications in the field of water development, Chapter 8 of this manual is devoted to this topic. Important issues such as the opportunity cost of water and a method for calculating the economic (opportunity cost) value of water are discussed in this chapter, whilst Chapter9 provides an explanation of the environmental considerations and the importance of the role of the ecological infrastructure in water-security.

As part of this CBA Manual, eight examples of the practical application of CBA in South Africa are presented for a wide variety of projects. These examples are the outcome of the use of the theory, principles, procedures and data bases for CBA discussed in this manual. These examples, and a dynamic computer model for calculating shadow prices for various capital and operational costs are for download from the WRC separately from this CBA manual.

CHAPTER 2: POLICY OBJECTIVES AND THE UTILITY, NATURE, APPLICATIONS AND LIMITATIONS OF COST-BENEFIT ANALYSIS

2.1 THEORETICAL FOUNDATIONS OF COST-BENEFIT ANALYSIS

2.1.1 Background

The origin of the basic theory and principles behind the practice of Cost-Benefit Analysis (CBA) dates back to the middle of the nineteenth century. The idea of measuring the net advantages of a capital investment project in terms of society's net utility gains (welfare economics) originated with (Dupuit, 1844, 1849b) well-known publication in 1844[2]. He started to develop his definition of what is now called consumers' surplus (i.e. the willingness to pay for a good or service over and above its market prices) as a measure of the net welfare gained from a project. This aspect of the definition of net social benefit is fundamental to CBA, and is extended to instances where persons who are not direct beneficiaries of a project obtain some form of spill over benefit. Accordingly, the measurement of net social benefits requires the estimation of all the consumers' surpluses to whoever they accrue.

According to (Boardman et al., 1996) CBA can be thought of as providing a protocol to measure allocative efficiency in the economy. This approach is based on the work of the famous Pareto, who formulated the Pareto optimum condition viz: "An allocation of goods is Pareto efficient if no alternative allocation can make at least one person better off without making anyone worse off"[3].

There is a direct relationship between net benefits and the Pareto efficiency. As long as all impacts are valued in terms of the willingness-to-pay concept and all required inputs in terms of opportunity costs, then the sign (positive or negative) of the net benefits indicates whether or not it would be possible to compensate those who bear costs sufficiently so that no one is made worse off. Positive net benefits indicate the potential for compensation to make the policy Pareto efficient; negative net benefits indicate the absence of this potential.

This state of affairs is sometimes also referred to as the Kaldor-Hicks criterion[4]. Important pre-conditions are that gainers must be able to compensate losers and still be better off.

2.1.2 The Function of Profits

Based on the classical theory of economics (including welfare economics), which has as its main underpinnings perfect free-market conditions with the rule of laissez-fair, profits (must) measure the gain which society derives from investment. Profits also serve as an essential signalling mechanism for guiding investment decisions. CBA in its traditional format does assume that actual receipts (benefits) adequately measure social benefits and actual expenditure measures social costs.

The traditional approach to CBA assumes that if the private capital markets in a country were perfect and if there were no taxes or subsidies at the margin on profits and income, the market interest rate would be the appropriate rate for discounting future costs and benefits. If the Economic Rate of Return (ERR) on

[2] Dupuit J. "On the Management of the Utility of Public Works" 1844. Translated from the French, in International Economic Papers, no.2 (London 1952).
[3] Boardman et al., pp 29.
[4] Sassone PG & Schaffer WA. CBA, A Handbook: Academic Press; New York 1978, p 9.

investments equals that of market interest rates, the balance between investment and consumption at any point in time would be correct; that is, the economy would be on its optimal growth path.

If the economy was on an optimal growth path, then the objective function for the National Income, i.e. (Y) can be stated in terms of the maximisation of the sum of aggregate consumption (C) and investment (I) that is national income, at any point in time. Thus, maximum social benefit is simply C + I, given that changes in C are equally as valuable as changes in I. Those who use the traditional approach usually talk, not about consumption effects but about national income effects. There is no difference as long as investment is equally as valuable as present consumption at the margin – Social Rate of Return therefore equates to the ERR. This also implies a "fair" distribution of income and wealth between the population and income groups [Equity = Efficiency].

2.1.3 The Use of Shadow Prices

In the real world, because market imperfections such as tariffs, quotas and monopolies create distortions in demand and supply, there is little chance that the market price will reflect the true economic value and cost of inputs and outputs.

To rectify this situation in order to demonstrate the real measure of efficiency with which the economy utilises its scarce resources does require adjustments to the current prices of services and commodities. These adjusted prices are referred to as shadow prices.

2.1.4 The Situation in Developing Countries

The traditional approach to CBA discussed in the previous section, even adjusted for shadow prices, is mainly aimed at determining the economic (efficient) rate of return of a specific project. For in practice, due to market distortions, the Financial Rate of Return (FRR) of a private investment project, usually differs from the ERR. Put in another way, the FRR is not necessarily a true reflection of the most efficient utilisation of scarce resources.

One of the main criticisms against the traditional approach to CBA is that even if shadow prices are used, the impact on wealth and income distribution is neglected. [We must remember that the traditional Pareto principles use as departure point full employment and equilibrium in all markets at the margin]. For example, a 2% rate of growth with an even distribution of benefits is hardly the same as a 2% rate of growth with a highly uneven distribution. Trade-offs between growth and distribution pose important policy choices that cannot be dismissed by putting forward "trickle-down" or similar theories of the development process.

Much of the recent published work on growth and development has criticised the social valuation implicit in the traditional approach. This has led to the development of a new approach that is quite open-ended in its social valuation. This new approach does not compel one to reject the traditional view, but allows the use of different judgements. Decision-makers can use it as a flexible tool – for example, to place a greater weight on investments than implied by the traditional approach or to incorporate the objective of redressing poverty and economic inequality. This new approach has been called "social" to distinguish it from the traditional or so-called efficiency approach.

If different fundamental objectives are selected, the valuation of benefits and costs will also differ. The shadow prices used in the new approach are often called social prices to distinguish them from the shadow prices used in the traditional approach, which are correspondingly called efficiency prices. To illustrate, the efficiency shadow wage rate will be the marginal product of labour in certain cases. The social shadow wage rate may differ, however. If the employment of an additional unit of labour in the project would increase labour income, then the social shadow wage rate would reflect, in addition to the effect on output, both the benefit of that increased income in redressing poverty and the cost of any reduced savings and reinvestment. The main objective of the "new" approach is to bring the ERR as close as possible to the Social Rate of Return.

2.2 CBA IN RELATION TO OTHER DECISION-MAKING SUPPORT TOOLS

2.2.1 Economic impact analysis

Whereas CBA is concerned exclusively with comparisons of direct benefits and costs to society created by an investment project, economic impact analysis examines the distribution of many secondary economic impacts and outcomes that traditionally fall outside the scope of CBA. An economic impact analysis does this by studying changes occurring across broadly defined sectors of the economy. The intent is to ascertain who gains and who loses as a result of the project, and by how much.

The types of impacts and outcomes addressed in an economic impact analysis coincide, to a certain extent, with those considered in any macroeconomic analysis. These impacts represent indirect effects on markets, rather than direct shifts in consumer or producer surpluses that are the focus of CBA. Nonetheless, these effects may have significant implications on how particular groups fare as a result of a particular project. Major categories of potential economic impacts are described below:

- Changes in economic growth and productivity: Negative impacts on regional or national productivity and economic growth can result if an investment project creates significant opportunity costs, such as the "crowding out" of investments. Alternatively, new outputs may improve the overall productivity of capital.
- Price impacts: large projects may create a significant supply of outputs that may in turn stimulate shifts in supply or demand for related goods. During the operational life of a project for example, irrigation water supplied by a dam may affect markets and prices for substitutes (such as water conservation equipment) and, for example, equipment for higher-value irrigated crops.
- Production and employment impacts: When a project's construction requires significant capital, workers and construction materials, this may create shortages in related markets for labour and other factors of production (i.e. land, capital).
- Changes in government revenues and expenditures: If a project is financed with public funds, this may require large fiscal outlays by the government that may in turn have repercussions on the money supply, inflation, and government indebtedness. Conversely, a project located in a depressed area may boost regional economies (through household and business incomes) and generate higher tax revenues for the government.
- International trade and competitiveness impacts: If a project is large enough to increase productivity and lower the cost of production at a national level, a country's exchange rate, export position, balance of payments, and international competitiveness may improve.

2.2.2 General Equilibrium Approaches

Several analytical economic tools are available to assess "ripple" (secondary and tertiary market) effects on the economy of the region or country. These tools, known as "general equilibrium" models, attempt to capture the interactions of a project's direct and indirect impacts throughout the economy.

Three general equilibrium approaches for assessing macroeconomic effects follow below:

Input-Output (I-O) Models. These models characterise the interdependence of sectors within an economy by generating data on multipliers and leakages. Multipliers show that the impact of a particular sector on the regional/national economy (in terms of some of the above criteria) is larger than the value/volume associated solely with that sector's output. Leakages indicate where economic impacts, such as project revenues, move ("leak") from one region or economy to another.

Social Accounting Matrices (SAMs). SAMs use a mathematically based matrix presentation to represent the flow of funds linked to demand, production and income within a national or regional economy. SAMs can be designed with a special emphasis on social rather than economic attributes (i.e. low income households) and, thereby, also provide information about equity and distribution issues. SAMs can be regarded as an extension of I-O models.

Computable General Equilibrium (CGE) Models. CGE models incorporate more realistic descriptions of consumer and producer behaviour than do I-O models and SAMs, by accounting for reactions to changes in market conditions (i.e. price). Yet their detailed breakdown of industries and commodities and regions are usually limited in order to achieve a workable model solution by approximation.

It is important to remember that CBA is not designed to evaluate macroeconomic performance. As noted earlier where standard assumptions regarding CBA, such as full employment of resources are non-existent, measuring the secondary effects may be admissible as additional welfare indicators. In this regard, projects that have regional development goals in rural areas of developing countries where underemployment may exist may wish to consider the wider economic impacts of the projects. Of course, as the objective of the project – i.e. regional development – has an inherent distributional objective, models for the evaluation of regional impacts should be considered as a tool in project planning, monitoring and evaluation in any event. [This aspect will be dealt with in more detail in Chapter 3].

2.2.3 Multi-Criteria Decision Analysis

Another analytical instrument for project evaluation is Multi-Criteria Decision Analysis (MCDA). MCDA aims to take into account multiple criteria to arrive at a scientific conclusion on the impact of the proposed project or program on various aspects of society. MCDA allows for the application of both quantitative and qualitative criteria. Consequently, the types of key issues which are to be considered at a project or program level are not restricted by requiring monetary values.

In many policy decision-making settings, there is a requirement (and practicality) to prepare supplementary assessments that are either 'stand-alone' or used in conjunction with CBA. This is particularly the case where hard-to-quantify factors need to 'captured' as part of the advice to policy makers.

In order to overcome the view (put forward by some commentators and academics, for example) that CBA relies heavily on monetary valuations and the alleged omission of factors for which money valuations are difficult or impossible, the use of multi-criteria analysis (MCDA) as supplementary (as opposed to an alternative) is often adopted. The MCDA approach is often used as a supplementary measure to CBA to examine qualitative values when assessing significant change proposals or investment decisions. There would not be any real necessity to contemplate using MCDA where it is obvious that the vast majority of costs and benefits of a proposal have been satisfactorily identified, quantified and monetised.

As touched upon in theoretical section above (par 2.1) theoretical origin of CBA is based on Neo-Classical economic theory. Criticism against this theory and method of determining the welfare impacts of a project is mainly directed at the fact that CBA attempts to achieve efficiency by mimicking a perfectly competitive market. Maximising efficiency does not necessarily promote equity and sustainability. By introducing the use of income distribution weights in CBA, the issue is addressed to some extent.

On the other hand, the MCDA does not limit the number and nature of objectives and criteria. According to a WRC Report on MCDA, trade-offs between different stakeholders and criteria are a focus of attention[5]. In contrast with CBA, the gains to one group of stakeholders are not assumed to compensate for losses to another stakeholder groups.

The World Commission on DAMS (WCD) also advocates the use of MDCA as an alternative approach to a decision support system exclusively based on CBA[6]. In this regard the WCD "recognises that projects often have multiple objectives and not simply economic welfare maximisation. Experience to date with these multi-criteria approaches suggest that whilst economic criteria remain important, these decision frameworks have the benefit of allowing disaggregated information on social and environmental impacts to enter directly into the decision analysis. Such decision support systems appear particularly appropriate and useful in the case of large dams when implemented within a participatory, transparent multi-stakeholder approach.

It is not the intention of this report to present an extensive comparison between the main features of the CBA vs. MCDA. Suffice to say at this stage is that both methods have their merits and demerits depending on the nature of the project involved and circumstantial characteristics. Based on evidence up to date, there is no way that the one method could profess superiority over the other and should absolutely exclude one another. There is in any case a large degree of overlapping between the two methods/approaches. (See: Stewart et al., 1997).

2.2.4 Cost-Benefit Analysis as Opposed to Cost Effectiveness Analysis

The key question to determine whether a cost-benefit or cost-effectiveness analysis (CEA) is used is: *Can any of the Major Benefits or Savings of the Proposed Project be quantified?*

If the answer is 'yes', then the evaluation should be a CBA. Only when the major benefits or savings of the proposed project cannot be quantified, should a CEA be considered. The major difference between CEA and CBA is that, in CEA, the major benefits cannot be valued in dollar terms but only identified and quantified in physical terms. A CEA essentially compares projects and/or options in terms of their effectiveness and their cost.

2.3 THE NEED FOR AND USEFULNESS OF CBA IN THE PUBLIC SECTOR

2.3.1 Background

The limited economic means and boundless needs inevitably forces government to rational decision-making in the provision of collective goods and services by spending limited funds in such a way that they more or less reflect the likes and dislikes over and above the financial acceptability of the project. CBA is a technique which can be used to determine the relative merits of alternative projects in order to reach a high degree of

[5] Stewart JT. et al. Tlou; Multiple Criteria Decision Analysis: Procedures for Consensus Seeking in Natural Resource Management – WRC Report No. 512/1/97.
[6] World Commission on Dams (WCD), Dams and Development; A new framework for decision-making, 2000. P 182.

economic efficiency in the application of funds. It is ideally suited to the evaluation of capital projects, i.e. projects that require immediate capital expenditure but which only realise net benefits over time. CBA can also be applied to current programmes, i.e. projects that require minimal initial capital expenditure but involve costs incurred over the entire analysis period. The inoculation programme referred to in the introduction is an example of such a programme.

The efficient allocation of scarce resources should be one of the primary objectives of the public sector in its entirety. By the public sector is meant all spheres of government, i.e. central, provincial and local government as well as public corporations, i.e. parastatals. Where the State is involved in large investment projects in the private sector, it is desirable to carry out cost-benefit studies because relatively large projects can influence the economic structure and price levels, as well as the environment, or they can cause externalities in the form of additional non-allocable costs to the community.

It is also possible that large investment projects in the private sector, particularly of an infrastructural nature, could result in certain social benefits, on the grounds of which the private sector can expect the co-operation of the State. Against this background it is clear that CBA techniques have a potentially wide scope of application in the public sector. It is important therefore, that, as far as possible, a uniform set of guidelines (or principles) should be laid down for CBA in this sector and that all the institutions concerned should adopt them. If this consensus is not achieved, the comparison of results becomes more difficult and there is increased arbitrariness in the choice between projects, with the result that an overall efficient allocation of resources cannot be achieved.

2.3.2 Policy Objectives

In many ways public sector projects form the vehicle by which governments pursue their policy goals and express their priorities. The following fundamental considerations are at stake here.

2.3.2.1 Present and Future Consumption

An important objective of economic policy is the improvement of living standards, which implies the increased consumption of goods and services. As a result of the scarcity of economic resources, current consumption competes with future consumption, and the policy-maker should, implicitly or explicitly, weigh current consumption against consumption at every stage in the future.

Where the government emphasises current consumption, the situation will probably be characterised by relatively low tax rates and low levels of saving and investment. Should the premium be placed on deferred consumption, the opposite will most likely occur. Naturally, it is politically difficult to persuade the public to defer consumption because this is normally associated with unpopular policy measures such as higher taxation.

It is possible for a project to influence current and future consumption patterns. It can serve as a tool to encourage savings when relatively capital-intensive projects (which contribute to savings via profits and depreciation allowances) are undertaken – this is in contrast with labour-intensive projects, where the relatively higher wage payments are usually channelled to consumption. Capital-intensive projects therefore tend to discourage short-term consumption and employment, whilst encouraging savings and therefore growth and potential future consumption.

The value that a given community attaches to present versus future consumption is calculated in CBA through the use of what is called a social discount rate. This rate is discussed in detail in Chapter 3.

2.3.2.2 Division of Consumption between Contemporaries

A further important objective of economic policy is that of equity. In this case it is necessary for the planner to allocate weights to the value that consumption has for different individuals, normally grouped into certain income-groups and/or regions. These weights can be derived from the principles underlying the policy and do not necessarily have to be quantified. For example, progressive taxation systems reflect the greater weight that the planner assigns to the lower-income groups relative to the higher-income groups.

A project can serve as an instrument of income distribution in that both the geographical situation and the labour-intensity of the project are related to the redistribution possibilities of the project. In studying the distributive aspects of a project, the first problem is to determine the net benefit of a project by geographical region. Thereafter weights are assigned to the consumption that is generated in different regions, with the aim of valuing the consumption generated in poorer areas higher than that in more affluent areas. Project choices also have an influence on income distribution in that projects that depend heavily on labour (relative to capital) promote the redistribution of income over the short term.

2.3.2.3 Secondary objectives

In addition to the above-mentioned two primary objectives, there are secondary objectives which are reflected either explicitly or implicitly in a project choice.

(i) One such objective is the creation of employment opportunities, which is often seen as an objective on its own, but is essentially a derivative of the goal of equity, since it promotes the division of consumption between contemporaries. To the extent that the creation of job opportunities goes hand in hand with political stability, such an objective has an independent right of existence.

(ii) A further objective is the achievement of economic independence with respect to certain goods or natural resources obtained from overseas. This is particularly important where the foreign supply is unstable or where it is possible that such supply could be completely cut off.

(iii) The acquisition of power and prestige is another objective which may influence project choices without consumption considerations being taken into account. In such circumstances it is particularly important for CBA to be applied so that the price which is paid for such projects in terms of the general standard of living is not hidden.

The decision-maker must therefore in any CBA consider a mixture of objectives, some of which may be contradictory. Dealing with the situation analytically is not easy, but the decision-maker should attach conceptual weights, be it implicitly or explicitly, to the different objectives involved in the optimisation.

2.4 ANALYTICAL FRAMEWORK OF CBA

2.4.1 The Nature of Cost-Benefit Analysis

The methodology set out in this document provides guidance in performing CBA (CBA) which is to be used for economic evaluations of water-related projects and other investment proposals. Although the initial impetus for the preparation of the methodology was water-related projects, this document has been drafted in such a way as to make the methodology a suitable framework in which to assess the economic merits of any investment proposal or policy change undertaken by planners and decision-makers.

When a private institution evaluates the merits of different investment options, the first step is to ensure that all the projects are feasible at the technical level. After this, the firm applies capital budgeting techniques to ensure that the project will be financially profitable, in other words that it will contribute to increasing the net value of the business. The net value is the surplus of assets over liabilities as reflected in the balance sheet of the firm. In order to contribute to the net value of the firm, it is necessary for the project to be profitable, and the firm will therefore discount the expected stream of profits and/or losses to the present time in order to determine the effect on the net value.

In the public sector (with the exception of the government business enterprises and public corporations which at least have to break even) profit is not the main objective. A variety of financial analyses can, however, be carried out in the place of profit determination. One of these, for example, amounts to an analysis of the source and application of productive resources valued at market prices with the aim of determining whether the use of the limited resources is efficient. Since the objectives of the processes of profit determination and of the analysis of the source and application of funds differ, there are important differences between the two methods of analysis (See Section 1.5).

In the first place, with profit determination, depreciation is accounted for by the systematic write-off method because it reduces gross profit, whilst in the case of the source and application of funds, depreciation is not taken into account, since it affects both the source and application of funds. Secondly, income tax is included in profit determination but excluded from the determination of the source and application of funds since it does not directly contribute to a more effective or less effective application of funds. In the third place, interest payments are included in profit determination but excluded from the analysis of the source and application of funds because these do not influence the conversion of inputs into outputs, and can therefore be considered merely as a transfer payment.

There are a number of aspects, however, which are considered neither in profit determination nor in the analysis of the source and application of funds, such as the determination of the actual scarcity value of inputs and outputs and the measurement of intangible advantages and disadvantages. For this it is necessary to carry out a complete economic analysis.

However, a comprehensive economic analysis should include the following:

- As a starting point it is necessary to do a financial analysis reflecting the profitability of the relevant project at market prices. It should be noted that the financial analysis can, depending on the context in which it is used, refer to one or more accounting techniques, i.e. cash-flow analysis, profit determination, or the analysis of the source and application of funds. “Financial analysis” as used in this manual refers to an analysis at market prices from which present and future expenditure and income is calculated to determine the financial feasibility of a project.
- The economic analysis, to determine the real scarcity value of goods and services used in the project and arising from the project; this is mainly based on opportunity-cost considerations; and
- The social analysis, which is an investigation into the effect of the project on the distribution of welfare and other social aspects.

This manual focuses mainly on the economic and social analysis. The financial analysis in the broader sense is used as a fairly standard practice in the public and private sectors and this manual therefore does not expand thereon.

2.4.2 Financial Analysis

In the case of financial analysis, calculations are performed using either current or constant prices. In the case of public projects, financial analysis in current prices provides an indication of the pressure the project will place on the exchequer and the degree of subsidisation it will require.

2.4.3 Economic Analysis

In the case of economic analysis, projects of re-evaluated at prices that reflect the relative scarcity of inputs and outputs. Economic analysis normally follows an analysis of the source and application of productive funds, which is done at market prices that represent opportunity costs, and reflect the actual economic value of inputs and outputs. The opportunity cost is the value of the best alternative application of an input or an output of the project. The market price of land, for example, does not necessarily reflect the opportunity cost of the land. As such, when a price has to be determined for a piece of agricultural land used for maize farming but on which an airport is planned, the opportunity cost of the land is the discounted net output from the maize. The uses and calculation of shadow prices as a substitute for market prices are set out in more detail in Chapter 3.

2.4.4 Social Analysis

Social analysis determines the consequences of a project for the distribution of welfare in a community where an evaluation can be made of the effects on social factors such as security, equity and the aesthetic values of the community. This aspect will be discussed later (See Section 3.4) for more detail.

2.5 THE DIFFERENCES BETWEEN COST-BENEFIT ANALYSIS IN THE PUBLIC SECTOR AND PROFIT DETERMINATION IN THE PRIVATE SECTOR

Important differences exist between CBA in the public sector and profit determination in the private sector. The first difference is to be found in the fact that private enterprise is concerned only with the interests of its owners or shareholders when profits are being calculated, whilst the interests of the community are the focus of CBA in the public sector where a much wider spectrum of costs and benefits have to be considered than in the case of pure profit determination. For example, a new transport system that is less expensive and provides more comfortable transport for a part of the population, but entails environmental costs in the form of air and noise pollution. The latter aspects would be ignored in the determination of profits in the private sector, but will be taken into account in a CBA as part of the costs that the community must bear.

In the second place, CBA differs from pure profit determination in that all variables in the latter case are measured in terms of market prices, whilst the economic and/or social benefits in the former case are often provided at subsidised prices so that the market prices of inputs and outputs, where they exist, often do not reflect the actual economic and/or opportunity costs and benefits. Because CBA depends on the use of opportunity costs, market prices have to be adjusted to reflect the actual economic value of costs and benefits.

The third important difference between CBA and the determination of profits as applied in the private sector is the interest rate used in the discounting process. Whilst the discount rate used in private sector profit determination is a market related rate that reflects the cost of funds, uncertainties and risk; the discount rate used in CBA represents the time preference of the community, and is referred to as the social time-preference rate.

The most important differences between CBA as practised in the public sector and profit determination in the private sector are summarised in Table 2.1 below.

Table 2.1: The Main Differences between Cost-Benefit Analysis in the Public Sector and Profit Determination in the Private Sector

		CBA	Profit Determination
1.	From the point of view of	**Community**	**Shareholders**
2.	Goal	**Apply scarce resources effectively and efficiently**	**Maximise net value of firm**
3.	Discount rate	**Social time-preference rate**	**Market rate or weighted marginal cost of capital plus uncertainty and risk premium**
4.	Value unit	**Opportunity cost**	**Market price**
5.	Dimensions	**All aspects necessary for a rational decision**	**Limited to aspects of decision-making that may affect profits**
6.	“Advantages”	**Additional goods, services, products, income and/or cost savings**	**Money income**
7.	“Disadvantages”	**Opportunity costs in terms of goods and services foregone.**	**Money payments and depreciation calculated according to accounting principles (GAAP)**

2.5.1 Constant vs. Current Prices

Using constant prices to value the economic effects of a project is usually sufficient for decision making where the basic decision is whether to invest in a project or not. The alternative is to assign the scarce investment resources to other more lucrative investment possibilities. Moreover, it is necessary for resources to be valued at present economic prices to reflect their values for different uses or opportunities at the time when the investment decision is made.

If constant present prices are used throughout the project analysis – for future years as well as the initial year – then resources will be consistently valued at prices reflecting their value in alternative uses. Future economic developments will then be valued in the same unit prices as in present times. The use of constant prices is relevant both to capital from a national point of view and equity capital in particular. From both points of view the basic question to answer is: is the project worthwhile.

Another price adjustment that is required is to provide for changes in relative prices over the life span of a project. It is possible that prices of certain commodities or services will rise or fall relative to others pertinent to the project. For example, it may be foreseen that the prices of energy inputs will rise relative to the present prices for outputs and other inputs; or it may be foreseen that the price of an agricultural output such as rice may fall relative to the present prices of other intermediate inputs, including labour. Where a particular price is expected to change in real terms, that is, relative to other items in the project statement, then the constant price analysis can be adjusted for this relative price change as it will affect the feasibility of the project.

2.6 THE USES AND LIMITATIONS OF COST-BENEFIT ANALYSIS

It has already been noted that CBA is aimed at evaluating the costs and benefits of alternative investment projects or programme expenditures on a comparable basis, especially through the use of a common measuring instrument, namely prices that are determined on a consistent basis. In this way, the problem of choice is simplified since qualitative arguments for or against a certain project are backed up by numerical criteria.

The main problems with CBA arise from the question of quantification. These aspects are discussed in more detail in later chapters (refer also to the theoretical discussion of CBA, Section 2.1). The following aspects among others should be kept in mind when using CBA:

(i) CBA in reality constitutes a particular conceptual framework viewed as a model that represents a simplified version of reality that can be dealt with in an analytical way. Through the application of the conceptual framework the policy-maker is forced to think through the full repercussions of the expenditure decision. This prevents people from misunderstanding each other and, thus, increases the effectiveness of joint decision-making, even if no formal analysis is done.

(ii) CBA attempts to bring about a more effective distribution of resources based on Pareto optimality, which indicates that at least one person in the community is better off whilst no one is worse off. A necessary prerequisite here is that the social benefits of the proposed project should exceed the social cost. The central role that the Pareto principal plays ensures that CBA is aimed at distributional effectiveness, and that a given aim is achieved with the application of the minimal resources possible in cost-effectiveness studies. Attempts to find a single criterion that covers all the essential aspects of importance in a decision on a project have not been very successful. Where possible, therefore, the Pareto criterion must continue to be supplemented with additional criteria and additional analyses. These include performance auditing, utility studies, impact studies, operational research, systems analysis, organisational analysis, econometric studies, sensitivity analysis, etc.

(iii) In general, CBA is aimed at decision-making in respect of projects to be undertaken in the future and, as such, involves assumptions and projections regarding future developments. This means that a boundary of uncertainty will exist. It is therefore desirable that CBA should be supplemented by the analysis of risk and uncertainty, as well as related information.

(iv) The specific criteria used to rank alternative projects should be supplemented with sensitivity analysis to show the effect of possible alterations in selected parameters.

(v) CBA is not equally suitable for all projects and, therefore, it is necessary to clarify the types of expenditure programmes (current and capital) where CBA can be performed. Many experts believe that CBA is particularly useful in the fields of agriculture, infrastructure and industrial development; however, the latest studies indicate that it can be applied to almost any field. In those fields where CBA is not readily applicable, there is a need for cost-effectiveness analyses so that the decision-maker can be sure that objectives are achieved with the use of minimal resources. Even with the field of application clearly described, the information that the analysis provides is not always sufficient for the decision that has to be made in the public sector. This is because different national economic objectives of a strategic or political nature will not necessarily always be reconcilable.

In any CBA, the ranking of alternative projects or programmes according to certain criteria must be supplemented with the results of all other analyses, apart from economic and social analyses, and all of these must, as far as possible, be quantitatively evaluated. In addition, qualitative analyses should be undertaken where quantification is not possible. All the impacts and consequences of a project should be pointed out in sufficient detail to promote “optimal” decisions concerning the project.

(i) Unfortunately, there are differences of opinion amongst experts concerning the way in which certain aspects should be dealt with in CBA, i.e. shadow prices and the social discount rate. As mentioned, the aim of this manual is therefore to bring about, as far as possible, a uniformity of approach and method between institutions in the public sector, given all of the underlying limitations.

(ii) An important aspect of the application of CBA is that the secondary economic impacts of projects under review outside the immediate sphere of influence of the project (i.e. factors such as consequences for the balance of payments or potential for employment creation) are omitted, or evaluated independently. In cases where such limitations apply to the field of influence, reference is made to CBA on the grounds of partial equilibrium analysis. If, however, the evaluation of the consequences is significant for price levels, production or large parts of the economy that lie outside the fields directly affected, this requires general equilibrium analysis using econometric models, I-O models and semi-input-output models.

(iii) It must be emphasised that reliable statistics are very important for the implementation of a CBA system. Specific aspects will be spelt out in detail in later chapters.

(iv) It is generally recognised that errors may arise in CBA studies. According to Boardman[7], one must guard against self-interest when conducting a CBA. There is considerable evidence that people systematically overestimate benefits and underestimate costs. It can therefore be more useful to make use of independent analysts to counter this type of bias.

From the discussion above it is clear that the methodology and application of CBA requires not only technical skill, but also broad knowledge, profound insight and a clear-headed approach to problem solving. It is particularly important that the key aspects that are essential to the reaching of sound decisions should be separated from secondary information, of which note should also be taken. Exceptional expert knowledge, insight and experience are therefore required for the successful application of the technique, along with complementary methodologies. In spite of the limitations mentioned, no other evaluation method provides more satisfactory results than CBA.

[7] Boardman, Greenberg, et al. Ibid Chapter 15.

CHAPTER 3: DETERMINATION OF VALUES IN COST-BENEFIT ANALYSIS

This chapter discusses important principles and criteria relating to the calculation of values in CBA. This includes some observations regarding scarce resources that can be used for the achievement of economic objectives, and the prices of such resources.

3.1 PRICES IN COST-BENEFIT ANALYSIS

Since resources are always limited, an important consideration in their application is to find optimal combinations of resources through which the net community benefit can be maximised. The values of inputs and outputs depend to a large degree on the level of development of the economy in which prices are determined. Market prices of products and services often do not reflect the real value (scarcity value) of products and services since governments interfere in the operation of product and services markets through, for example, tariff protection, taxes or subsidies[8]. Therefore, to assess the economic effectiveness of the application of resources within projects, it is essential that the prices of inputs and outputs indicate their economic scarcity value.

Scarce resources are traded at specific prices, namely market prices. Provided certain conditions are met, market prices are the best criteria upon which the allocation of resources for specific uses can be based. The assumption is that markets are perfectly competitive, and that supply and demand determines the prices of inputs and outputs. When the free operation of the markets is interfered with, by for example the restriction or stimulation of either supply or demand or by price interference, market prices do not reflect economic scarcity values and the use of shadow prices becomes necessary.

3.1.1 Terminology

To prevent possible confusion, it is necessary to describe the definition of shadow prices. The literature on CBA contains different interpretations of “shadow prices” and “accounting prices”. Therefore, key terminology related to shadow prices is defined below. Although the terminology used may possibly not coincide with that which the reader is familiar with, it is important to ensure uniformity in concepts for the purpose of this manual.

3.1.1.1 Price Year

The price year in an economic evaluation is the year in which the value of all costs and benefits are expressed. That is, the Rand units represent the same purchasing power.

3.1.1.2 Selection of the Base Year

The base year is the year to which costs and benefits are discounted to arrive at a present value (PV). The base year affects the magnitude of the reported results, with an earlier base year resulting in lower magnitude of results. When undertaking project evaluations, it is preferable to discount to the base year in which the decision to proceed will actually be made so that PV means just that.

[8] There are other factors that also impede the free workings of the market mechanism. For example, the presence of monopolistic tendencies in industries.

The base year is usually the same as the price year. Generally, the base year and the price year should be the year in which the evaluation is conducted. The base year must be common to all alternatives being considered.

3.1.1.3 Treatment of Inflation and Interest Rates

It is important that the effects of inflation do not distort the cost and benefit streams. Inflation causes the costs and benefits that occur later in the evaluation period to appear higher than they should. This causes bias towards projects with later benefits.

Inflation does not increase the real value of costs and benefits; it only increases their monetary value. As such, the monetary value of costs and benefits should be expressed in ‘real terms’ at the general price level prevailing in the year the evaluation is conducted. Therefore, only Real or Constant Prices – prices net of inflation – are used in CBA. Furthermore, interest payments should be excluded from the evaluation because they are implicitly reflected in the discounting process.

3.1.1.4 Relative Prices

It is possible (even likely) that the prices of different inputs used in a project may not move at the same rate, resulting in relative price changes. The expected relative price change can be accounted for directly.

If there is good reason to believe that an input is going to increase at a different rate from others, then the correct rate in period t is imputed by multiplying the input using the following expression:

$$P = \frac{(1+g)^t}{(1+p)}$$

Where:

P = relative price
g = rate of increase in the nominal price of the input
p = general rate of inflation (i.e. CPI)
t = time interval.

If differential rates of inflation are expected for individual cost or benefit items, the difference between the expected value of the costs and benefits needs to be included. Where cost or benefit items are expected to increase at a rate greater than general price inflation (i.e. as typically measured by the Consumer Price Index – CPI), then they should similarly be adjusted upwards. This may occur with wages or civil construction costs, for example.

If there is a situation where the analyst has strong evidence to believe that a particular category of costs or benefits is highly likely to grow at a rate ‘over and above’ general inflation, there is a risk of underestimation of effects in the economic evaluation. The use of a Delphi technique session could be useful here in soliciting the views and/or experience from relevant experts for gaining ‘direction’ to appropriate statistical or other data.

The approach recommended is to increase the particular cost and/or benefit stream(s) by the difference between CPI and the expected rate of change (which may also vary over time) prior to discounting. Obviously, where adjustments are significant, sensitivity testing will become an important consideration. Where this approach is taken for any category of cost or benefits, there should be sufficient supporting documented evidence provided in the CBA report to show the rationale underpinning the approach being adopted.

3.1.1.5 Market Prices

Market prices are those perceived prices at which products and services trade, irrespective of the level of interference in the market, i.e. the market wages of labour, the price of 2 kg of maize meal, the price of 1 kilowatt-hour of electricity, etc. In theory, market prices are indeed manifestations of the willingness to pay.

3.1.1.6 Shadow Prices

Shadow prices are the opportunity costs of products and services when the market price, for whatever reason, does not reflect these costs in full. Examples are shadow wages of labour where the fact that minimum wages are fixed, is taken into account; a shadow price for fuel where taxes and subsidies are excluded; the marginal cost of generating 1 kilowatt-hour of electricity; etc.

3.1.1.7 Accounting Prices

Some writers use “social accounting prices”, or “accounting prices” for short, as a substitute for the shadow price concept when a specific type of shadow price is referred to. The shadow prices used in the new approach are often called social prices because of additional endeavours to “adjust” shadow prices to better reflect social costs/benefits. In the rest of this manual, the original definition of shadow prices is referred to.

3.1.1.8 World Prices

The world price is the cost-insurance-freight (c.i.f.) price of imported or locally produced products or services that are internationally traded and that are locally consumed in South Africa. The f.o.b. (free on board) price is used for exported products or services. These prices reflect the opportunity cost of products and services when the possibility of international trade exists.

The c.i.f. price of imported capital equipment and the f.o.b. price of exported iron-ore or deciduous fruit are examples of world prices. It is important to consider the transport costs of imported products up to the point where the product is economically applied.

3.1.1.9 Shadow Exchange Rate

The shadow exchange rate gives the future value of the Rand relative to other currencies when there is no intervention in the foreign exchange market through, for example, the pegging of exchange rates or limits on capital flows. The shadow exchange rate is therefore the nominal exchange rate adjusted for the effect of interventions[9].

This manual recommends an adjustment to the future effective exchange rate. This adjustment makes provision for the change in relative prices of imports and exports. This is necessary to specifically provide for the fact that the South African exchange rate does not follow the trend of the buying parity theorem. According to this theorem, the exchange rate will behave according to the difference in the South African inflation rate and that of its major trading partners. Over the long term, the Rand is, however, depreciating faster than the relative difference in those inflation rates.

[9] This adjustment is in line with the United Nations Industrial Development Organisation, where the adjustment factor roughly equates the level of protection in the economy – Guide to Practical Project Appraisal; Social Benefit-Cost Analysis in Developing Countries. Unido, Vienna, 1986, pp 46.

3.1.1.10 Surrogate Prices

Surrogate prices are used to value costs and benefits when no market prices exist, or where no market price can be determined. Examples are the value of time and the value of a human life. These prices can be determined with the aid of the willingness to pay principle and other products or services of a similar nature. For example, the price of clean air can be derived from what the community (as represented by the State) is prepared to pay for combating air pollution. Surrogate prices for water are discussed in Chapter 7.

3.1.2 Use of Shadow Prices

3.1.2.1 General Considerations

In practice, shadow prices should be used in CBA only when the market prices of products and services clearly do not reflect their scarcity value or economic contributions. In cases where market prices give an accurate indication of the scarcity of products and services, market prices are used not only in the financial analysis but also in the economic analysis.

Under circumstances where the effectiveness of projects is not reflected by market prices, project input and output prices should be adjusted. Examples of these are where the market mechanism does not equate the marginal cost and marginal revenue of products and services, or where serious structural imbalances exist in markets. The decision to use shadow prices will be influenced by the likelihood and consequences of the wrong use of market prices. A reasonable knowledge of the relevant economy is therefore a prerequisite for responsible price choices in CBA.

The calculation of the shadow prices of products and services is often difficult, and is further complicated because it may be necessary to calculate shadow prices on a regional basis since structural imbalances may exist between regions that are not reflected in market prices.

3.1.2.2 Regional Considerations

CBA is usually used to evaluate the effectiveness of projects undertaken within a specific national economy. Furthermore, the distribution of income between different population groups, income groups and regions is affected in this way. Regional differences in costs and benefits are indeed very important when the effectiveness of projects is researched and the distributional consequences are assessed.

From the above, it follows that, when market prices are used to value resources, they should reflect the value for different regions. In cases where market prices are not acceptable, shadow prices should reflect the value of resources for the region where they are purchased. The same applies to surrogate prices.

In order to consider the above aspects correctly in project evaluation, it is necessary to investigate the political aspects which influence shadow and surrogate prices.

3.1.2.3 Political Aspects and Shadow Prices

Political ideologies, objectives and choices to a large extent determine the nature of community costs and benefits and the way in which they are maximised; and influence, amongst others, the following:

(i) the social time preference rate;
(ii) the value of capital;
(iii) market prices;
(iv) job opportunities and wages and consequently the value of recreational time;

(v) the value of externalities, i.e. noise and damage to the ecology; and
(vi) the income distribution and regional weightings.

Political considerations constitute an integral part of the decision-making process. The analyst is therefore forced to specifically take them into account when analysing any project.

3.1.2.4 Conditions for the Use of Shadow Prices

It is important to distinguish between the generally valid conditions for the use of shadow prices and the conditions specific to the use of shadow prices in South Africa.

3.1.3.4.1 General Conditions

An optimisation process presupposes limited resources. The economic problem is to find that combination of resources that maximises some specific objectives. Scarce resources are traded at specific prices. If certain conditions are met, the price mechanism is the best way in which scarce resources can be allocated to those who will use them to the maximum social advantage. These conditions are that:

(i) the prices of final consumption goods should reflect their social benefit (value); and
(ii) the prices of scarce resources should give an indication of relative scarcity (costs).

Provided both conditions are met, supply and demand in the goods and factor markets will tend towards equilibrium. As has been argued, however, disturbances occur in practice that result in market prices not being true measures of scarcity, and this should lead to the use of shadow prices.

3.1.3.4.2 Pre-Conditions for the Use of Shadow Prices in South Africa

In order to apply CBA effectively in South Africa, it is important to keep in mind the limitations under which shadow prices are used. At the same time, it must be remembered that shadow prices are a prerequisite for responsible expenditure decisions. To ensure that shadow prices are used appropriately, it is necessary that:

(i) South Africa should be viewed as a constitutional entity, with the reservation that regional and local objectives should be included in project assessment, as long as this can be accommodated within the broader political objectives;

(ii) a list of advantages and/or disadvantages should be drawn up and allocated to those communities who are to benefit and/or be adversely affected before any attempt is made at quantifying or analysing;

(iii) the financial costs of projects be allocated to the principal owner that is investing, irrespective of the origin of funds;

(iv) costs and/or benefits be allocated to those stakeholders who are to benefit and/or be adversely affected, irrespective of who the investor, donor, lender or principal for project analysis is; and

(v) apart from the analysis implied in (i) to (iv) above, every CBA should be undertaken from the view of the whole of South Africa in order to prevent any unnecessary duplication of projects. Under some circumstances the principal may feel that the cost-benefit study should be applied to the whole of Southern Africa, i.e. the Southern African Customs Union and/or Southern African Development Community (SADC).

3.2 PRINCIPLES IN THE CALCULATION OF SHADOW PRICES

There are a number of important approaches relating to the way in which shadow prices ought to be calculated. The first can broadly be called the 'world price' approach and the second the 'opportunity cost' approach.

The opportunity cost approach refers to the marginal social cost and marginal social benefit of a commodity. The marginal social cost in terms of shadow prices is the value of the resources required to produce an extra unit of the relevant commodity. On the other hand, the marginal social benefit reflects the benefit evaluated in social terms derived from supplying an additional unit of the relevant commodity in the economy.

A third important approach rests on the willingness of the community or groups in the community to pay for goods or services. The first two approaches form the basis of shadow price calculation, whilst the willingness-to-pay approach is only a method of calculating the marginal social benefit or cost.

3.2.1 World Price Approach

The world price approach takes into account world prices of products and services, especially with regard to those goods that are freely traded on international markets. Important examples are mineral and agricultural products for which active free international markets exist. Where local market prices are distorted because one or more of the conditions are not met, the relevant world price serves as the shadow price after adjustments have been made for costs in the import and export of goods.

This approach is not always reliable, however, because governments often peg currencies at artificial levels that do not reflect their scarcity value. Adjustments are then required to the value of the currencies. However, not all inputs and outputs can necessarily be converted to an appropriate currency value. For example, labour is one of the most important inputs in developing countries, but there is no free international market making it possible to attach a currency value to surplus labour.

3.2.2 Opportunity Cost Approach

The opportunity cost (marginal social cost) approach uses, as the shadow price of production inputs, the production that is given up elsewhere by withdrawing these inputs from their alternative use. On the other hand, for the shadow price of outputs (marginal social benefit), the additional incremental benefit achieved by undertaking the project, relative to the situation had the project not been undertaken, is used. In this way an attempt is made to accentuate internal considerations in order to find a reliable measure of the acceptability to the community of projects.

In line with this approach, it is therefore recommended that where projects substitute imports or promote exports, the world price approach is adopted. Locally purchased inputs are valued at international prices where the possibility exists that they could be imported or exported. The inputs for which no international prices exist are valued at the local opportunity costs.

In practice it seems that the following line of reasoning is applicable[10]:

Impact	:	Basis for shadow pricing
Consumption within in the economy	:	Marginal social benefit (consumer willingness to pay)
Production within the economy	:	Marginal social cost of production
International trade	:	World prices

[10] For a summed-up version of this approach, see UNIDO-publication. Ibid. p. 22.

3.3 GENERAL PROBLEMS WITH THE DETERMINATION OF SHADOW PRICES

Shadow prices should be determined as scientifically as possible so that different project evaluators can achieve the same results. Therefore, it is important to take a stand on how externalities, inflation, taxation and subsidies, the project life, and the value of the relevant currency should be dealt with.

3.3.1 Externalities

Externalities are the effects of a project on the environment, ecology or general standard of living of a community that are not reflected by the prices of inputs or outputs.

Externalities are difficult to include in project assessment because they cannot be directly allocated to the project and, furthermore, are difficult to quantify. The requirement that prices of products and services should reflect their relative scarcity value on the basis of all costs and benefits continues to apply however; and, therefore, externalities should be considered in the analysis of a project. For example, the cost to the community of polluted air can be approached by using the degree to which government is prepared to bear the cost of eliminating air pollution as a measure of the community's willingness to pay for clean air.

Where it is suspected that a project will produce some form of externality this aspect should be carefully investigated.

3.3.2 Inflation

The objective of a CBA is to measure community advantages and disadvantages after the relative scarcity value of project inputs and outputs have been taken into account. However, inflation, the continued rise in general price levels, makes the determination of relative scarcity values more difficult.

Inflation is not taken into account in the economic analysis, and all evaluations are done in base year prices with allowance for relative price shifts. On the other hand, the financial results of profit-orientated projects viewed in nominal terms, are affected by the inflation rate, and the internal yield rate will have to be at least equal to, but preferably higher than the inflation rate to ensure that the project continues to exist. Alternatively, the net present value of the project must be positive when costs and benefits are discounted by means of the inflation rate.

3.3.3 Indirect Taxes and Subsidies

Taxes and subsidies influence the optimal application of production factors, and the analyst will have to take these into account indirectly when he/she forecasts the combination of inputs that will apply after the implementation of the project. It is not, however, easy to deal with indirect taxes and subsidies in CBA.

From the point of view of the economy as a whole, indirect taxes and subsidies are transfer payments, and when new inputs that have to be taxed or subsidised are considered in the national interest, the value is calculated from the point of view of the producer by subtracting taxes and adding subsidies. When the impact of a project on a particular area is considered, however, the effect of indirect taxes and subsidies on the local economy also has to be taken into account. In such a case, the market prices, including the taxes and after subtracting the subsidy, indicate the social marginal value of the input or benefit. The tax loss or subsidy gain of the region should be shown as a redistribution effect to or from the overall authority respectively.

It must be kept in mind that certain “taxes” added on to prices should be taken into account as part of the project cost. An example is where a component of a certain tax can be viewed as a user’s charge, i.e. the fuel levy for the building of roads.

Sometimes, uncertainty arises with regard to surcharges that are levied for specific purposes, which, in reality, serves as a consumer charge. The general point of departure here is that, in circumstances where tax would normally be subtracted, all taxation (even taxes that serve as user charges) is subtracted from market prices to calculate the scarcity value; and that a cost-element is added for the use of the input. Where it is very difficult to impute the value, the analyst can consider keeping the relevant tax in the price as an estimate of the user charge. For example, part of the tax on petrol serves as a user charge for the use of roads. The analyst can consider not subtracting this tax from the price of petrol so that it can serve as an estimate of the damage to existing roads that results from a project.

All direct taxation (i.e. income tax) and indirect taxation is included in financial analysis, but direct taxation is not taken into account in economic analysis, and indirect tax is to be dealt with as set out above.

3.3.4 Project Life

Project life is equal to the expected economic life of the project, which means that the analysis period will vary from project to project. As is well-known, many factors have a determining influence on the decision of how long the economic life of a particular project would be. This decision would obviously have a crucial impact on the outcome of CBA calculations.

One important factor that will determine the economic life, and results of the CBA, is the expected growth of the benefit stream over the time horizon chosen for the project. For example, the future demand for irrigation water in a particular area will be determined by the expected demand (locally and overseas) for the agricultural products made possible by irrigation. Various methods exist by which such demand forecasts can be made, of which macroeconomic forecasting models are explicit examples.

Any assets which may remain at the end of the economic life of the project should appear as a residual item, and be imputed either as a positive or negative impact on the cost stream. In most cases it will be possible to sell the residual part of the assets for a positive amount. This value should be subtracted from the cost stream.

In some cases, however, there is a cost involved to get rid of the assets. For example, in the case of the closing down of an open cast coal mine, the rehabilitation cost involved should be brought in as an add-on cost.
In CBA calculations, one should also take into account a situation where the economic life of some assets could be shorter than the analysis period. In such instances, the capital expenditure should be repeated for the relevant year.

3.3.5 Currency

The price of any imported product or mineral is converted by means of an exchange rate to internal price levels. Irrespective of restrictions on the flow of capital, the Rand is fairly representative of the forces of supply and demand as determined by imports and exports and is, therefore, used as the shadow price of currency.

It has already been argued that, in the absence of free currency markets, the exchange rate does not necessarily reflect the scarcity value of a currency and that it will therefore be necessary to determine a shadow exchange rate by some other method. For this, the purchasing power parity or currency-cost-approaches can be used. Since the use of these alternative approaches is not recommended, they are not discussed any further.

Because of the volatility of the exchange rate, it is essential that exchange rate calculations are combined with sensitivity analysis.

3.4 VALUATION OF INPUTS AND OUTPUTS

The sources (or production means) are the scarce factors that are needed in the production process and that lead to the supply of goods and services by the private sector and government. The discussion that follows concentrates on general characteristics of sources and the determination of their financial value (market prices) and shadow prices.

During the production process, project inputs are transformed to outputs. The most important project inputs are capital, raw materials, labour and purchased services. Price information is usually available at market prices; but, as has been mentioned, the use of shadow prices is sometimes necessary.

3.4.1 Capital Goods

Capital goods are those production inputs that are not consumed in one or two years in the production process. For the purpose of this manual, these are divided into land, buildings and machinery, and equipment and transport equipment. Capital goods are usually viewed as the fixed assets utilized in a project. Capital goods, like any other product, can be subject to imperfect market conditions that result in the market price not reflecting the relative scarcity of the product. Therefore, it is necessary to investigate the valuation of these production means for possible incorrectly-determined prices.

Normally, capital expenditure takes place at the start of a project. However, this may also occur during the economic life of the project where it may be necessary to replace capital goods. The residual value of capital goods at the end of a project should be written back as a negative cost. However, it could also be a further cost if regarded as an externality, for example in the case of a rehabilitation requirement at mines.

The following table is provided to assist the researcher in taking into account the replacement of capital goods during the lifetime of the project, as well as to estimate the residual value[11]:

Table 3.1: Replacement of Capital Goods

Type of Asset	Sector	Lifetime Years
Residential buildings	Agriculture	50
Non-residential buildings	Mining	50
Construction works	General government*	80
	Other	30
		80
Transport equipment	Manufacturing	50
Machinery and other equipment	Mining and electricity, gas and water	8
	Other	8

3.4.1.1 Land

Land can be used in the economic process in a number of ways, i.e. as agricultural land, as an industrial input, or as the basis of infrastructure creation. The market price of a given piece of land cannot simply be accepted as a measure of its scarcity. The inherent value of land is dependent on its physical characteristics, the climate, and the production technology applied to it. The shadow price of land is based on its opportunity cost, in other words the optimal alternative use. In order to calculate this price, the following information should be available:

11 SARB, 1999, South Africa's national accounts 1946-1998, An overview of sources and methods, p. 9.

- The historical use of the land and the value of the output derived from it in the past;
- Other developments in the area which can affect it; and
- Information concerning the proposed use of the land and the output from the alternative application.

It is important to remember that the expected return of any project is determined by prices that most probably reflect interventions and imperfections in the past that will manifest in the economy for the duration of the project. Therefore, the expected return should be adjusted so that the economic value of the land can be calculated in terms of the economic value of the production given its optimal (most efficient) application.

For instance, the Department of Transport has to decide whether a local airport should be retained and upgraded, or a new airport developed. An opportunity cost of nil (besides maintenance costs) is allocated to the existing runways on the grounds that there are no other uses for them, and that their scrap value is zero. The land surrounding the airport does, however, have alternative uses in the form of low-quality agricultural land, housing, or even industrial applications which should be taken into account.

3.4.1.2 Buildings

Buildings are essential to protect the production process from the ravages of nature and as such are included in any CBA. In order to determine economic prices, the following information may be useful:

- The date when the building was bought or built;
- The current construction, i.e. replacement cost of an equivalent building and the book value of the building; and
- Alternative applications of the relevant building.

The shadow prices of existing buildings are calculated on the opportunity-cost basis, and that of new buildings on the basis of construction costs. Where construction costs serve as a basis for these calculations, adjustments have to be made for possible distorted labour prices that serve as an input, as well as possible tariff protection on any locally purchased material inputs.

3.4.1.3 Machinery, Equipment and Transport Equipment

Machinery and equipment are not usually consumed immediately in the production process. Except where they are destroyed by natural phenomena or man-made disasters, machinery and equipment become obsolete as a result of wear and tear, and the availability of improved production technologies. Depreciation of machinery and equipment is never, however, reflected directly in any CBA. Depreciation is taken into account indirectly in that the initial cost of the fixed assets normally appears at the beginning of the analysis period and the scrap or residual value appears as a credit at the end of the period.

The shadow price of machinery and equipment is determined in the same way as that of raw materials (see paragraph 2.4.2) by making a classification in terms of –

- Machinery imported, with and without any restrictions on quantity and price, and
- Machinery purchased locally or made by the contractor of the project

Where equipment is leased, or where machinery is carried over from other projects to the proposed project, the use value is shadowed for labour content, tariff protection, other indirect taxes and subsidies.

3.4.2 Raw materials

Raw materials are found in a variety of formats and are converted through a variety of processes by the addition of labour and capital into goods and services. The opportunity cost (scarcity value) of a raw material, and, consequently, the shadow price of the raw material, depends on a number of factors.

- Where a country is richly endowed with a raw material but the raw material is a diminishing asset (i.e. coal), it cannot simply be accepted that the market price reflects the relative scarcity of the asset since the Government may influence the price for other reasons, i.e. in order to achieve a better balance of payments position.
- Monopolies or cartels are in a position to force up the price of the raw material artificially to a level higher than its scarcity value.
- The subsidisation or taxing of the use of raw materials will distort the prices so that they no longer reflect scarcity values.
- Rationing restricts the demand for, or supply of certain goods and distorts the market prices so that the economic value is not reflected in the price.

For discussion of the shadow price of raw materials it is necessary to identify three possibilities.

(i) Where raw materials are imported without tariff protection or purchased locally, the market price, which, by definition, is the world price plus freight and insurance (c.i.f.) to the point of consumption, is used in the economic analysis. In the case of quotas that increase the price of the imported product on the local market, the same approach is used, i.e. the shadow price is equated to the c.i.f. world price of the product. If government interferes with the operation of the currency market, however, adjustments should be made in the exchange rate (see paragraph 2.3.5).

(ii) Where raw materials on which import tariffs are applicable are imported or purchased locally, the shadow price is calculated by subtracting the percentage tariff protection from the local price. In the case of quotas, the c.i.f. world price approach is used.

(iii) Where raw materials are purchased locally, and these raw materials are not normally traded globally without influencing the local price or the local availability of the raw material (i.e. bricks), it can be accepted that the scarcity value of the product is reflected by its market price, adjusted for indirect taxes and subsidies.

3.4.3 Labour

Labour differs in many aspects from other production factors. In South Africa, for example, it is possible that there can simultaneously be a shortage of skilled labour and a surplus of semi-skilled and unskilled labour. At the same time certain factors apply to the labour market that result in the labour wage not reflecting relative scarcity. One such factor is the fixing of minimum wages (through the pressure from trade unions and/or government policy), which forces the wage above the marginal product of labour and, thus, restricts employment.

All factors that cause the price of labour to deviate from the marginal product of labour should be considered in a CBA. The following approach for determining the shadow price of labour is proposed.

(i) Where unemployment does not exist, the market price of labour is used for all labourers. If the quality of a specific category of labour within a sector is homogeneous, and the market operates fairly freely, then the average wage of that category in that sector can be accepted as reflecting the market price in the relevant sector. Under conditions of full employment, and especially where skilled labour is scarce, this method will probably underestimate the opportunity cost of labour, but in the absence of specific information, it is not normally possible to calculate it more accurately.

(ii) For a worker who has very poor technical skills, and who lives in a region where unemployment exists, the income per earner in the region is used as a measure of the production lost (shadow wage) when the worker is employed. Such income is usually lower than the minimum wage, and is a more accurate reflection of the opportunity cost of labour. The minimum wage is artificially set too high as a result of the power of trade unions and social pressure.

3.4.4 Services

Purchased services are not always concrete or visible in the final product of a product or service that is produced, but nevertheless form an integral part of the product or service, i.e. electricity, gas, water, transport, promotions, advertising and research and development.

The opportunity cost of a service is the value that the remainder of the community has to forgo if they are denied the service, or the cost imposed on them to deliver the service. If, for example, a project needs electricity, the shadow price of the electricity in a given region will be equal to the long-term marginal cost of provision. The same approach applies to the cost of water, gas and transport.

3.5 SURROGATE PRICES

3.5.1 Advantages and Disadvantages Not Reflected by a Market

Some intangibles have a value, but are not tradable in a market, i.e. the value of time or a human life. In order to determine the value of these, the following approach is recommended.

In determining the value of time, a decision has to be made as to whether the valuation is done in respect of working time or leisure time. The value of working time is theoretically equal to the marginal productivity of labour and, in a perfect labour market, it would be reflected in ruling wages. It must be noted, however, that wages are not paid only for the free time that has to be given up to work, but also for the exertion required. Therefore, the value of free time is equal to the ruling wage, less the compensation for the working effort.

Where free time is saved as a result of faster transport, the value must be increased or decreased in order to take into account the value of travelling pleasure, or the productive application of travel time, or the unpleasantness of the journey. In practice it is difficult to deduce the value of free time from the value of working time by means of this approach, and it is customary to estimate it in an empirical way by means of observations of time savings and related expenditure.

The accurate estimation of the value of working time by analysing wage packets for those involved on a sample basis, and by conducting surveys to derive the value of free time is necessarily a time-consuming process, but it is essential where the results will be of critical importance for decision-making. Where the value of time savings for the general public is included as one of the benefits of a project, it is normally sufficient to accept the average per-capita income per time unit as representative.

In determining the value of a human life, the economically productive life of an individual must be calculated in order to determine the lost production caused by death. The consequences and costs of injuries and, if the injury is temporary, the lost production attached to it, must also be determined.

This is not, however, the only method for determining the value of a life. Thompson (1983)[12] also refers to the Pareto method, the consumption-value method, the value according to potential earnings, the willingness-to-pay method and the social value method. According to this author, the social value method is preferable, but the lost production method is most often used in practice.

3.6 ALTERNATIVE APPROACH

In some cases, benefits are difficult to quantify in terms of market prices or even surrogate prices, and should therefore be valued by calculating the saving between the situations after the project is completed, and the situation before it was started.

If the costs of the project are lower than the costs without the project, then the project provides benefits for the user. The opposite is true where "without-project" costs are lower than the "with-project" costs. This analysis is known as incremental benefit analysis, and it calculates the incremental saving that a project brings about. An example of this is the benefits of an e-mail service relative to a fax machine, where communication results in a higher labour content.

[12] Thompson MS. 1980. *Benefit Cost Analysis for Program Evaluation*. London: Sage Publications.

CHAPTER 4: CRITERIA FOR PROJECT ASSESSMENT

After completion of the financial and economic analyses, every project should be assessed in order to determine whether it will increase community welfare. Regarding the composition of a capital expenditure programme, the projects should be ranked in priority order in terms of financial and economic criteria. This chapter discusses the project assessment criteria systematically, and an indication is given of the most suitable criterion to use under specific conditions. This is followed by a discussion of sensitivity analysis and income distribution measurement. The composition of a capital expenditure programme is discussed in Chapter 5.

4.1 DEFINITION OF TERMINOLOGY

4.1.1 Mutually Exclusive and Independent Projects

Mutually exclusive projects are alternative methods of performing the same task, or reaching the same goal. For example, if the aim is to protect vehicles against weathering, a variety of alternatives can be considered. Eventually, only one of the alternatives will be chosen. The economic assessment of mutually exclusive alternatives therefore involves choosing the most cost-effective alternative.

Independent projects are completely unrelated, and more than one of the projects can be carried out. In fact, it is possible to carry out all independent projects when there is no shortage of funds. Examples of independent projects are the construction of a new highway between towns A and B and the construction of a bridge between towns C and D. Where funds are scarce, however, it is important to rank the projects in order of acceptability so as to determine which project should enjoy the higher priority. Even if it is possible to finance all of the projects, it is still important to have criteria that can be applied to ensure that each project is in the interests of the community.

Logically speaking, projects are assessed in a predetermined order. The mutually exclusive projects are usually assessed first to find the most cost-effective alternative, after which the chosen project competes for funds with other projects that are chosen in the same way (all independently of each other), in a second assessment phase. The most effective alternative in a particular situation is not necessarily the best project when a programme is initially being compiled (See Chapter 5).

4.1.2 Discounting

Discounting is the reverse of adding (or compounding) interest. It reduces the monetary value of future costs and benefits back to a common time dimension – the base year/date. Discounting satisfies the view that people prefer immediate benefits over future benefits (social time preference), and it also enables the opportunity cost to be reflected (opportunity cost of capital).

Costs that are immediately incurred and benefits that are gained in the present time are judged differently by the community from costs and benefits that materialise over a period of time. The community would rather prefer to receive a benefit today than in the future, whilst deferred costs are more attractive than immediate payment. Therefore, the monetary value of costs and benefits over time cannot simply be added together; the time preference of the community has to be taken into account through the use of a weighting process. This weighting by the community is done with the aid of a discount rate that reflects the value of a benefit or cost over time, and is known as the social discount rate.

Suppose b0, b1, …, bn are the project benefits in years 0,1,2, …, n and c_0, c^1, …, c_n are the costs in years 0,1,2, …, n, respectively, and i is the social discount rate, then the present value of the benefits is given by

$$b_0/(1 + i)^0 + b_1/(1 + i)^1 + . . . + b_n/(1 + i)^n$$

and the present value of the costs are given by

$$c_0/(1 + i)^0 + c_1/(1 + i)^1 + . . . + c_n/(1 + i)^n$$

The analyst needs to determine the following when preparing to undertake the Discounted Cash Flow (DCF) aspects of CBA:

- The appropriate price year for cost estimates, and the level of prevailing inflation
- Whether analysis of relative prices is necessary for some cost items (i.e. labour costs)
- What the base year (or discount year) is to be
- What is the base/initial evaluation discount rate to be, and
- The evaluation period (or project period).

4.1.2.1 The choice of a social discount rate

When considering an appropriate social discount rate, note must be taken of the various points of departure in the economic literature[13], as well as of the rates applied in other countries and by international development institutions.

The point of departure in the literature can be divided broadly into three schools of thought, namely:

- Those who argue that the discount rate should be equal to the marginal return on capital (opportunity costs of capital)
- Those whose argument rests on long-term real interest rates (cost of funding to the State), and
- Those who advocate a social time preference rate

The first two schools take an economic view, whilst the third school adopts a multiple-goal approach that includes social aims. In the debate in the literature, arguments and criticism are based on purely economic grounds, as well as on the basis of what exactly the “public interest” involves. A lack of space makes detailed discussion of the arguments impossible, and the reader who wants more background on this interesting (and sometimes deeply philosophical) debate is referred to the book by Sugden and Williams (1983)[14].

There is no consensus concerning what method should be used to determine the social discount rate. A relative pragmatic approach is proposed which takes the following into account:

(i) The discount rate should not be influenced by business cycle conditions and policy since the preferences that find expression in this rate are aimed at the extension of the long-term welfare structure.

[13] For an up-to-date presentation of the theoretical foundations of social discount rates, as well as alternative social discount rates methods in the absence of perfect markets, see Boardman, Greenberg, et al, Ibid Chapter 5.
[14] Sugden R and William A. 1978. *Principles of Practical Cost-Benefit Analysis*. Oxford University Press.

(ii) A low discount rate generally favours projects with a high initial capital cost and low future current costs, whilst the opposite applies to high discount rates. Since labour costs are part of current expenditure, a high discount rate favours the employment of labour in future.

(iii) If the real social discount rate is lower than the real implicit discount rate in the private sector, then investment by the public sector will be encouraged at the expense of investment by the private sector. The larger the gap between the two, the stronger the effect.

4.2 PROJECT ASSESSMENT CRITERIA

There are several project assessment criteria, which can be classified broadly as limited methods or more comprehensive methods.

4.2.1 Limited Methods

These criteria include the payback period method, the peak profit method, and the average profit method. All three are very simple, and are restrictive because efficiency is not the main consideration. As a result, these limited methods may produce misleading results. The use of these methods is not recommended, and therefore they are not discussed here in detail.

4.2.2 More Comprehensive Methods

4.2.2.1 The Net Present Value Method

According to this method the difference between the benefits and costs (the net benefit) in a specified year is discounted to the present by using the social discount rate. The discounted sum of all these net benefits over the economic project life is defined as the net present value (NPV), where:

$$NPV = \Sigma b_j/(1 + i)^j - \Sigma c_j/(1 + i)^j.$$

The criterion for the acceptance of a project is that its NPV must be positive. In other words, funds will be voted for a project only if the analysis produces a positive net present value. Where a choice has to be made between mutually exclusive projects, the project with the highest net present value will be chosen since it maximises the net benefit to the community.

4.2.2.2 The Internal Rate of Return Method

The internal rate of return (IRR) is the discount rate at which the present values of cost and benefits are equal. It is therefore the value of the discount rate r that satisfies the following equation:

$$\Sigma b_j/(1 + r)^j - \Sigma c_j/(1 + r)^j = 0.$$

Only projects with an IRR higher than the social discount rate, which forms a lower limit, will be considered for funding. The IRR must be handled carefully, because there are situations in which the mathematical solution of the above equation is not unique. This happens when the stream of net benefits over the assessment period changes its sign (positive or negative) more than once.

4.2.2.3 The Discounted Benefit-Cost Ratio Method

The discounted benefit-cost ratio (BCR) is the ratio of the present value of the benefits relative to the present value of the costs, i.e.

$$BCR = \{\Sigma b_j/(1 + i)^j\} / \{\Sigma c_j/(1 + i)^j\}$$

A project is potentially worthwhile if the BCR is greater than 1. This means that the PV of benefits exceeds the PV of costs. Under this decision rule, if alternatives are mutually exclusive, the alternative with the highest BCR would be chosen.

It is recommended that the BCR is not adopted as the prime decision rule. BCRs can sometimes confuse the choice process when the policies under consideration are of a different scale, yielding misleading results. For example, if proposal A has a PV of benefits of 200 and PV of costs of 100, it has a NPV of 100 and a BCR of 2. If the alternative proposal, B, has a PV of benefits of 600 and costs of 400, it has a smaller BCR (1.5) but a larger NPV (200). It would be more efficient to choose proposal B.

The NPV, IRR and BCR criteria are not the only discounting measures used in CBA. There is also the Net Discounted End Value, the Net Benefit-Investment Ratio and the Yearly Value Method. The first-mentioned three are, however, theoretically well founded and are the ones most commonly used in practice. These three criteria should be applied in respect of every project analysed.

An example will illustrate the use of the NPV and BCR methods. Table 4.1 reflects the present values of the benefits and costs involved in the construction of a dam.

Table 4.1: The Present Value of Benefits and Costs of the Construction of a Dam (Rand)

Benefit/Cost	Present benefit	Present cost
Construction of dam		2 501 000
Annual Maintenance		259 000
Household Water Benefits	2 851 000	
Irrigation Water Benefits	473 000	
Recreation	716 000	
TOTAL	**R4 040 000**	**R2 760 000**

In the example above, the NPV = R4,04 million – R2,76 million = R1,28 million and the BCR = (R4 040 000 – 259 000)/2 501 000 = 1,51. In terms of both measures the project can therefore lay claim to funding. The internal rate of return method would have arrived at the same results.

A further example will illustrate the use and limitations of the NPV and BCR measures in comparing a number of mutually exclusive projects. The road analysed above now competes with two mutually exclusive projects for funds. The details are contained in Table 4.2 below.

Table 4.2: Present Values of Costs and Benefits: Three Mutually Exclusive Projects (different dam sites)

(Rand)

Dam Sites	Present Value of Benefits	Present Value of Capital Costs	Net Present Benefits	BCR
1	**3 781 000**	**2 501 000**	**1 280 000**	**1,51**
2	**5 000 000**	**3 500 000**	**1 500 000**	**1,43**
3	**3 350 000**	**2 200 000**	**1 150 000**	**1,52**

Looking only at the BCR, it appears that dam Site number 3 is the best choice since it will provide R1,52 worth of benefits for every Rand spent. However, it can be seen that this reasoning is incorrect if Site 1 is compared with Site 3. By spending a further R301 000 on Site 1, a benefit of R431 000 more than that of Site 3 is achieved. This means that Site 1 provides a Pareto improvement relative to Site 3. Those who benefit from

Site 1 can compensate all losers and still leave a surplus of R130 000. Using a similar argument, it can be shown that Site 2 is an improvement on Site 1, and is therefore the best of the three alternatives. Generally, it can be argued that, in the case of mutually exclusive projects, the project with the highest NPV has the highest potential Pareto improvement.

4.3 GENERAL SENSITIVITY ANALYSIS

4.3.1 Background

In most cases, a CBA is performed for new future projects and thus entails the estimation of certain key variables such as expected prices and quantities. Although it could be accepted that the decision-maker is fully aware of the fact that the projected outcome of a project cannot be interpreted in absolute terms, it is important that the analyst provides the decision-maker with some idea of the degree of certainty/uncertainty to which the project outcome would be subjected to.

4.3.1.1 Selective Sensitivity Analysis

Project evaluators usually perform a so-called Selective Sensitivity Analysis in order to establish the sensitivity of a project's outcome to changes in a limited number of key input variables. In essence, the analyst selects a key variable/parameter, one which he/she feels is both subject to wide variations, and is capable of significantly affecting the results of the CBA. The analyst then selects likely high and low (best and worst) outcomes for this parameter, and repeats the computation of the CBA using these values. The decision-maker is thereby presented with several possible results for each project – a high, a medium, and a low outcome for each of the parameters selected for the sensitivity analysis.

The major drawback of this limited approach is that it is not very suitable for the analysis of anything more than a few parameters. It not only causes problems when attempting to present the results in a scientific manner, but it also omits a great deal of information important to the decision-maker. Normally, the impact on the viability of a project through the change in any single parameter is compared to the base scenario. The ideal, however, is to calculate all of the combinations of worst, standard, and best for each parameter selected for the sensitivity analysis. Although this is technically possible, the presentation of such an analysis could be a major problem. To illustrate, when doing a sensitivity analysis with 10 parameters, each with a worst, medium and best value, the model calculated 310 or 59 049 possible outcomes for the project.

4.3.2 General Sensitivity Analysis

In using General Sensitivity Analysis, the problems encountered in Selective Sensitivity Analysis, namely the limitations with regard to the number of input parameters are overcome to a large degree. A General Sensitivity Analysis hinges on the derivation of a probability distribution of possible outcomes. As such, all the information contained in the above-mentioned 59 049 individual possible outcomes is captured in a format that is very convenient to the decision-maker for interpretative purposes. Without describing the methodology of the General Sensitivity Analysis in detail, it can be stated that it involves the following:

- The calculation of results using all possible combinations of input parameters
- The probability of occurrence of each combination, and
- The construction of a cumulative probability distribution function.

The following information can be obtained from the analysis:

- The probability of the project being viable

- The probability that the project will not be viable
- The probability that the project will yield a particular return, and
- The expected return (or best single estimate)

4.3.3 Computer Model

General Sensitivity Analysis is undertaken by making use of a computer programme called @RISK (advanced risk analysis for spreadsheets) produced by the Palisade Corporation, USA. @RISK 8 has been rebuilt on the latest programming technology from the ground up. This forward-looking foundation ensures that @RISK will continue to provide the most reliable, accurate, and robust quantitative risk analysis available anywhere for years to come.

@RISK uses simulation, sometimes called Monte Carlo simulation, to perform a risk analysis, where simulation refers to a method whereby the distribution of possible outcomes generated by letting a computer re-calculate the CBA worksheet over and over again, each time using different randomly selected sets of values for the probability distributions of each key input variable. In effect, the computer is trying all valid combinations of the values of input variables to simulate all possible outcomes. This is similar to running hundreds or thousands of “what-if” analyses on the worksheet, simultaneously.

4.4 INCOME DISTRIBUTION (WELFARE DISTRIBUTION BETWEEN CONTEMPORARIES)

As mentioned above, CBA is geared towards the improved allocation of scarce resources, where the objective is the achievement of Pareto optimality. This means that resources are used in such a way that at least one person will be better off, whilst no one will be worse off. If the discounted benefits of a proposed project exceed the discounted costs, the possibility exists of bringing about a Pareto improvement, provided that the winners compensate all the losers for their losses whilst, at the same time, retaining their surpluses. In practice this does not necessarily happen, with the result that the practical effects of the project on income distribution have to be determined.

All of the project assessment criteria discussed so far have been exclusively concerned with the achievement of a potential Pareto improvement and have not touched on the equitable distribution of consumption between contemporaries. Since this is one of the important objectives of economic policy, the government should quantify the most important distribution aims by allocating weights to specific groups.

The fundamental point of departure is that additional incomes for lower income groups should be relatively more important than additional incomes for higher income groups. It is important to analyse the project in order to determine who the winners and losers will be. The following effects are of importance:

- Who pays more and who pays less as a result of the project;
- Who receives more and who receives less as a result of the project; and
- Who benefits and who loses in other ways as a result of the project.

The following serve as broad guidelines concerning the role-players that could be involved in such an evaluation:

- The contractor of the project;
- Other businesses that provide project inputs;
- Government, which may profit from charging tariffs or may have to support the project financially in one way or another;

- The workers, or different categories of workers;
- The end-users of the product or service; and
- Foreign countries, which may be affected through imports and exports.

The role-players who are referred to can also be seen in the context of a local, regional or national perspective. Accordingly use can be made of regional or local weights to achieve specific development objectives for an area.

The weights to be allocated to the different groups are not easily determined, and depend largely on political decisions. It should, however, be related to the marginal utility that additional income provides for each of the groups. In order to make effective decisions, it is important for the decision-maker in the government sector to know what weights the politicians attach to particular groups or regions at a particular point in time, so that, after the completion of the financial and economic analysis, the income distribution potential of each project can be highlighted in detail.

In South Africa such weights are not explicitly available. Nevertheless, recent developments in the compilation of more contemporary SAMs, have made it possible to include such weights for household income groups for CBA-purposes. The theory and practice are set out in the following section.

4.4.1 Income Weighting Systems

4.4.1.1 Theory

From the above discussion, it is obvious that the concept and practice of weighting different income groups should be viewed with a great deal of circumspection; especially in the South African context where large differences between high- and low-income groups occur.

For the purposes of this manual, it is proposed that the first round of calculating the income distribution impact (with the help of a SAM-based model) is done without a weighting system. After obtaining the initial results, use can be made of appropriate ratios to demonstrate the relative impact on the lower-income groups. For example, what percentage of the total impact on personal income (direct and indirect) is earmarked for the lower, medium and higher income groups? In the absence of elasticity data, as a first round of weighting, use can be made of deviations from the mean/average national income per capita of each income group.

As stated previously, in principle, distributional objectives can be incorporated in project selection by assigning weights to income changes to different groups. This weighting of income flows to different groups allows revised NPV and IRR measures to be calculated and hence allows a distributional objective concern to be built into conventional decision-taking criteria. In response to the perceived importance of distributional issues there is a well-developed methodology for income weighting[15].

The best-known form of weighting involves a simple formula that assumes that the social value placed on a unit of income declines at a constant rate for all income levels. Application of this approach requires two parameters. The first is a reference level of income that will have a weight of unity. The main candidate for this reference level is average per-capita income in the economy, but alternatives include a poverty line estimate, or the income at which individuals become eligible for government subsidies.

[15] For more detail please consult:
Guide to Practical Project Appraisal, Social Benefit – Cost Analysis in Developing countries, Under Vienna; 1986 in Chapter VII.
Project Analysis in Developing Countries – Second Edition – Steve Curry and John Weiss, Macmillan Press Ltd. – Second Edition, 2000, Chapter II.

The second parameter is technically the elasticity of the social utility function for income. It reflects the rate at which the income weight for an individual or group declines as per-capita income rises, and, in principle, captures the strength of society's preference for income equality. By assumption, this rate of decline or elasticity is constant for all income levels.

The income weight formula is thus:

$$D_i = (Y_a/Y_i)^n$$

where:

D_i is the weight for group or individual i
Y_i is per-capita income for i
Y_a is the reference income, which we assume is the national average per-capita income,
n is the elasticity parameter

Using this formula, income weights will decline the higher Y_i is relative to Y_a – that is, the better-off i is relative to the national average, and the higher n is, the stronger is society's commitment to equality. Use of this formula can be illustrated using values of n of 0.5 and unity in Tables 4.3 and 4.4 below.

Table 4.3: Illustration of Income Weights

Income (Ya = 100)	n = 0.5 weights	n = 1.0
Yi = 50	**1.41**	**2.00**
Yi = 80	**1.12**	**1.25**
Yi = 200	**0.71**	**0.50**
Yi = 300	**0.58**	**0.33**

Table 4.4: Re-valuation of Project with Income Weights

Stakeholders	NPV	Average income	Income n = 1.0, Ya = 100	Weighted NPV
Project owners	0.46	500	0.20	0.09
Lenders	-2.20	500	0.20	-0.35
Government	-2.04	100	1.00	-2.04
Project workers	0.91	80	1.25	1.14
Telephone users	6.15	70	1.43	8.79
TOTAL	**3.28**			**7.63**

Source: S. Curry and J. Weiss – pp 290-291.

Using income weights to revalue the telecommunications project presented in Curry and Weiss[16] would require a choice of n and an estimate of the average income of the different groups affected by the project. The tables above illustrate the approach using the income figures at domestic prices. They assume that 20% of telephone users are poor, with a per-capita income of Pesos 50 whilst the remaining 80% have a per-capita income of 75, which is 75% of the national average. The weighted average income of users is therefore Pesos 70. They then use the national average income as the reference level for weighting.

It is assumed that project owners have an income five times the national average and that lenders are a private sector institution whose losses represent a reduction in profits for shareholders, once again with an income level five times the national average. Reductions in government income are assumed ultimately to affect those

[16] "Project Analysis Ibid on cit. p 290.

on average incomes through higher taxes. Finally, project workers are assumed to have an income of 80% of the national average. In calculating the weights, a value of n = 1.0 is used.

With the use of income weights the project's NPV has increased substantially to Pesos 7.63 million. This is primarily because its main beneficiaries, the users, have below average incomes and some have very low incomes and are classed as poor. On the other hand, one of the losing groups, the lenders, have high incomes and their losses have little social value. When weights are applied consistently, projects can be ranked by their economic NPVs and, in this case, the project should look better relative to alternatives because of its egalitarian distributional effect.

Although this methodology of weighting is well known, it is rarely applied in practice. This is in part owing to what are seen as the complications regarding its additional data requirements. More importantly, perhaps, is the point that the use of a particular set of weights is essentially subjective since their value will vary with the assumed elasticity parameter n. In the absence of any agreement on this parameter, there is the possibility of inconsistency in decision-taking with comparisons between projects where different weighting regimes have been applied.

In addition, weights such as those in the tables above have been criticized since they can imply the justification of a high level of economic inefficiency in pursuit of distributional goals. For example, with n = 1.0 a project with benefits of 25 and costs of 100 (that is, with a net loss of 75) would be justified if the benefits went solely to those with an income of half the national average (and thus a weight of 2.0), whilst its costs were borne solely by those with an income twice the national average (and thus a weight of 0.5).

The point here is that, whilst raising the income of the project beneficiaries by 25 may be justified in terms of social priorities, doing it at a net cost of 75 is likely to be a very inefficient means of reaching this target group. The expectation would be that there would be less costly means of affecting the transfer (for example, through subsidy schemes or targeted work programmes) than implementing a loss-making project.

4.4.1.2 Practice

As discussed above the income weight system is still being debated. Although the theoretical principle is probably sound, the practical application is still problematic. In view of this it is recommended that the principle of the income weight system should be introduced gradually. In this regard it is proposed that the elasticity of the social utility function for income could be set as a guideline at 0.20. This factor is in line with the priority that the government has given to income distribution indirectly via the percentage allocation in respect of government tenders to previously disadvantaged individuals.

In view of the fact that the income weighting system is subject to criticism, a rather conservative elasticity of 0.20 is therefore suggested. It is important that the relevant CBA results should be presented to the decision-maker before and after the weights are applied. Furthermore, it is also important that sensitivity analysis is applied by means of different elasticity parameters.

With regard to the reference level of income, here it is proposed that the average per-capita income in the South African economy is used. The relevant figures can be obtained from the SARB Quarterly Bulletin. Table 6.1 also reflects provincial per-capita income levels for unskilled workers. However, it is important to note that the decision-maker should always be supplied with the results of the CBA analyses before and after the income weights are applied.

4.5 WELFARE CONSEQUENCES

The real locative effect of a project is only one of the effects that can be classified as being of welfare consequence. In general, welfare effects include all the consequences that a project has for a human being's social milieu. These effects are related to changing living standards, new opportunities for development and self-improvement and the protection of the environment; but also with population movements and all the negative consequences attached to them, etc. Welfare effects are hard to quantify, but it is important that the analyst should systematically point out any such effect in detail to the decision-maker, even if it is by qualitative means, to enable him/her to attach a subjective weight to it in order to arrive at a more considered decision.

4.6 POLITICAL AND CONSTITUTIONAL CONSEQUENCES

The project evaluator always operates within a certain constitutional environment that influences the shadow prices and the choice of distributive weights. Analysts will, however, endeavour to point out all the consequences of a project as objectively as possible. When decision-makers act contrary to the recommendations of the analyst it must be very clear what price the community is paying for such politically inspired action.

It is not always possible to include all of the political consequences in a CBA on a quantified basis, although it is the responsibility of the analyst to point them out in detail on a qualitative basis.

4.7 STRATEGIC CONSEQUENCES

Projects may be classified as strategic on grounds of the following philosophies:

- The self-preservation philosophy, which emphasises the survival of the community; or
- The egoistic philosophy, which wishes to deny other parties access to the markets but is often disguised as per the above.

Strategic projects are aligned to both national objectives and sectional objectives that are presented as national objectives. The objectives can be of various kinds – self-sufficiency in abnormal times, national prestige, the development of new technologies, etc. The calculation of the strategic value of projects should be done on the basis of the probability that the circumstances being guarded against will materialise, and the degree to which the country is already dependent on the party against whom the project gives protection.

This type of analysis should form part of the sensitivity analysis of the project. However, since strategic consequences are also difficult to quantify, care should be taken to guard against the misuse of the strategic argument in cost-benefit analyses.

In the last three sections, it has been argued that the analyst must systematically point out non-quantifiable consequences in detail to the decision-maker in order to enable him/her to allocate a subjective weight to them so as to arrive at an optimal decision. Where an analyst or decision-maker expresses an opinion or decides between alternative projects, it is expected of the analyst or decision-maker unambiguously to indicate the considerations that have led to the decision.

CHAPTER 5: COMPOSITION OF CAPITAL EXPENDITURE PROGRAMMES

This chapter deals with methods for formulating a capital expenditure programme subject to a fixed budget when (i) only independent projects are presented for consideration and (ii) both independent and mutually exclusive projects are considered. The examples are derived from the book by M.S. Thompson (1980)[17].

5.1 INDEPENDENT PROJECTS

When a choice has to be made between a number of independent projects, given a fixed budget, the BCR measure is the preferred criterion. An example will illustrate this point. Suppose a local authority with a limited budget of R5 million has to make a choice between twenty-six independent projects, five of which are presented in Table 5.1.

Table 5.1: Present Value of Benefits and Costs for a Number of Independent Projects (Rand)

Project	Present Benefit	Present Capital Cost	Net Present Benefit	BCR
A	420 000	300 000	120 000	1,4
B	1 350 000	1 000 000	350 000	1,35
C	350 000	200 000	150 000	1,75
D	900 000	600 000	300 000	1,5
•	•	•	•	•
•	•	•	•	•
Z	640 000	400 000	240 000	1,6

Here, the BCR criterion is the preferred measure to use. The project with the highest BCR value is selected first, followed by the one with the second highest BCR value, and so on until the budget is exhausted. Thus, the five projects in Table 5.1 will be chosen in the order C, Z, D, A and B. In this way, the benefit per Rand spent is maximised.

5.2 INDEPENDENT AND MUTUALLY EXCLUSIVE PROJECTS

Suppose the objective of the decision-maker is to maximise community benefits subject to the restriction of a fixed budget, and that both mutually exclusive and independent projects are under consideration. A method of project assessment based on the incremental principle is recommended. The method consists of seven steps, and although it is complicated, it can easily be carried out with the aid of a computer. The steps are as follows:

(i) Determine the size of the budget. Where some degree of freedom exists as to the total amount available, the amount can be expanded incrementally, and the marginal benefits compared with the marginal expenditure to determine whether any expansion of the budget is justified.

(ii) Eliminate all projects that exceed the budget limits, as well as all projects that do not satisfy the minimum acceptance criteria as set out above.

(iii) Determine which project has the highest BCR within each group of mutually exclusive alternatives and then leave out the rest of the possible projects in the group.

[17] Thompson MS. 1980. Benefit Cost Analysis for Program Evaluating. London.

(iv) From the projects under consideration choose the one with the highest BCR.

(v) Review the choice of the best project in each group of mutually exclusive projects by reconsidering all the more expensive projects and, noting the marginal BCR within each group of mutually exclusive projects by firstly reconsidering all more expensive projects and noting the BCR. Within each group of mutually exclusive projects, the project with the highest marginal BCR is identified and compared with the rest of the independent projects. Secondly, the available budget is adjusted to reflect the effect of the projects already chosen, and all remaining projects that exceed the balance of the budget are left out.

(vi) Repeat steps (iv) and (v) for as long as possible. The iteration process ends when the budget is exhausted or when no acceptable projects remain for consideration.

(vii) Consider adjustments to chosen projects when the budget is not completely exhausted, and a small adjustment in a chosen project may provide marginal net benefits.

An example will clarify this procedure. Suppose a government has R1 million to spend. The projects under consideration are summed up in Table 5.2. Projects A_1, A_2, A_3 and A_4 are four mutually exclusive projects.

Table 5.2: Present Value of Costs, Benefits and Benefit-Cost Ratios of a Number of Projects. R'000

Project	Present Capital Cost	Present Benefit	BCR
A_1	135	280	2,07
A_2	170	370	2,18
A_3	210	440	2,10
A_4	270	530	1,96
B	150	250	1,67
C_1	250	315	1,26
C_2	280	405	1,45
C_3	600	890	1,48
D_1	110	175	1,59
D_2	150	235	1,57
E_1	100	220	2,20
E_2	200	480	2,40
E_3	300	670	2,23
E_4	400	830	2,08
E_5	500	1030	2,06
E_6	600	1170	1,95
F	60	140	2,33

There is no project that exceeds the budget limit of R1 million; and, furthermore, there is no project with a BCR of less than one. As such, all projects are included for further analysis. In Step (iii), the best projects are chosen from groups A, C, D, and E, and the projects that enjoy attention in the next step are reduced to the following:

Project	Present Capital Cost	Present Benefit	BCR
A_2	170	370	2,18
B	150	250	1,67
C_3	600	890	1,48
D_1	110	175	1,59
E_2	200	480	2,40
F	60	140	2,33

E_2 is chosen from these six projects. Now the more expensive projects in the E group are considered in terms of the marginal BCR. The marginal BCRs of the four projects more expensive than E_2 are as follows:

Project	Present Capital Cost	Present Benefit	BCR
$E_3.E_2$	100	190	1,90
$E_4.E_2$	200	350	1,75
$E_5.E_2$	300	550	1,83
$E_6.E_2$	400	690	1,72

The greatest marginal benefit is achieved by replacing E_2 with E_3; this replacement within the E group must now be considered together with the other projects. There is now R800 000 left, and none of the project exceeds this limit. The six alternatives now under consideration are as follows:

Project	Present Capital Cost	Present Benefit	BCR
A_2	170	370	2,18
B	150	250	1,67
C_3	600	890	1,48
D1	110	175	1,59
$E_3.E_2$	100	190	1,90
F	60	140	2,33

Project F is therefore chosen, and R740 000 of the budget is left. The next project to include is A_2, which immediately places the more expensive project in group A under the spotlight. The relevant marginal ratios are as follows: $A_3.A_2$ = 1,75 and $A_4.A_2$ = 1,6. The former is now compared with the remaining projects. There is R570 000 left to spend, and this eliminates project C_3, which is more expensive. C_2 takes the place of C_3 on the basis of the BCR criteria. The list under consideration is now as follows:

Project	Present capital cost	Present benefit	BCR
$A_3.A_2$	40	70	1,75
B	150	250	1,67
C_2	280	405	1,45
D_1	110	175	1,59
$E_3.E_2$	100	190	1,90

$E_3.E_2$ has the best ratio and E_3, replaces E_2 as chosen project. This costs an additional R100 000, leaving R470 000 for spending. The marginal BCR measures within the E group are as follows: $E_4.E_3$ = 1,60, $E_5.E_3$ = 1,80 and $E_6.E_3$ = 1,67. The list of competing projects is now as follows:

Project	Present Capital Cost	Present Benefit	BCR
$A_3.A_2$	40	70	1,75
B	150	250	1,67
C_2	280	405	1,45
D_1	110	175	1,59
$E_5.E_3$	100	360	1,80

Project $E_5.E_3$ has the largest BCR, which means that E_3 is replaced at a cost of R200 000. This leaves only R270 000 and means that C_1 now replaces C_2 on the list of competing projects.

Project	Present Capital Cost	Present Benefit	BCR
$A_3.A_2$	40	70	1,75
B	150	250	1,67
C_1	250	315	1,26
D_1	110	175	1,59
$E_6.E_5$	100	140	1,40

Project A_3 is chosen to replace project A_2 which leaves R230 000 and eliminates C_1. The following projects remain for consideration:

Project	Present Capital Cost	Present Benefit	BCR
$A_4.A_3$	60	90	1,50
B	150	250	1,67
D_1	110	175	1,59
$E_6.E_5$	100	140	1,40

Project B is now chosen, leaving R80 000. Since only $A_4.A_3$ falls within this limit, A_4 replaces A_3, leaving another R20 000 in the budget. Therefore it is decided to fund A_4, B, E_5 and F at a total cost of R980 000. Benefits to the value of R1 950 000 are gained in the process.

In the last step, small adjustments are made to increase the total benefits. The most attractive project eliminated on the grounds of the budget limit was D_1. Sufficient funds can be acquired to pay for D_1 if A_2 is funded instead of A_4. This leaves R15 000 of additional benefits at R10 000 of additional cost, and the final list of projects is therefore:

A_2, B, D_1, E_5 and F.

Underlying this complicated procedure is the very simple notion that the decision-maker should endeavour to achieve the greatest possible benefit for every Rand that s/he spends. A small computer programme will greatly simplify this technique.

CHAPTER 6: PROCEDURE FOR THE APPLICATION OF COST-BENEFIT ANALYSIS

6.1 INTRODUCTION

This chapter sets out the proposed procedure for the practical application of CBA. The procedure is of a general nature, and is, therefore, appropriate for a wide range of public sector projects. Although the procedure implies a number of steps taken in a specific order, the proposed order must not be viewed as absolutely rigid. It may be necessary for the analyst to return to previous steps once s/he has acquired greater insight into the problem.

Furthermore, it is important that there should be constant interaction between the principal and the analyst. This interaction implies, amongst other things, that the analyst can make suggestions to the principal with regard to the amendment of the alternatives and/or the identification of new alternatives.

Such interaction is only meaningful if the principal is acquainted with the theoretical points of departure of CBA, the scope and limitations of the technique, and possible problems with regard to the availability of data. The principal must realise that CBA is part of the decision-making process in order to promote rational decision-making.

6.2 APPLICATION PROCEDURES

In simplified terms a CBA entails:

- Identification of the impact of a project in terms of the costs and benefits resulting from it
- Quantification by measurement or estimation of the streams of costs and benefits that are generated by a project, where measurement and estimation techniques vary according to the nature of the costs and benefits.
- Cost and benefit streams are expressed (i.e. valued) in a common monetary denominator
- Shadow prices are used in the valuation of some cost or benefit streams when market prices are either unavailable or inappropriate because they are distorted due to market imperfections.
- Discounting of the streams of costs and benefits to present values to allow comparison of the value of costs and benefits that are incurred, or which accrue over different periods of time
- A standardised rate is selected as the discount rate for the calculation of the present values of all cost and benefit streams.
- Determination of the present value of costs and benefits, and the calculation of the internal rate of return of the project (the IRR) and the ratio of benefits to costs (the BCR), and
- Sensitivity analysis is undertaken of the impact of variation of cost and benefit streams on project IRR and BCR, where IRR in the economic application of CBA is known as the economic rate of return (ERR).

Figure 6.1 below provides a conceptual framework for the development of CBA, where the framework charts the process and steps of CBA, and indicates the activities required.

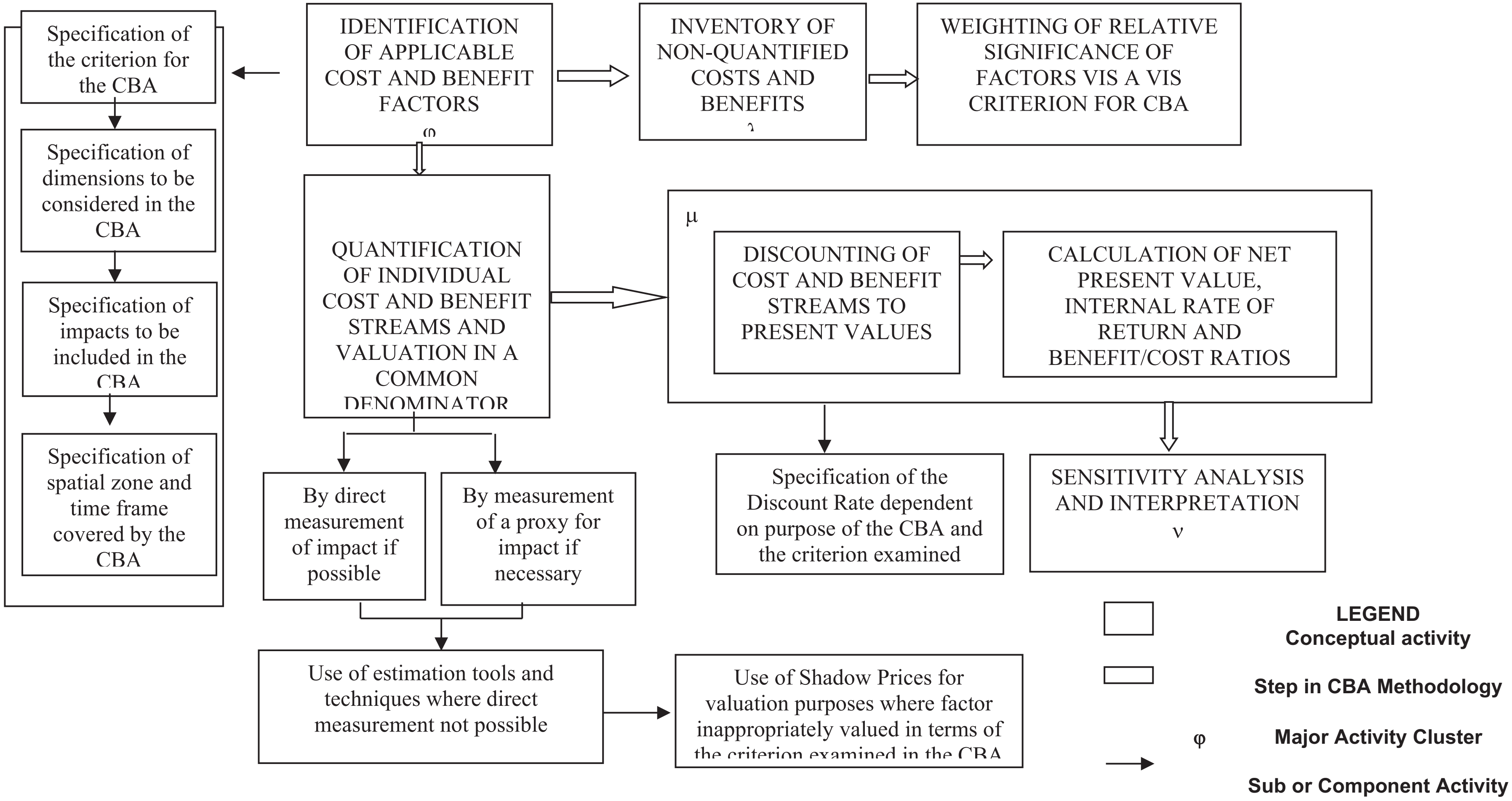


Figure 6.1: Conceptual Framework for Development of Cost-Benefit Analysis Practice

Source: © Development Bank of Southern Africa, 2000.

Some of the activities are of a conceptual nature, and are required to define the scope and focus of the analysis (such as specification of the purpose of the analysis, the criterion to be examined, dimensions to be considered, and impacts to be included), whilst other conceptual activities are required to give effect to the intent of the analysis (such as use of shadow prices where necessary and the defining of a discount rate with which to calculate the present values of cost and benefit streams). With the aid of the above framework, the generic nature and process of CBA is described below.

6.2.1 Steps in Execution of Cost-Benefit Analysis

The practical steps required to execute CBA are summarised in Table 6.1 below[18].

Table 6.1: Practical Steps in Execution of CBA

Step	Activity
1	**Specification of the purpose of the CBA and specification of project boundaries within which the analysis is to be conducted.** **By the setting of a perspective, it is important that the analyst will acquaint her/himself with all the relevant facts in order to develop a feeling for the problem, the proposed solutions and the milieu within which a recommendation is to be made.**
2	**Identification of all impacts, i.e. costs and benefits generated by a project within the boundaries specified for analysis. It must once again be emphasised that the analyst should measure the costs and benefits relative to the nil alternative. Further, it is important that the analysis should not be done in terms of only a single set of parameters, but that a whole number of critical scenarios should be investigated with the aid of sensitivity analysis.**
3	**Quantification of cost and benefit streams via direct measurement of the impact itself or, if necessary, measurement of an appropriate proxy for the impact. If direct measurement of the impact or proxy is not possible, the impact or proxy should be estimated using appropriate estimation tools and techniques.**
4	**Impacts, which are difficult to measure, should nevertheless be recorded in qualitative terms, and, if possible, ranked in order of importance.** **The analyst should also, as far as possible, quantify the social consequences of a project, and where such quantification is not possible, they should be reported qualitatively. The following social consequences of a project should be addressed:** • Distributional effects between income groups, population groups or geographical regions; • Welfare consequences; • Political and constitutional implications; • Strategic consequences; • Prestige; • The creation of job opportunities; • The achievement of economic independence; and • Population movements.
5	**Discounting of project cost and benefit streams to present values**
6	**Calculation of NPV, ERR and BCR to define the value of the project in economic terms.**
7	**Sensitivity analysis on the cost and benefit streams. The analysis should be based on risk factors, which have been identified in the project setting.**
8	**Interpretation and reporting of the results of the analysis.**

18 Procedures used by DBSA.

6.3 REPORT WRITING

It is necessary that the research should be well documented for future reference. However, it is important to convey to the decision-maker the results of the CBA in such a manner that (s)he understands the project and is able to take a decision without studying detailed unnecessary information.

The last task of the analyst involves the completion of a summary that gives the decision-maker an overview of the most important aspects of the analysis. The summary should preferably not be longer than five pages, and should cover the following aspects – it is important to note that the following should be seen as a guideline that can be deviated from by way of exception where valid reasons exist:

Purpose of the CBA

This section contains a short specification of the purpose of the CBA, formulated as a problem statement. The boundaries (project boundaries) within which the analysis was conducted are also specified. In more detail it entails the following:

(i) An introductory paragraph that covers the following aspects:
- The long-term expenditure programme and the expenditure vote/programme within which the project must/can be accommodated;
- The fact that the summary is intended to set out the most important financial, economic and social implications of the project.

(ii) The project identification, which includes the following:
- The determination of a need; an explanation of the present situation, the nature of the problem that gave rise to the need for a solution, and the solution that is presented;
- The technical solutions; an explanation of the alternatives identified by the principal and evaluated in the analysis.

(iii) The aim of the analysis:
- An explanation of the fact that the aim of the analysis is to identify the financial, economic and social implications of the alternatives in order to identify the best alternative.
- An explanation of the costs and benefits included and excluded from the analysis.

(iv) The limitations:
- An explanation of any considerations that may lead to the elimination of any of the alternatives, for example strategic or political implications, or legal restrictions.

Key assumptions

This section contains a specification of the key assumptions and proxies used in the calculation of the CBA.

Results of CBA

In this section, the results of the CBA calculations of NPV, ERR and BCR are reported. They are then interpreted against project selection criteria.

Aspects that should be reported on include:
- tariffs
- government and other subsidies
- funding options.

Inventory of non-quantified costs and benefits

In this section, an inventory of non-quantified costs and benefits is made and their relative significance to project economic impact, indicated. It should indicate the social, welfare, political, constitutional and strategic consequences.

Sensitivity Analysis

A description of the sensitivity and critical considerations, which include:

- The identification of that parameter (assumption or prediction) that has been pointed out as the most critical;
- provision of the most likely spectrum of values of this parameter;
- Identification of the cut-off point within this spectrum of values;
- Explanation that the success of the project may depend on the completion and/or success of another project or projects.

Reasoned Recommendation

In this section the rationale for recommending or declining support for a project on the basis of impact on society welfare is summarised.

CHAPTER 7: DETERMINING SHADOW AND SURROGATE PRICES FOR SOUTH AFRICA

7.1 INTRODUCTION

In practice, determining shadow and surrogate/associated prices for use in a CBA is normally a task that requires the application of underlying economic principles to specific circumstances. This requires a basic knowledge of the relevant economic principles and the specific inputs and outputs being analysed. However, it is important to bear in mind that, in the light of the various prices, and the variation in prices used in a CBA, it is not possible to calculate shadow and surrogate prices for every input and output.

Nevertheless, general practical guidelines and broad estimates can be provided for prices of certain inputs and outputs. This is done on the understanding that certain cases may require a more detailed approach. Where the results of a CBA can be largely dependent on the method of shadow price calculation, the effect of alternative shadow prices on the results of a project should be subjected to a sensitivity analysis.

7.2 THEORY OF THE REAL SOCIAL DISCOUNT RATE

7.2.1 Over-arching Approach to Determine the Discount Rate

The United States Environment Protection Agency (EPA), cited by Luus and Mullins (2007)[19], distinguishes between two major discounting approaches: intra-generational discounting and inter-generational discounting, depending on the expected impact of an investment decision over time.

7.2.1.1 Intra-Generational Discounting

The intra-generational discounting approach is best suited for analysing costs and benefits that derive from an investment over a relatively short period of time – up to decades-long time frames. This approach does not explicitly confront the extremely long-time horizons and impacts of an investment decision on unborn generations. Generally, this approach applies an exponential[20] discounting method, using a constant discount rate converting the future costs and benefits of a given investment into net present values.

7.2.1.2 Inter-Generational Discounting

On the other hand, the inter-generational discounting approach is appropriate for discounting future costs and benefits derived from an investment over extremely long time periods, the impact of which will spread over more than a generation, or even hundreds of years.

Generally, the inter-generational discounting approach is used for discounting long-term impacts such as climate change. Unlike the intra-generational approach, the inter-generational approach makes use of a hyperbolic[21] discounting approach that applies a variable discount rate that does not effectively decline as steeply towards the end of the programming period.

[19] Luus C.W. and Mullins D. 2008. The Discount Rate for Cost-Benefit Analysis by the DBSA. p 8.
[20] See Annexure 2 for more information concerning intra-generational discounting and exponential discounting.
[21] See Annexure 2 for more information concerning inter-generational discounting and hyperbolic discounting.

7.3 THEORETICAL SUBSTRUCTURE FOR THE CALCULATION OF THE SOUTH AFRICAN DISCOUNT RATE

7.3.1 Social Opportunity Cost Rate Method

As already indicated, the social opportunity cost rate method is the rate of return to balance the social opportunity cost of undertaking the project in the public sector versus the next best alternative in the private sector where rates are observable. The formula to calculate this rate is based mostly on the yield that a project in the private sector earns in real terms.

The weighted average cost of capital (WACC) formula forms the basis of the social opportunity cost rate method. The discount rate would be the weighted average cost of capital. The formula is:

$$WACC = (1 - Tc)\ kb\ D/ (D + E) + ke\ E/ (D + E)$$

Where:
- Tc = corporate tax rate
- kb = return on debt
- ke = return on equity
- D = amount of bonds (debt)
- E = amount of equity (share capital)

In the study conducted by Luus and Mullins (2008)[22], this rate was calculated as 9.6% if no taxes are assumed (i.e. for public sector funded projects).

7.3.2 Social Time Preference Rate Method

Another school of thought argues that the correct rate of discount to be used for public projects is the social time preference rate (STPR), which is also called the subjective communal discount rate, or the consumption rate of interest (CRI). The rationale for this argument is quite simple: the purpose behind investment decisions is to increase future consumption, which involves a sacrifice of present consumption. Therefore, what we need to do is ascertain the net consumption stream of an investment project and then use the STPR. The constituent elements of such a social time preference rate are:

- Diminishing marginal utility of increasing consumption;
- Pure time discount rate; and
- Risk.

A simplified linear form of this model is as follows:

STPR = i.e. + m

Where:
- STPR = social time preference rate
- g = growth rate of real per-capita income / consumption
- e = elasticity of marginal utility of income / consumption
- m = pure time discount rate

[22] For a detailed discussion on the empirical rates and assumptions used, see: Luus C.W. and Mullins D. (2008); The Discount Rate for Cost-Benefit Analysis by the DBSA

Based on historical per-capita income and expenditure data for South Africa, and global empirical research on pure discount rates, an STPR of 8.35% was arrived at in the study conducted by Luus and Mullins (2008)[23].

Considering that the Third Edition of the CBA manual is already recommending a real discount rate of 8%, and that this rate is used in project evaluations in the public sector, it seems appropriate to retain 8% as the applicable discount rate for South Africa. Based on current evidence, the 8% discount rate would also be closer to the theoretically argued and calculated rates based on opportunity costs and time preferences.

7.3.3 Discount Rate for Intra-Generation Projects

The real social discount rate proposed for South Africa is based on the principle of the social rate of time preference (SRTP) method, which is one of the methods of calculating a real discount rate for intra-generational projects. The SRTP is the rate at which households are willing to trade a unit of current consumption in exchange for more future consumption.

There are two models for estimating the SRTP. One is the approximation of the SRTP by the after-tax rate of return of government bonds or other low-risk marketable securities. The other is the application of the Ramsey formula[24], according to which the SRTP is derived from an economic growth model, and SRTP is the sum of two elements: the first is the utility discount rate reflecting the pure time preference of consumers; and the second is the product of two sub-elements, i.e. the elasticity of the marginal utility of consumption, and the annual rate of growth of per-capita real consumption. The second element of the formula reflects the fact that, when per-capita income grows over time, consumption is also expected to grow, and people will become less willing to save in the current period to obtain more in the future because of the diminishing marginal utility of consumption.

There is a general consensus amongst economists worldwide that the SRTP approach should be used especially when discounting inter-generational projects[25]. Also, the SRTP seems appropriate for South Africa because it proves to be much more stable and does not fluctuate with the business cycle such as other rates.

It should be noted that, apart from the SRTP method, three other methods of calculating the discount rate for intra-generational projects can be put forward: (i) Social opportunity cost (SOC), (ii) Weighted average approach, and (iii) Shadow price of capital (SPC) approach.

Social Opportunity Cost

The social rate of discount (SOC) calculated by this method is based on the rate of return of the next best alternative use of funds. Generally, the next best alternative use of funds is thought to be the average return on investment in the private sector. Luus and Mullins (2008)[26] cited three models for estimating the social opportunity cost which are: Capital asset pricing models (CAPM); Arbitrage pricing theory (APT), and Fama and French's multi-factor model.

Weighted Average Approach

Since SRTP does not take into account the social opportunity cost of public investment, and SOC does not take into account the impact of public investment on consumption spending, several economists have suggested that the social discount rate should be a weighted average of the SRTP and SOC[27] .

[23] For a detailed discussion on the empirical rates and assumptions used, see: Luus C.W. and Mullins D. (2008); The Discount Rate for Cost-Benefit Analysis by the DBSA
[24] Zhuang J., Liang Z., Lin T., and De Guzman F. 2007. Ibid. p4.
[25] Zhuang J., Liang Z., Lin T., and De Guzman F. 2007. Ibid. p16.
[26] Luus, CW., and Mullins, D., 2008. Ibid. p. 19.
[27] Boardman, J. and Winning W. 1996. CBA – Concepts and Practice; Prentice-Hall Inc; p28-29.

Shadow Price of Capital Approach

The shadow price of capital (SPC) approach attempts to reconcile the SRTP approach with that of SOC and, at the same time, addresses the limitation of the weighted average approach. In practice it is very difficult to ascertain what the SPC actually would be and requires sophisticated formulas and models.

7.3.4 Discount Rate for Inter-Generational

Luus and Mullins (2008, distinguished between the social welfare planner approach and approaches based on existing individual's time preferences as methods of calculating a social discount rate for extremely long-term projects, which involve unborn generations. The two methods can be described below.

Social Welfare Planner Approach

One popular recommendation is that social discounting for inter-generational projects should be based upon optimal growth analyses. In optimal growth models, the social rate of discount generally equals the sum of two factors. One is a discount rate for pure time preference, which measures the degree to which the social planner favours the utility of current and near future members of society over that of individuals in the more distant future. The second factor is an adjustment reflecting the fact that the marginal utility of consumption will decline over time as consumption per-capital increases (equal to the elasticity of marginal utility multiplied by the rate of increase of consumption over time).

Approaches Based on Existing Individuals' Time and Consumption Preferences

The major alternative to the social welfare planner approach for inter-generational discounting is to rely on the preferences of current individuals that will indicate an appropriate discount rate. At its core, this perspective rejects the view that the problem is one of balancing the interests of all humans who will live now and in the future. Instead, according to this perspective, it is fundamentally about individuals alive today allocating their scarce resources to competing ends, one of which happens to be the welfare of future generations.

Both the above two methods mentioned make use of the hyperbolic discounting method when analysing costs and benefits that occur in the "far future", where in hyperbolic discounting, the discount rate is not constant over the programming period, and can be presented algebraically as follow:

Equation 1:

$$PV = \frac{FV}{(1 + rt)}$$

Where:
r = discount rate;
t = time

As indicated before, the exponential discounting method is mostly applied to projects straddling over intra-generational periods. The discount rate remains constant, and can be presented by the following equation:
Equation 2:

$$PV = \frac{FV}{(1 + r)^t}$$

The following Table 7.1 explains the differences in impact of an investment project with a discount rate of 8% over 100 years, using either the exponential or the hyperbolic discounting method.

Table 7.1: Difference between Exponential and Hyperbolic Discounting (Rand)

Years	Observed Value	Exponential discounting	Hyperbolic Discounting
10	100	46.32	55.56
20	100	21.45	38.46
30	100	9.94	29.41
40	100	4.60	23.81
50	100	2.13	20.00
60	100	0.99	17.24
70	100	0.46	15.15
80	100	0.21	13.51
90	100	0.10	12.20
100	100	0.05	11.11
Total Net Present Value		86.25	236.45

Source: Conningarth simulation.

Based on a discount rate of 8%, it can be seen from Table 7.1 that the present value of an investment, using exponential discounting, declines rapidly during the latter part of the programming period. In contrast, the present value of an investment, using hyperbolic discounting, takes much longer before it starts to taper off and, when it does, it is at a much slower rate than the exponential method.

This method makes it more suitable to deal with long-term inter-generational projects giving more weight to benefits/costs that might accrue at the latter parts of the programming periods. This way of discounting future benefits and costs makes it more suitable for analysing the environmental impacts of projects.

It is important to note that the hyperbolic discount figure is much closer to the observation figures (future value) and it is advisable to make use of the hyperbolic discounting for analysing the environmental impact of an investment project.

7.4 CURRENT INTERNATIONAL DEVELOPMENT REGARDING DISCOUNT RATES

This section provides a survey of the social discount rates used by different countries and financial institutions around the world. Table 7.2 below contains the recommended discount rate used by various countries around the world. As is to be expected the discount rates vary significantly among countries.

Table 7.2: Real Social Discount Rates in Selected Countries and Institutions

Country	Discount Rate (percent)	Theoretical Basis
Philippines	1991: 8% : SOC rate annually reviewed	SOC approach
Canada	Pre- 2007 rate 10%, after 2007 rate is 8%	SOC approach
Peoples Republic of China	8% for short term and medium-term projects: lower than 8% for long-term projects	Weighted Average Approach
France	Real discount rate set since 1960:set at 8% in 1985 and 4% in 2005	1985 : To keep a balance between public and private sector investment
Germany	1999 : 4% 2004 : 3%	Based on federal refinancing rate, which was over the late 1990s was 6% nominal: average GDP deflator (2%) giving 4% real.
India	12%	SOC Approach
Italy	5%	SRTP Approach
New Zealand	Before 2008 standard rate of 10%. Post 2008 default of 5%	SOC Approach
Norway	1978 : 7% 1998: 3.5%	Government borrowing rate in real terms
Pakistan	12%	SOC approach
Spain	6% for transport : 4% for water	SRTP approach
United Kingdom	1967 : 8% 1969 : 10% 1978 : 5% 1989 : 6% 2003 : 3.5% Different rates lower than 3.5% for long term projects over 30 years	SOC approach until 1980s; thereafter SRTP approach
US (Office of Management and Budget)	Before 1992 : 10%;after 1992 : 7%	Mainly SOC approach
US (Congressional Budget Office and General Accounting Office)	Rate of marketable Treasury debt with maturity comparable to project span	SRTP approach
US (Environmental Protection Agency)	Intragenerational discounting: 2-3% subject to sensitivity analysis in the range of 2-3% and at 7%. Intergenerational discounting : range of 0.5-3% and at 7%	SRTP approach

Source: Asian Development Bank (ADB). Zhuang et al (May 2007).

Note: Following the release of the second edition of the Manual, the above table updates the discount rates for Canada (now 5%) and New Zealand (5%).

Broad conclusions that can be drawn from the literature on discount rates are (1) there is no one-size-fits-all solution to the choice of the social discount rate, (2) that countries often have multiple discount rates for different public interventions and (3) that sensitivity testing should form an important component of selecting a specific discount rate.

As an example, the European Commission (EC) recommends the use of a SOC rate in cases where the financial return of the project is an important public concern, such as investment by a public enterprise that is expected to operate without subsidies. On the other hand, the EC recommends the use of an SRTP for the more typical CBA of public projects. Likewise, Spain uses 6% for transport projects, but a lower SRTP of 4% for water projects. The Office of Management and Budget in the US recommends a real rate of between 2.5-3%, depending on the horizon of the project under consideration, based on the cost of borrowing for the government to assess the cost effectiveness of potential interventions and 7% for CBA.

Theoretically, differences amongst countries can be attributed to the differences in time preferences of societies, where developing countries generally use higher discount rates, whilst developed countries use lower discount rates. This can be explained by various factors such as that developing countries have a capital shortage compared to developed countries; and that the risk factor is larger with developing countries compared with that in developed countries. There are also other factors such as differing inflation rates, quality and quantity of labour resources, etc. The literature suggests that a lower discount rate is labour unfriendly, therefore, it favours capital-intensive projects, whilst the opposite is true for higher discount rates.

Some bodies face institutional constraints on explicitly promoting a specific formal analytical framework as discussed earlier. According to Zhuang et al. (2007), Development Finance Institutions such as the World Bank, African Development Bank, Asia Development Bank and the European Bank for Reconstruction and Development apply a real social discount rate of between 10 and 12%. This benchmark has not changed over the years.

7.5 PROPOSED DISCOUNT RATE

7.5.1 Arguments for a Lower Discount Rate

Currently, there is a view amongst some economists that the current 8% discount rate applicable in South Africa might be too high. This is sometimes attributed to the fact that some developed countries have lowered their discount rates over the course of the last decade (see Table 7.2 France, Norway, Germany, New Zealand and Canada). The rationale why these countries have lowered their discounting rates is that their interest rates have declined appreciably in recent years.

The following arguments do not support the view of lowering the current 8% discount rate:

- In a survey conducted by the Asian Development Bank[28] on the Real Social Discount Rate, the following findings are worth highlighting: “The survey’s authors define the real social discount rate as a reflection of a society’s relative valuation on today’s wellbeing versus wellbeing in the future. The appropriate selection of a social discount rate is crucial for CBA, and has important implications for resource allocations. There is wide diversity in social rates, with developed nations typically applying a lower rate (3-7%) than developing nations (8-15%).
- Given the relatively low domestic savings rate in South Africa, and the higher savings rates in capital exporting countries, one can argue that the real discount rate in South Africa is still relatively low. Interest rates in advanced economies came down significantly in recent years as well as in South Africa where both the real interest rate and the SRTP are well below 8%. Nevertheless, a discount rate of 8%

[28] Symons, E-K Reviewing Social Discount Rates. Asian development Bank No. 2 June 2008.

does not reflect South Africa's true shortage of investment capital, and, therefore, the premium on using capital resources more productively. At present (2018-2020) gross domestic savings in South Africa have dropped below 15.0% of GDP, which is well below saving rates in peer countries. The GDP growth rate breached 3% on the upside only once over the last ten years (3.3% in 2011). In order to generate a 6% sustainable economic growth required to absorb unemployment in South Africa, it will imply more pressure on using scarce capital resources productively. One way to do this is to have a high discount rate that ensures that only the best projects are considered for funding. A relative high discount rate also favoured labour intensive projects.

- By using different methods for estimating the real social discount rate for South Africa, Luus and Mullins (2008)[29] found that most of these estimates range between 8.4 and 9.6% in real terms.
- The South African 10-year Government Bond rate can also be used as an indication of an opportunity cost of using capital (Discount Rate). According to Figure 7.1, The South African Government Bond Yield averaged at 2.7% (real terms) over the period 2004-2020. It is important to note that the Government Bond rate is regarded as a risk-free rate. If a risk premium of between 5% to 6% is added to the risk-free rate of 2.7% it translates to an equivalent discount in the order of 8%. A risk premium of between 5% and 6% could be viewed as conservative. This 6% can also be viewed as a risk premium that the private sector takes into account when they make investment decisions.

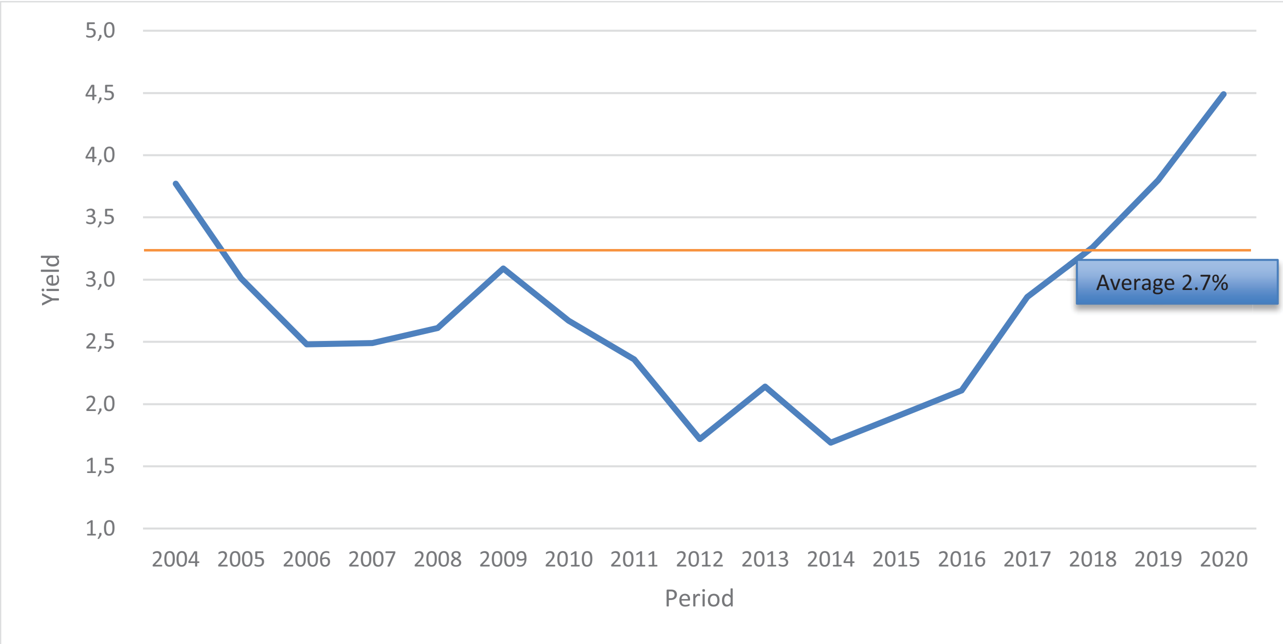


Figure 7.1: South African Government Bonds Real Yield, (2004-2020)

Source: South African Reserve Bank

[29] For a detailed discussion on the empirical rates and assumptions used, see: Luus C.W. and Mullins D. (2008); The Discount Rate for Cost-Benefit Analysis by the DBSA

7.5.2 Recommended Discount Rate

Taking into account the international discount rate benchmarks and the marginal return on capital approach, the current “official” 8% discount rate applicable in South Africa still seems reasonable for both inter and intra-generational discounting.

Therefore, a real discount rate of 8% is recommended for use in all standard CBA undertaken for evaluation of programmes and projects in South Africa. This is also applicable for projects involving environmental purposes. Specifically see how environmental projects should be handled in the subsequent section, (7.5.3).

7.5.3 Discounting for Environment Purposes

Note: This section should be read in tandem with Section 7.3.3. Due to the long-term impact of environmental issues such as climate change and global warming on future generations, the discount rate has received renewed international interest on how discounting should be applied with regard to such projects, the impact of which could spread over more than one generation or even hundreds of years[30].

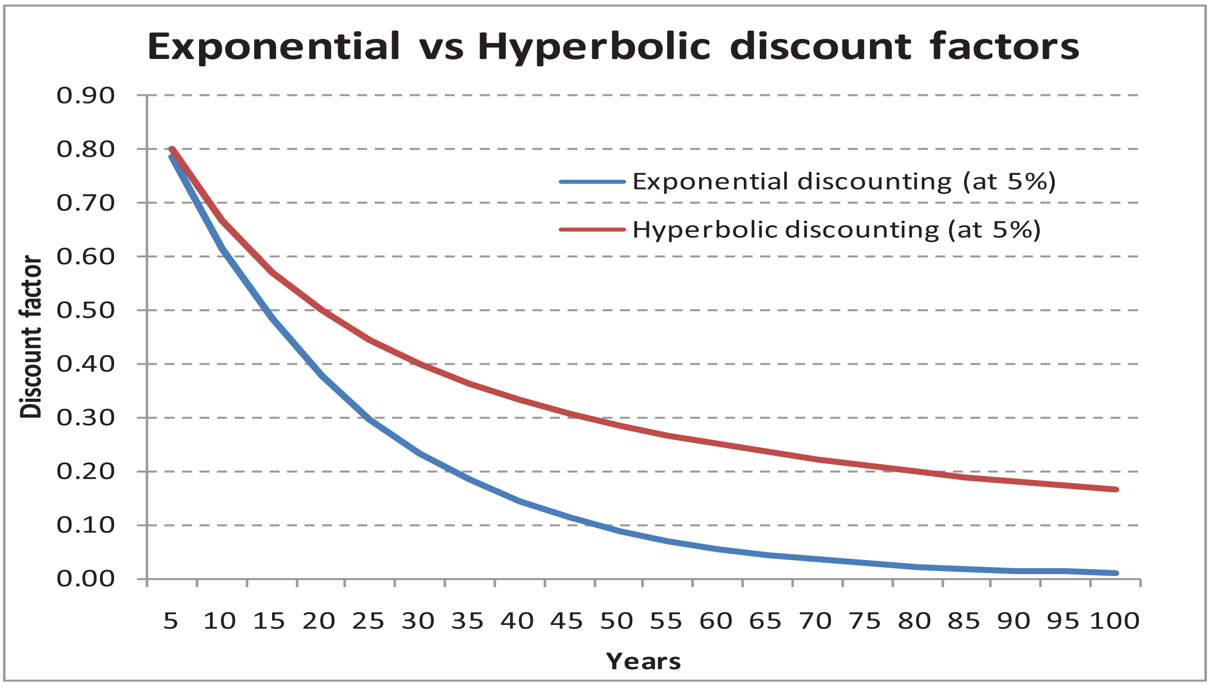
The fourth edition of the CBA Manual acknowledges that problems exist that should be addressed with regard to environmental issues in terms of their impact that only originate over the long term. As explained earlier, the conventional discount rate method (exponential) does not accommodate these phenomena.
It is proposed that environment projects in South Africa should be discounted at the official discount rate of 8%, but, by making use of a hyperbolic discounting factor and not the conventional (exponential) discount rate. Furthermore, it is also important that these impacts should be discounted over a longer time horizon as compared to conventional private and public sector project scenarios to properly internalise their impacts over the longer term.

The graph below portrays the difference in outcome of the exponential versus the hyperbolic discounting method. The hyperbolic discount method gives more weight to environmental issues over the long term, whilst the exponential method is appropriate over the general life span of many commercial and social projects. The environmental impact is normally not less severe over the early years of the programming period.

[30] Zhuang J., Liang Z., Lin T., and De Guzman F. 2007. Theory and Practice in the Choice of Social Discount Rate for Cost-benefit Analysis: A Survey. Asian Development Bank. Working paper series No. 94. p 14.

Graph 7.1: The Trend of the Discount Factors Using Exponential and Hyperbolic Discounting

Source: Luus and Mullins (2008).



7.6 SHADOW PRICES FOR LABOUR INPUTS

As was discussed under the heading of shadow prices for labour (Paragraph 2.4.3 in Chapter 2), it is highly probable that the price of labour will deviate from the marginal product of labour; and, as such, shadow prices for labour should be used to determine the correct impact of labour utilisation.

7.6.1 Unskilled Labour

The full-employment basis for the pricing of labour is the market price of labour for all workers. Where unemployment does exist, shadow wages are estimated for unskilled, and in some instances, semi-skilled workers. Professionals, managers and skilled labour should be valued at market prices, even where unemployment exists. The principles that apply to the determination of shadow wages are set out in detail in Paragraph 2.4.3 in Chapter 2.

The methodology used for the calculation of shadow wages for unskilled workers is discussed in **Box 7.1**.

Box 7.1: Calculation of Shadow Wages for Unskilled Workers

The source of 'official' labour market statistics in South Africa is the Quarterly Labour Force Survey (QLFS). The survey is compiled quarterly by Statistics South Africa (Stats SA); however, the comparatively small sample and volatility associated with quarterly sampling surveys, makes it advisable to work with annual data. Specific tables are not published by Stats SA, which means that they need to be compiled from the original data, and transformed and aggregated into the correct format.

Nine occupational groups are provided for in the survey. In order to obtain a wage rate for unskilled labour, the group entitled "elementary occupation" was utilised. The wage rates are obtained from the Labour Market Dynamic Survey (LMDS) compiled by StatsSA. The labour wages in the LMDS are in 2019 base-year prices, and were converted to 2020 base-year prices with an index calculated from the total remuneration-per-worker in the non-agricultural sector time series available from the Reserve Bank website (code KBP7013).

In principle, the shadow price for unskilled labourers is equal to the per-capita income in urban and non-urban areas in the various provinces, with the per-capita income of labourers being viewed as the economic value of labour. This shadow price is used as a proxy of labour's opportunity cost, i.e. the value of production lost to the economy when labour moves from an existing job to a newly created job, or from an unemployed situation to a new job.

It is important to note that all the Tables referred to in these sections are grouped together in section 7.12.

Table 7.3 reflects the weekly, monthly and annual market wages for unskilled labourers by province (data provided by Stats SA). These shadow wages are used only where unemployment exists, and the skill levels of workers are low. If the workers for a project cannot be limited to a specific province, then the relevant national figure should be used. If sufficient information cannot be found, unemployment amongst workers involved should be viewed as insignificant.

For practical purposes, it is sometimes useful to work with a shadow wage rate factor, and not with nominal wage rates as such. Table 7.4(a) reflects the factors for adjustment of the market wage rate for unskilled labourers per province. By expressing the unskilled labour remuneration for urban and non-urban areas in each province relative to the urban wage rate in Gauteng (the most prosperous province), the shadow wage rate factors reflect the relative benefit poorer provinces and non-urban areas will receive when conducting CBA.

7.6.2 Skilled Labour

As mentioned above, professionals, managers and skilled labour should be valued at market prices even where unemployment exists. However, for purposes of completeness and convenience, the relevant remuneration for these categories is given to assist users of this manual. The methodology used for the relevant calculations is given in Box 7.2.

Box 7.2: Calculation of Shadow Prices for Skilled Labour

The wage rate of skilled labour was obtained from the Labour Force Survey (LFS) 2021, Statistical Release P0211. Nine occupation groups were given in the survey:

- Legislators, senior officials and managers
- Professionals
- Technicians
- Office clerks
- Service, shop and market sales
- Skilled agriculture and fishing
- Crafts and related trades
- Plant and machine operators
- Elementary occupations

The first 8 groups were used as they were seen to be skilled and semi-skilled, with elementary occupations being deemed to be unskilled. If required, the same process used to inflate wage rates (see box 1) for unskilled labour should be utilised to inflate the wage rates for skilled labour.

Table 7.5 provides the estimated remuneration for the 8 occupational categories that make up skilled and semi-skilled labour. For purposes of this manual, occupations one and two are deemed skilled labour whilst occupations three to eight are deemed semi-skilled.

7.7 FOREIGN EXCHANGE

The shadow price of the real effective exchange rate of the Rand (i.e. the weighted average exchange rate of the Rand against the currencies of the RSA's most important trading partners, taking into account inflation differentials) is given in Table 7.6. The methodology for determining the relevant rate is explained in Box 7.3**.**

Box 7.3: Calculation of Shadow Price for the Real Effective Exchange Rate

A historical series of the real effective exchange rate of the Rand from 1970 to 2021 was obtained from the South African Reserve Bank (SARB), with 2020 being used as the base year. A long-term time series and trend analysis was applied to the data in order to determine a long-term estimate of the direction of the real effective exchange rate of the Rand.

The long-term trend of the real effective exchange rate was then used to estimate the real effective exchange rate up to the year 2040. The trend that best fits reflect a constant annual rate of change (exponential fit) was used to determine a constant rate of change that a depreciation of the real effective Rand over the long-term, which translates into an average depreciation of 0.6% per annum from 2020 to 2040, and then continue to depreciate at that rate as shown in Table 7.6.

Given the various explanatory variables (i.e. time, politics, international commodity prices, international capital flows, etc.) that play a role in influencing the exchange value of the Rand, the Rand remains volatile. The reason for this is that developments related to the variables mentioned above are unpredictable over the medium- to long-term but there appears to be constant depreciation of the real effective Rand with trading partners after taking account of inflation differentials with major trading partners.

The Current Account Balance of the Balance of Payments (BoP), but, more so, the movements on the Financial Account of the Balance of Payments, tend to have a profound impact on the Rand as financial flows not only reflect the investor mood, but also sentiments towards South Africa. This long-term trend, nevertheless, captures the major impacts on the Rand, i.e. that of import and export volumes, forex market perceptions, foreign financial flows, the exchange value of the currencies of South Africa's most important trading partners, and inflation differentials between South Africa and its trading partners.

It is accepted that currencies in Southern Africa that are on par with the Rand will follow the same trend as the effective real exchange rate of the Rand. As such, the shadow price for foreign currencies also applies to projects in Swaziland and Lesotho.

7.8 GOODS AND SERVICES (EXCLUDING FUEL AND ELECTRICITY)

The underlying principles for the valuation of inputs and outputs have been discussed in Paragraph 2.4.2. In this regard the following guidelines are provided:

(i) The opportunity costs of agricultural products traded internationally are indicated by commodity prices on world markets, as given in International Financial Statistics, which are issued monthly by the International Monetary Fund. For restricted imports that require permits, and to which import duties and surcharges are applied, reference is made to the Customs Tariff Book issued by Jacobsons Publishers (Pty) Limited[31]. This data is also available from Cargo Info Africa.

(ii) Details of goods on which excise and other domestic taxes are payable are given in the schedule to the Customs and Excise Act. As a result of ongoing adjustments made in the National Budget of the Department of Finance, it is necessary to ensure that the most recent information is obtained from the relevant Departments.

Details of goods on which VAT (Value Added Tax) is payable can be obtained from the South African Revenue Service (SARS). In Box 7.4 the calculation of shadow prices for goods and services is denoted.

Box 7.4: Calculation of Shadow Prices for Goods and Services

TAXABLE SUPPLIES

A taxable supply is any supply of goods or services by a vendor in the course of furtherance of an enterprise. Tax is charged at one of the following rates:

- Standard rate, currently 15%
- Zero-rate (i.e. 0%)

Standard Rated Supplies

As a general rule, all goods and services are standard rated unless specifically zero-rated or exempt.

Standard rated supplies are taxable supplies, taxed at the rate of 15%. These include the supply of both goods and services that are not taxed at the rate of 0%, or exempt. Some examples of standard rated supplies are the supply of:

- aircraft fuel
- books and newspapers
- building materials and services
- business assets sold
- cigarettes, cool drinks and liquor
- white bread
- electricity, water and refuse removals
- clothing -
- furniture
- hotel accommodation
- meat or fish
- lawyer’s services
- medicines

local aeroplane flights

- medical services (other than by State hospitals)
- transport of goods
- motor repairs
- motor vehicles and spares

- paraffin (excluding illuminating kerosene)
- postage stamps
- telephone services
- restaurant services
- washing powder
- entrance fees to sporting events

Zero-rated supplies; taxable supplies, taxed at a rate of 0%. These include:
- certain foodstuffs (except when sold as a meal or refreshment)
- brown bread
- dried mealies
- brown bread flour excl. bran
- stamp
- eggs
- fresh/frozen fruit and vegetables
- maize meal
- dried beans
- lentils
- pilchards in tins or cans
- rice
- vegetable oil excluding olive oil
- milk, cultured milk, milk powder and dairy powder blend
- edible legumes and pulses of leguminous plants
- illuminating kerosene
- fuel levy goods (i.e. petrol and diesel)
- sale of a business or part of a business as a going concern (if in writing and meeting certain requirements).
- certain services provided to foreign residents and businesses – provided goods are temporarily imported for modification, service or repair and the importer furnishes you with a VAT 262 form which has been completed and certified by the Controller of Customs
- direct exports (See Chapter 10 of VAT 404 VAT Guide for Vendors)

DEEMED SUPPLIES

As a registered vendor, you may sometimes be required to pay output tax even though you have not supplied any goods or services. These are called deemed supplies.

Circumstances that will give rise to deemed taxable supplies include the following:
- goods/services taken for own use
- certain fringe benefits to staff
- assets retained at the time of deregistering as a vendor
- Short-term insurance claims that have been paid to you in respect of your business (i.e. Insurance pay-out received for damaged stock.
- subsidies or grants received from the State
- goods acquired under an instalment credit agreement that have been repossessed from you

EXEMPT SUPPLIES

Exempt supplies are supplies of goods or services on which VAT is not chargeable at either the standard rate or the zero-rate and do not form part of your taxable turnover. If you make only exempt supplies, you may not register as a vendor for VAT purposes. VAT incurred on any expenses in order to make exempt supplies may not be claimed as an input tax credit.

Exempt supplies include the following:

- financial services (interest, life insurance, medical schemes, provident, pension and retirement annuity funds)
- donated goods or services sold by non-profit bodies (i.e. church bazaars)
- renting a dwelling for use as a private home (but not holiday accommodation)
- passenger transport in South Africa by taxi, bus or train
- educational services (crèches, primary and secondary schools, universities, technikons and other institutions registered under an educational Act.)

The prices of services provided by Transnet and the Post Office are determined administratively. Since the prices of many of Transnet's services are supposed to be market-related, and the new national transport policy in the RSA allows for free competition between the different modes of transport, the difference between market-determined and controlled prices for land transport should gradually disappear. Therefore, as the public transport component of most projects is fairly small, it is doubtful whether the calculation of shadow prices for this purpose is necessary. It may, however, be important where the transport content of a project is high, or where a decision has to be made concerning the establishment of transport infrastructure.

The same approach should be adopted in respect of services delivered by the Post and Telecommunication services.

7.9 SHADOW FUEL PRICES

The shadow price of fuel is the pump price of fuel, minus levies and taxes for those users who do not directly benefit. As such, taxes that can be viewed as consumer levies on roads may be included, whilst other general fuel taxes that are used to benefit general public services may be excluded.

The shadow price of farm diesel differs from the shadow price of diesel for road transport as user levies for roads and vehicle accident insurance are excluded. The diesel rebate for farmers is a refund on diesel for farming purposes.

The shadow price of diesel used for construction purposes differs from the road transport diesel price where the diesel price for construction purposes excludes the Road Accident Fund (RAF) levy and government expenditure on roads.

General government (including national, provincial, local spheres of government and extra government funds) recurrent expenditure on roads includes spending on road maintenance, traffic management and road safety. Dividing the above-mentioned recurrent expenditure on existing roads with the volume of fuel consumed by road traffic users reflects the spending-per-litre of fuel consumed, which is about 101 cents per litre.

The composition of the pump price of diesel and petrol was obtained from the Department of Mineral Resources and Energy website http://www.dmre.gov.za/. Shadow prices for petrol and diesel must also be adjusted for transport costs according to magisterial districts. Table 15 provides shadow prices for the various types of fuel in price zone 9C, Gauteng. In order to calculate shadow prices for the other provinces, a transport adjustment factor must be calculated according to magisterial district. Table 16 provides a list of these adjustment factors, which were calculated relative to zone 9C (Gauteng). The magisterial districts and the zones in which they appear are indicated in Appendix 2.

The index in Table 7.9 can be used for estimating the future fuel price. This index is based on the projection for crude oil prices from 2020 to 2040 assuming a rate of increase similar to the long-term trend and a projection of the Rand/US dollar exchange rate (using a similar methodology explained in Box 7.3) and assuming a continuation of present fuel levies (see energy.gov.za). All other costs that are part of the pump price of fuel remain unchanged. For an alternative view on projected medium-term crude oil prices see the websites of the World Bank and the International Monetary Fund (IMF).

7.10 ELECTRICITY PRICES

Eskom's tariffs are based in part on historical costs, and hence do not necessarily fully reflect the opportunity cost that is entailed to provide electricity to users in future. Consequently, it is necessary to calculate a shadow price for electricity that takes account of marginal costs in providing generating facilities.

Electricity tariffs are comprised of generation, transmission and distribution costs. Currently (2020), demand and supply are closely matched due to an underperforming economy. However, future demand for electricity is expected to increase significantly, with the result that it is imperative that new electricity generation plants will have to be constructed, which will cause an increase in capital and generation costs.

In view of the envisaged expansion by Eskom (the main supplier of electricity in South Africa), projections of the relative price movements for electricity were made. Eskom embarked on a major expansion programme that started in 2005 and aimed to add 17 GW of much-needed electricity-generating capacity by 2018/19. An estimation of the probable real (above inflation) tariff increases for electricity that will be required to service and repay these capital outlays over twenty years implies real increases in Eskom's tariffs well above inflation.

The National Energy Regulator of South Africa (NERSA) therefore grants Eskom annual increases of about 5% above inflation. In real terms, assuming an inflation rate of 5%, the annual increase granted came to 8%. These increases must be included in the shadow price of electricity.

In a report prepared for the Development Bank of Southern Africa[32], the consultants emphasised that funding options could have far-reaching repercussions for economic growth and development. The baseline funding option identified in the report envisages funding made up of 60.6% by loans, 30% of state equity in the form of annual capital transfers to Eskom in order to strengthen its equity and 9.4% in the form of a social grant from the Fiscus to make good for the losses as a result of households who cannot pay. This scenario implied an increase in electricity tariffs of 3.7%-points above inflation on an annual basis for the period 2011-2025. Other options developed in the report resulted in higher tariffs.

The rating downgrade reflects the combination of Eskom's unsustainable capital structure and continuing financing needs, coupled with a high probability of a debt reorganisation. Whilst the company, supported by the South African government, appears to remain committed to make debt payments when due and will seek to avoid a default, any debt reorganisation will be a complex and protracted exercise against the backdrop of deteriorating cash flows and sizeable debt maturities.

In the financial year ended March 2020, Eskom's debt increased despite government equity support as poor operational performance, coupled with the level of tariffs set relative to costs, a high cost base and deteriorating collection of municipal debt weighed on the company's cash flows. Eskom's performance will continue to weaken with the impact of the coronavirus pandemic, increasing the company's reliance on the government equity injections to continue operations. Whilst tariff changes could support Eskom's earnings over the medium term, they will not be enough to put the company on a more sustainable footing without additional measures to bolster balance sheet strength. In this regard, the lack of meaningful progress in execution of the company's turnaround plan has increased the risks to Eskom's capital structure in the context of significant refinancing risks, rising debt service costs and weakening in the sovereign credit quality.

The credit rating agency has affirmed Eskom's credit rating. This action was taken primarily in light of increased regulatory and operating risk, and weakened profitability owing to an unfavourable regulatory decision.

[32] Guidelines/Principles for the Optimal Provision of Electricity in South Africa – an Economic Growth and Development Perspective. Report prepared for the Development Bank of Southern Africa by Conningarth Economists 2010.

Table 7.10 provides the estimated relative real tariff movements in the form of an index for the generation and distribution of electricity. Eskom's projected tariff increases as allowed for by the MYDP3 have been used, fully aware that risks as recently expressed by Standard and Poor's (S&P) are on the upside.

The index should be applied to the existing electricity tariff over the period of the project being evaluated in order to make provision for changes in relative movements in electricity tariffs. In the relevant calculations, provision has been made so that only generation costs will increase. Therefore, the index in Table 7.10 should be applied to total electricity costs.

7.11 SURROGATE PRICES

7.11.1 Value of time

Table 7.3 provides an estimate of the value of time per working and recreational hour for low-, middle- and high-income groups in each province, as well as the value of time for all workers, expressed in 2020 prices. The relevant methodology is discussed in Box 7.5.

Box 7.5: Calculation of the Value of Time

The average provincial annual remuneration for 9 occupational categories (see Table 7.4a) served as the basis for the calculations for Table 7.11. The figures for these 9 categories were aggregated to represent high, middle and low remuneration groups, with "legislators, senior officials, managers" and "professionals" being classified in the high-income group, whereas the "elementary occupations" was assumed to represent the low-income groups. The remaining categories were then aggregated to form the middle-income group.

The value of a working hour per income group in each province (see column 1 in Table 7.11) was obtained by dividing the average for a specific income group by the total number of working hours for that group per annum. The total number of working hours per year was calculated as the product of the total number of weeks (52), and the average number of working hours per week (40). The result was 2 080 hours, which was rounded off to 2 000 hours in order to take into account that not all workers are fully employed on a yearly basis.

The value of a recreational hour for workers per income group per province (column 3) was calculated as the value of a working hour per income group, divided by the total number of hours per annum, i.e. 365.25 days times 24 hours, which equals 8 766 hours.

In order to calculate the provincial value of a recreational hour for all persons (see column 2 of Table 7.11), a dependency ratio per income group in each province was required. The Labour Force Survey of 2020 provides the basic information from which a dependency ratio per province for the total population could be calculated. The methodology for obtaining the dependency ratios per income group is explained below. As the same method was followed for each province, only the method for the Western Cape Province will be explained.

The Labour Force Survey provides, on a race basis, the number of people working in each occupational group in each province. The total population per race group per province can be sourced from Stats SA's Mid-year Population Estimates (P0302) or from StatsSA Census data. By dividing the total population (per race group) in the Western Cape by the total number of employed individuals (per race group) in the province, the dependency ratio per race group was obtained. From the Labour Force Survey, the number of people employed in each of the nine occupations could be aggregated into a high medium and low-income category:

1) High income category: legislators, managers, and professionals.
2) Low-income category: elementary occupations.
3) Middle income category: The rest of the occupation categories fell into the middle-income group.

The percentage distribution of black, coloured, Indian and white was obtained across the three income groups. The dependency ratio calculated per race group was multiplied with the equivalent race group's distribution per income level to arrive at a weighted dependency ratio for each income level.

The value of a recreational hour for all persons was then obtained by dividing the value of a recreational hour for workers in each income group by the relevant dependency ratio per income group. As mentioned above this process was then repeated for each province, and for South Africa as a whole.

For forecasting purposes, the values in Table 7.3 should be viewed as constant real values. The value of time for recreation is only used if time saved or lost could include the productivity of workers, irrespective of the fact that it is not in working time. An example of this is the time a worker spends travelling to or from work. In all the other instances, the price of workers' time for recreation is the same as the time for recreation for all persons.

7.11.2 Input Data for the Economic Evaluation of Road Infrastructure Projects and Cost of Collisions

Road vehicle running cost, the cost of travel time and the cost of road collisions are critical input variables in determining the economic feasibility of proposed investments in road infrastructure. In this regard, a useful tool is the Highway Development and Management (HDM-4) software that was developed in the late 1960s under the auspices of the World Bank, which has been constantly improved and expanded since. It is currently being managed by HDM Global.

According to McPherson and Bennett (p39)[33], "HDM-4 is a tool for economic optimisation of maintenance of road networks and has been adopted or applied in many different countries for economic analysis and prioritisation. HDM-4 can operate with Strategy, Program and Project analysis. It utilises road network inventory and condition data, traffic data, and economic data to feed a series of road deterioration models and cost models, and to formulate candidate work programs for road networks." The focus and scope of the strategy analysis, the programme analysis and the project analysis are described in Box 7.6.

Box 7.6: Success factors for Road Management Systems

Strategy analysis:

Typical examples of strategy analysis by road agencies would include the following:

- Medium to long term forecasts of funding requirements for specified target road maintenance standards.
- Forecasts of long-term road network performance under varying levels of funding.
- Optimal allocation of funds according to defined budget heads; for example, routine maintenance, periodic maintenance and development (capital) budgets.
- Optimal allocations of funds to sub-networks; for example, by functional road class (main, feeder and urban roads, etc.) or by administrative region.
- Policy studies such as impact of changes to the axle load limit, pavement maintenance standards, energy balance analysis, provision of NMT facilities, sustainable road network size, evaluation of pavement design standards, etc." (Kerali, p13-14).

Programme analysis:

Programme analysis "… deals primarily with the prioritisation of a defined long list of candidate road projects into a one-year or multi-year work programme under defined budget constraints" (Kerali, p17).

Project analysis:

Project analysis deals with the "…evaluation of one or more road projects or investment options. The application analyses a road link or section with user-selected treatments, with associated costs and benefits, projected annually over the analysis period. Economic indicators are determined for the different investment options" (Kerali, p19). Projects may typically include "…the maintenance and rehabilitation of existing roads, widening or geometric improvement schemes, pavement upgrading and new construction" (Kerali, p19).

[33] McPherson, Kevin and Bennett, Christopher, R, 2005. Success factors for Road Management Systems. East Asia Pacific Transport Unit, the World Bank, Washington DC.

HDM-4 is increasingly being used internationally as the preferred tool for road project evaluation in both developing and developed countries. It contains all of the required datasets needed to perform an analysis. It is, however, important that datasets should be calibrated first to local (South African) conditions so as to ensure reliable results.

For low volume road projects, the World Bank's RED (Roads Economic Decision) model (using many of the relationships of HDM-4) can be used. As with HDM-4, datasets in RED must first be calibrated to South African conditions.

7.11.3 Economic Value of a Life in Terms of Future Productive Potential

Table 7.11 provides estimates of the economic value of a human life for different income groups in terms of their future productive potential based on their future wealth per annum, and on remaining life expectancy. The table provides the value of a human life per annum, as well as the capitalised value of the expected remaining lifetime for the relevant person. This is calculated by discounting the wealth per annum by 8% over the remaining lifetime. The relevant methodology is explained in Box 7.7.

Box 7.7: Calculation of the Value of a Human Life

The economic value of a human life in terms of future productive potential consists of the annual wealth, and the relevant person's remaining life expectancy. The economic life is calculated by discounting the economic value over the remaining life expectancy by using an 8% discount rate.

	NPV 8%	Total	Year 1	Year 2	Year 3
Low-income person	R194 629	R480 234	R16 008	R16 008	R16 008
Medium income person	R427 387	R1 089 700	R35 152	R35 152	R35 152
High income person	R1 541 991	R4 312 052	R126 825	R126 825	R126 825
Average	R487 400	R1 282 799	R40 087	R40 087	R40 087
Total	R2 651 407	R7 164 785	R218 072	R218 072	R218 072

Annual wealth is based on the value per recreational hour for all persons in Table 7.3. In order to express this value on an annual basis, it is multiplied by 8 766 hours (365.25 days per annum, multiplied by 24 hours per day).

In order to capitalise this wealth value over the expected remainder of a life it is necessary to calculate the remaining lifetimes in the three income categories. The basis for the life expectancy per income group is the life expectancy per population group as published by Stats SA as a statistical release "Mid-year Population Estimates 2020" (report P0302).

Life expectancies at birth:

	Average life expectancy
Africans	55.8
Coloureds	64.0
Indians	68.5
Whites	72.5

According to Stats SA data, the crude death rate (CDR) has declined from 12.9 deaths per 1 000 people in 2002 to 8.7 deaths per 1 000 people in 2020. However due to the AIDS epidemic experience, the crude death rate in South Africa did increase between 2002 and 2006 there after declining as access to HIV treatment and care became available. The RNI (rate of natural increase) fluctuates over time, mirroring the CBR, indicating the great influence of births in South Africa.

Life expectancy at birth declined between 2002 and 2006, largely due to the impact of the HIV and AIDS epidemic experienced, but expansion of health programmes to prevent mother-to-child transmission as well as access to antiretroviral treatment has partly led to the increase in life expectancy since 2007. By 2020 life expectancy at birth is estimated at 62.5 years for males and 68.5 years for females. According to StatsSA indicate that life expectancy is increasing, and this may be related to marginal gains in survival rates among infants and children under-5 post HIV interventions in 2005. The infant mortality rate (IMR) has declined from an estimated 55.5 infant deaths per 1 000 live births in 2002 to 23.6 infant deaths per 1 000 live births in 2020. Similarly, the under-five mortality rate (U5MR) declined from 75.3 child deaths per 1 000 live births to 34.1 child deaths per 1 000 live births between 2002 and 2020.

	Average age level
Africans	26.52
Coloureds	29.20
Indians	32.47
Whites	38.46

In order to calculate the remaining life period for these population groups, the difference between the average life expectancy and the age structure was calculated. The results are as follows:

	Average remaining life expectancy
Africans	29.28
Coloureds	34.80
Indians	36.03
Whites	34.04

For the purposes of this CBA Manual, it was necessary to convert the results for the population groups to income groups. The population per income group was already available from the value of time calculations. The source for this information was the Quarterly Labour Force 2020, where the population per occupation was given. As explained under the value of time, the occupational groups were aggregated to get the low, medium and high-income groups.

This information was used, in the form of weights, to convert the life expectancies from population groups to income categories. The remaining life period for the various income groups are as follows:

	High	Medium	Low
Expected Economic lifetime	32.45	30.89	30.11

If a specific age category is used, i.e. children or the aged, the remaining expected life in years should be used for purposes of calculating the relevant capitalised wealth.

The value reflected here is merely an indication of the economic value in terms of future productive potential of a person, and is an indication of the real value of human life in South African society. When human lives are under discussion, the number of lives involved should be pointed out in addition to the economic value of a life. This is essential to give the decision-maker a complete picture of the implications of his/her proposed decision so far as it relates to the preservation and protection of human lives.

7.12 TABLES DEPICTING SHADOW AND SURROGATE PRICES

In this section Tables depicting shadow and surrogate prices are grouped together to make it easier for the analyst to access.

Table 7.3: Estimated Remuneration for Unskilled Labourers per Province [Rand – 2020 Prices]

	Market wage in 2020 Prices					
Provinces	**WEEK**		**MONTH**		**YEAR**	
	Metro	**Non-Metro**	**Metro**	**Non-Metro**	**Metro**	**Non-Metro**
Western Cape	1 428	1 323	5 713	5 291	68 554	63 487
Eastern Cape	1 317	924	5 268	3 697	63 214	44 362
Northern Cape	-	1 014	-	4 057	-	48 685
Free State	1 575	935	6 299	3 739	75 587	44 863
KwaZulu-Natal	1 193	1 575	4 771	6 299	57 249	75 587
North West	-	1 673	-	6 693	-	80 316
Gauteng	1 777	1 420	7 108	5 680	85 292	68 154
Mpumalanga	-	1 219	-	4 875	-	58 502
Limpopo	-	1 405	-	5 620	-	67 442
Total	**1 586**	**1 233**	**6 344**	**4 931**	**76 130**	**59 167**

Whenever another base year is used, the above figures must be adjusted using the index for labour costs in the non-agricultural sectors, contained in the Reserve Bank Bulletin. When using wages for unskilled labour the wages in Table 7.4(a) should be adjusted by the shadow factor in Table 7.4(a).

Table 7.4(a): Factors for Adjustment of the Market Wage Rate for Unskilled Labourers per Province [Rand – 2020 Prices]

Provinces	Metro	Non-Metro
Western Cape	0.90	1.07
Eastern Cape	0.83	0.75
Northern Cape		0.82
Free State	0.99	0.76
KwaZulu-Natal	0.75	1.28
North West		1.36
Gauteng	1.12	1.15
Mpumalanga		0.99
Limpopo		1.14

Table 7.5: Estimated Annual Remuneration for Occupational Categories in South Africa per Province [Rand – 2020 Prices]

	Western Cape	Eastern Cape	Northern Cape	Free State	KwaZulu-Natal	North West	Gauteng	Mpumalanga	Limpopo
Legislators, senior officials & managers	345 510	354 228	399 820	343 075	412 004	416 734	459 536	386 955	351 248
Professionals	511 791	361 724	398 623	402 125	447 690	458 196	521 840	400 542	401 454
Technicians	221 030	176 192	264 185	198 880	164 105	243 291	205 440	187 101	239 002
Office clerks	130 317	153 576	125 434	150 005	118 385	159 968	171 629	143 270	183 365
Service, shop & market sales	90 411	86 964	121 056	95 219	103 121	126 299	131 875	133 212	91 849
Skilled agricultural and fishing	185 621	129 777	118 468	286 657	90 146	303 010	139 945	130 249	241 184
Crafts & related trades	101 233	104 400	184 774	107 013	114 282	131 045	170 680	179 217	142 780
Plant & machine operators	110 896	98 702	191 940	100 677	121 853	119 927	123 725	110 439	118 150
Elementary occupations	65 394	50 312	48 685	52 677	52 460	80 316	82 589	58 502	67 442

Table 7.6: Index of Projected Real Effective Exchange Rate of the Rand

Year	Foreign Exchange Index
2020	100
2021	99
2022	98
2023	98
2024	97
2025	96
2026	95
2027	94
2028	94
2029	93
2030	92
2031	91
2032	90
2033	90
2034	89
2035	88
2036	87
2037	87
2038	86
2039	85
And beyond	

Table 7.7: Shadow Price in Cent for Petrol and Diesel on 1 Sep 2021 for Gauteng Zone 9C – [Rand, 2021 Prices]

Components	Petrol 93 ULP	Diesel Price		
		Road Transport	Construction	On-Farm Use
Pump price	1834.00	1548.00	1548.00	1548.00
Minus: Total taxes and levies included in pump price	615.00	617.00	617.00	520.28
- Fuel taxes	393.00	379.00	379.00	379.00
- Custom and excise	4.00	4.00	4.00	4.00
- Farming rebate*	0.00	0.00	0.00	121.28
- RAF (road accident fund) levy	218.00	218.00	218.00	0.00
		16.00	16.00	16.00
Plus: Road related taxes and levies	362.05	402.23	0.00	0.00
- RAF	261.60	261.60	0.00	0.00
- Expenditure on roads	100.45	140.63	0.00	0.00
Shadow price	1581.05	1333.23	931.00	1027.72
Shadow factor	0.862	0.861	0.601	0.664

Source: Department of Minerals and Energy

The RAF levy has been increased to make provision for the shortfall of the RAF. Expenditure on roads for road transport was increased to make provision for the non-proportional impact on roads by heavy vehicles.

Table 7.8: Transport Adjustments for the Calculation of Shadow Prices for Petrol and Diesel According to Magisterial Districts

Price in cents per litre (September 2021)

Price Zone	Lead Replacement		Adjustments in cents		Unleaded Petrol		Adjustments in cents		Diesel			
									Wholesale Price		Adjustment in cents	
	93 Octane	95 Octane	93	95	93 Octane	95 Octane	93	95	0.05% Sulphur	0.005% Sulphur	0.05% Sulphur	0.005% Sulphur
1A	1753	1762	-102	-102	1753	1762	-102	-112	1487.48	1490.88	-101.8	-101.8
2A	1759	1768	-96	-96	1759	1768	-96	-106	1493.08	1496.48	-96.2	-96.2
3A	1764	1773	-91	-91	1764	1773	-91	-101	1498.08	1501.48	-91.2	-91.2
4A	1770	1779	-85	-85	1770	1779	-85	-95	1504.68	1508.08	-84.6	-84.6
5A	1780	1789	-75	-75	1780	1789	-75	-85	1513.98	1517.38	-75.3	-75.3
6A	1793	1802	-62	-62	1793	1802	-62	-72	1527.38	1530.78	-61.9	-61.9
7A	1805	1814	-50	-50	1805	1824	-50	-50	1539.28	1542.68	-50	-50
8A	1828	1837	-27	-27	1828	1847	-27	-27	1561.98	1565.38	-27.3	-27.3
9A	1851	1860	-4	-4	1851	1870	-4	-4	1585.88	1589.28	-3.4	-3.4
10A	1851	1860	-4	-4	1851	1870	-4	-4	1601.28	1604.68	12	12
11A	1889	1898	34	34	1889	1908	34	34	1623.78	1627.18	34.5	34.5
13A	1908	1917	53	53	1908	1927	53	53	1642.58	1645.98	53.3	53.3
15A	1869	1878	14	14	1869	1888	14	14	1603.28	1606.68	14	14
17A	1909	1918	54	54	1909	1928	54	54	1643.78	1647.18	54.5	54.5
19A	1898	1907	43	43	1898	1917	43	43	1632.88	1636.28	43.6	43.6
57A	1805	1814	-50	-50	1805	1814	-50	-60	1539.28	1542.68	-50	-50
69A	1898	1907	43	43	1898	1907	43	33	1632.88	1636.28	43.6	43.6
3B	1771	1780	-84	-84	1771	1780	-84	-94	1505.58	1508.98	-83.7	-83.7
5B	1784	1793			1784	1793			1517.98	1521.38	-71.3	-71.3
6B	1776	1785	-79	-79	1776	1785	-79	-89	1510.88	1514.28	-78.4	-78.4
7B	1788	1797	-67	-67	1788	1797	-67	-77	1522.18	1525.58	-67.1	-67.1
8B	1802	1811	-53	-53	1802	1811	-53	-63	1536.28	1539.68	-53	-53
9B	1799	1808	-56	-56	1799	1808	-56	-66	1533.28	1536.68	-56	-56
10B	1812	1821	-43	-43	1812	1821	-43	-53	1546.48	1549.88	-42.8	-42.8

Table 7.8 (continued): Transport Adjustments for the Calculation of Shadow Prices for Petrol and Diesel according to Magisterial Districts

Price Zone	Lead Replacement		Adjustments in cents		Unleaded petrol		Adjustments in cents		Diesel			
									Wholesale Price		Adjustment in cents	
	93 Octane	95 Octane	93	95	93 Octane	95 Octane	93	95	0.05% Sulphur	0.005% Sulphur	0.05% Sulphur	0.005% Sulphur
12B	1817	1826	-38	-38	1817	1826	-38	-48	1551.48	1554.88	-37.8	-37.8
14B	1828	1837	-27	-27	1828	1837	-27	-37	1562.88	1566.28	-26.4	-26.4
5C	1793	1802	-62	-62	1793	1802	-62	-72	1527.78	1531.18	-61.5	-61.5
6C	1802	1811	-53	-53	1802	1811	-53	-63	1536.58	1539.98	-52.7	-52.7
7C	1817	1826	-38	-38	1817	1836	-38	-38	1551.38	1554.78	-37.9	-37.9
8C	1830	1839	-25	-25	1830	1849	-25	-25	1564.08	1567.48	-25.2	-25.2
9C	1815	1824	-40	-40	1815	1834	-40	-40	1548.98	1552.38	-40.3	-40.3
10C	1832	1841	-23	-23	1832	1851	-23	-23	1566.28	1569.68	-23	-23
11C	1855	1864	0.00	0.00	1855	1874	0	0	1589.28	1592.68	0	0
12C	1858	1867	3	3	1858	1877	3	3	1592.38	1595.78	3.1	3.1
13C	1875	1884	20	20	1875	1894	20	20	1609.88	1613.28	20.6	20.6
14C	1896	1905	41	41	1896	1915	41	41	1630.78	1634.18	41.5	41.5
15C	1881	1890	26	26	1881	1900	26	26	1615.18	1618.58	25.9	25.9
16C	1879	1888	24	24	1879	1898	24	24	1612.98	1616.38	23.7	23.7
17C	1898	1907	43	43	1898	1917	43	43	1632.18	1635.58	42.9	42.9
57C	1817	1826	-38	-38	1817	1826	-38	-48	1551.38	1554.78	-37.9	-37.9
58C	1830	1839	-25	-25	1830	1839	-25	-35	1564.08	1567.48	-25.2	-25.2
60C	1832	1841	-23	-23	1832	1841	-23	-33	1566.28	1569.68	-23	-23
61C	1855	1864	0	0	1855	1864	0	-10	1589.28	1592.68	0	0
62C	1858	1867	3	3	1858	1867	3	-7	1592.38	1595.78	3.1	3.1
63C	1875	1884	20	20	1875	1884	20	10	1609.88	1613.28	20.6	20.6
64C	1896	1905	41	41	1896	1905	41	31	1630.78	1634.18	41.5	41.5
67C	1898	1907	43	43	1898	1907	43	33	1632.18	1635.58	42.9	42.9
31J	1829	1838	-26	-26	1829	1838	-26	-36	1566.68	1566.68	-22.6	-26

Table 7.8 (continued): Transport Adjustments for the Calculation of Shadow Prices for Petrol and Diesel According to Magisterial Districts

Price Zone	Lead Replacement		Adjustments in cents		Unleaded petrol		Adjustments in cents		Diesel			
									Wholesale Price		Adjustment in cents	
	93 Octane	95 Octane	93	95	93 Octane	95 Octane	93	95	0.05% Sulphur	0.005% Sulphur	0.05% Sulphur	0.005% Sulphur
32J	1851	1860	-4	-4	1851	1860	-4	-14	1589.68	1589.28	0.4	-3.4
33J	1868	1877	13	13	1868	1877	13	3	1589.28	1606.08	0	13.4
34J	1866	1875	11	11	1866	1875	11	1	1606.08	1603.68	16.8	11
35J	1873	1882	18	18	1873	1882	18	8	1603.68	1610.88	14.4	18.2
36J	1873	1882	18	18	1873	1882	18	8	1610.88	1610.58	21.6	17.9
37J	1888	1897	33	33	1888	1897	33	23	1625.98	1625.98	36.7	33.3

Source: Department of Minerals and Energy, 01 September 2021

Table 7.9: Index of Projected Price for Petroleum / Fuel Products (2020 = 100)

Year	Real	Nominal *
2020	100	100
2021	100	104
2022	100	108
2023	101	113
2024	101	117
2025	101	122
2026	101	127
2027	101	132
2028	101	137
2029	102	143
2030	102	148
2031	102	154
2032	102	161
2033	102	167
2034	102	174
2035	103	181
2036	103	188
2037	103	196
2038	103	204
2039	103	212
and beyond		

US dollar crude price to decline by 0.4% pa.

Real Rand to depreciate by 0.6% pa and nominal exchange rate to depreciate by 4.3% pa.

Table 7.10: Index (2020 = 100) of Estimated Increase in Electricity Tariffs above CPI Inflation

Year	Shadow price index
2020	100
2021	107
2022	109
2023	112
2024	114
2025	116
2026	118
2027	121
2028	123
2029	126
2030	128
2031	131
2032	133
2033	136
2034	139
2035	141
2036	144
2037	147
2038	150
2039	153
2040	156
2041	159
2042	162
and beyond	

Table 7.11: Estimated Time Cost According to Income Groups in 2020 Prices, Rand

Income Group	Value of a working hour	Value per recreational hour for all persons	Value of recreational hour for workers
EASTERN CAPE			
Low-income group	25.16	1.23	5.74
Middle income group	53.43	2.92	12.19
High income group	138.18	10.69	31.53
Total population	60.82	2.88	13.88
FREE STATE			
Low-income group	24.34	1.45	5.55
Middle income group	75.94	5.03	17.33
High income group	173.42	5.83	39.57
Total population	71.23	3.60	16.25
GAUTENG			
Low-income group	41.29	3.21	9.42
Middle income group	75.28	6.23	17.18
High income group	196.69	19.36	44.87
Total population	105.17	7.83	23.99

Income Group	Value of a working hour	Value per recreational hour for all persons	Value of recreational hour for workers
KWAZULU-NATAL			
Low-income group	26.23	1.22	5.98
Middle income group	55.95	3.08	12.77
High income group	157.85	12.33	36.01
Total population	64.29	3.15	14.67
MPUMALANGA			
Low-income group	29.25	1.58	6.67
Middle income group	72.21	4.15	16.47
High income group	150.32	10.84	34.30
Total population	70.49	4.46	16.08
NORTHERN CAPE			
Low-income group	24.34	1.45	5.55
Middle income group	75.94	5.03	17.33
High income group	173.42	5.83	39.57
Total population	71.23	3.60	16.25
LIMPOPO			
Low-income group	33.72	1.02	7.69
Middle income group	63.11	2.00	14.40
High income group	155.29	4.71	35.43
Total population	65.47	3.22	14.94
NORTH WEST			
Low-income group	40.16	2.02	9.16
Middle income group	65.96	3.46	15.05
High income group	175.58	10.67	40.06
Total population	72.83	3.83	16.62
WESTERN CAPE			
Low-income group	32.70	2.82	7.46
Middle income group	52.74	4.87	12.03
High income group	171.36	17.68	39.10
Total population	69.09	3.30	15.76
AVERAGE			
Low-income group	32.59	1.83	7.43
Middle income group	65.09	4.01	14.85
High income group	175.83	14.47	40.12
Total population	79.34	4.57	18.10

* In terms of 2020 prices, a worker earns about:
R0.00-R31 956 in the low-income category,
R31 956-R767 209 in the middle-income category and
R767 209 and more in the high-income category.

** Remaining life expectancies of persons in the following income groups are as follows

	Low:	30.55	years
	Middle:	30.92	years
	High:	30.74	years
	Average:	30.07	years

*** **Whenever another base year is used, the above figures must be adjusted using to consumer price index.**

Table 7.12: Economic Value of Life in 2020 prices (Rand)

Income group	Value of a life per year	Discounted life-time value of an average person
Low	R16 008	R194 629
Middle	R35 152	R427 387
High	R126 825	R1 541 991
Average	R40 087	R487 400

* In terms of 2020 prices, a worker earns about:

R0.00-R31 956 in the low-income category,

R31 956-R767 209 in the middle-income category and

R767 209 and more in the high-income category.

** **Remaining life expectancies of persons in the following income groups are as follows:**

	Low:	30.11	years
	Middle:	30.89	years
	High:	32.45	years
	Average:	31.15	years

*** **Whenever another base year is used, the above figures must be adjusted using to consumer price index**

7.13 COMPUTER PROGRAM FOR CONVERSION FACTOR FOR ASSETS

A computerised model has been developed for calculating a weighted shadow price of various inputs used in the production of capital assets. The assets that are included in the model are various water augmentation assets, typical assets found in a SAM specifically the South African SAM, and various other important assets. The output of the model is given in Table 7.13, and the model is also available in electronic format on the WRC website. It should be noted that the figures are only given for illustrative purposes.

When using the model, the shadow price adjustment factors for each input need to be adjusted according to the appropriate tables in the manual. For example, the factor used for unskilled labour is the wage factor for non-urban unskilled labour in the Western Cape. Thus, if the project in question is taking place in an urban area in the Eastern Cape, the factor needs to be adjusted in accordance with Table 7.4(a) in the manual. Space has been left in the model for the user to insert additional assets. If this is done coefficients for the inputs used in the production of that asset need to be calculated and placed in the model. Additional inputs can also be incorporated into the model for each of the assets listed. Once the relevant coefficients are entered into the model, it will run automatically. In the case of additional inputs, shadow price factors will have to be inserted into the model over and above the coefficients.

The model has been extended to include the operational sectors contained in the South African SAM. These sectors are not included in the output displayed in Table 7.13; however, they are available electronically.

Table 7.13: Conversion Factors

Development of Conversion Factors for Assets

CONVERSION FACTORS

RELATIVE IMPORTANCE OF INPUTS WHERE SHADOW PRICES ARE APPLICABLE	DIESEL	PETROL	PETROLEUM PRODUCTS (includes petrol and diesel)	ELECTRICITY	UNSKILLED LABOUR	(EXCHANGE RATE)	CUSTOMS DUTY	Other 1	Other 2	Other 3	Other 4	WEIGHTED SHADOW PRICE FACTOR
A. ASSETS CONTAINED IN THE SOUTH AFRICAN SOCIAL ACCOUNTING MATRIX												
1. Furniture	0.000	0.000	0.005	0.007	0.001	0.569	0.569	0.000	0.000	0.000	0.000	1.099
2. Rubber products	0.000	0.000	0.062	0.022	0.016	0.426	0.426	0.000	0.000	0.000	0.000	1.064
3. Structural Metal Products	0.000	0.000	0.005	0.002	0.015	0.475	0.475	0.000	0.000	0.000	0.000	1.077
4. Other Fabricated metal products	0.000	0.000	0.020	0.014	0.015	0.190	0.190	0.000	0.000	0.000	0.000	1.029
5. Machinery and equipment	0.000	0.000	0.021	0.005	0.010	0.668	0.668	0.000	0.000	0.000	0.000	1.109
6. Electrical machinery and apparatus	0.000	0.000	0.022	0.004	0.010	0.458	0.458	0.000	0.000	0.000	0.000	1.073
7. Manufacturing of transport equipment	0.000	0.000	0.005	0.001	0.007	0.844	0.844	0.000	0.000	0.000	0.000	1.142
8. Other manufacturing and recycling	0.000	0.000	0.005	0.003	0.011	0.279	0.279	0.000	0.000	0.000	0.000	1.045
9. Buildings	0.000	0.000	0.023	0.001	0.016	0.136	0.136	0.000	0.000	0.000	0.000	1.014
10. Civil Construction	0.000	0.000	0.048	0.002	0.020	0.138	0.138	0.000	0.000	0.000	0.000	1.009
11. Business activities (architects, attorneys, etc.)	0.000	0.000	0.025	0.001	0.011	0.10	0.10	0.000	0.000	0.000	0.000	1.009
B.WATER AUGMENTATION COMPONENTS												
12. Bulk water (dams)	0.120	0.060	0.000	0.020	0.130	0.000	0.000	0.000	0.000	0.000	0.000	0.934
13. Reservoirs	0.030	0.000	0.000	0.000	0.170	0.070	0.070	0.000	0.000	0.000	0.000	0.956
14. Pump stations (water & sewer)	0.030	0.000	0.000	0.000	0.170	0.100	0.100	0.000	0.000	0.000	0.000	0.961
15. Bulk pipelines (water & sewer)	0.070	0.000	0.000	0.000	0.170	0.170	0.170	0.000	0.000	0.000	0.000	0.964
16. Treatment works (water & sewer)	0.030	0.000	0.000	0.000	0.170	0.070	0.070	0.000	0.000	0.000	0.000	0.956
17. Reticulation (water & sewer)	0.030	0.000	0.000	0.000	0.170	0.100	0.100	0.000	0.000	0.000	0.000	0.961
18. Storm water	0.100	0.050	0.000	0.010	0.130	0.000	0.000	0.000	0.000	0.000	0.000	0.936
19. Roads	0.210	0.120	0.000	0.000	0.120	0.000	0.000	0.000	0.000	0.000	0.000	0.902
20. Parks and Recreation	0.210	0.120	0.000	0.000	0.120	0.000	0.000	0.000	0.000	0.000	0.000	0.902
21. Schools, Crèches, etc.	0.080	0.020	0.000	0.050	0.140	0.000	0.000	0.000	0.000	0.000	0.000	0.956

Development of Conversion Factors for Assets

CONVERSION FACTORS

RELATIVE IMPORTANCE OF INPUTS WHERE SHADOW PRICES ARE APPLICABLE	DIESEL	PETROL	PETROLEUM PRODUCTS (includes petrol and diesel)	ELECTRICITY	UNSKILLED LABOUR	(EXCHANGE RATE)	CUSTOMS DUTY	Other 1	Other 2	Other 3	Other 4	WEIGHTED SHADOW PRICE FACTOR
D. Costs Associated with Construction												
22. Maintenance and operation	0.160	0.090	0.000	0.020	0.170	0.000	0.000	0.000	0.000	0.000	0.000	0.909
23. Earth works	0.000	0.000	0.111	0.000	0.102	0.065	0.065	0.000	0.000	0.000	0.000	0.959
24. Research and development	0.000	0.000	0.007	0.018	0.017	0.022	0.022	0.000	0.000	0.000	0.000	1.004
25. Relocation costs	0.000	0.000	0.009	0.000	0.044	0.062	0.062	0.000	0.000	0.000	0.000	0.996
26. Other 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
27 Other 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
28. Other 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
29. Other 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
Shadow Price Adjustment Factor	0.791	0.844	0.804	1.337	0.704	1.222	0.950	1.000	1.000	1.000	1.000	

Note: **1. Customs duty (shadow price adjustment factor) is already adjusted to take into account the direct import content of the plant.**

2. The shadow price adjustment factor used for unskilled labour is the factor for non-urban unskilled labour in the Western Cape. This factor needs to be adjusted according to the location of the project in question using table 6.1a

CHAPTER 8: DETERMINATION OF THE PRICE/VALUE OF WATER

8.1 INTRODUCTION

This Chapter describes the process for determining the price of water. The price of water has two different connotations in relation to analysing the viability of water resource development. The first connotation concerns the financial price of water, which is equal to the cost of water development, and which is used to calculate the financial viability of a water development project.

The second connotation is the economic price/value of water that is equivalent to the value that the end-user places on water. Economic CBA, which analyses the development of water resources from the point of view of the community, uses the value that the end-user places on the water resource as its price.

The financial viability of water resource development is important for establishing the extent to which a project will pay for itself, and to what extent additional subsidies will need to be allocated to the project to make it financially viable, given that, in some cases, the cost of developing water is more than what consumers are able to pay.

8.2 WATER TARIFFS / FINANCIAL PRICE OF WATER

One of the financial measurements of water is the cost per cubic meter paid by consumers (i.e. the water tariff). Currently, water tariffs are determined in various ways, and seldom reflect the actual cost of water. The tariff values are mostly based on the production cost (treatment & pumping), and sometimes include socio-political objectives (i.e. cross-subsidization), but seldom reflect the full sustainability and conservation aspects of water (i.e. scarcity, social and environmental costs).

The elements of the value chain of water supply and demand from which the water tariffs are determined/calculated, are shown in Figure 8.1 below.

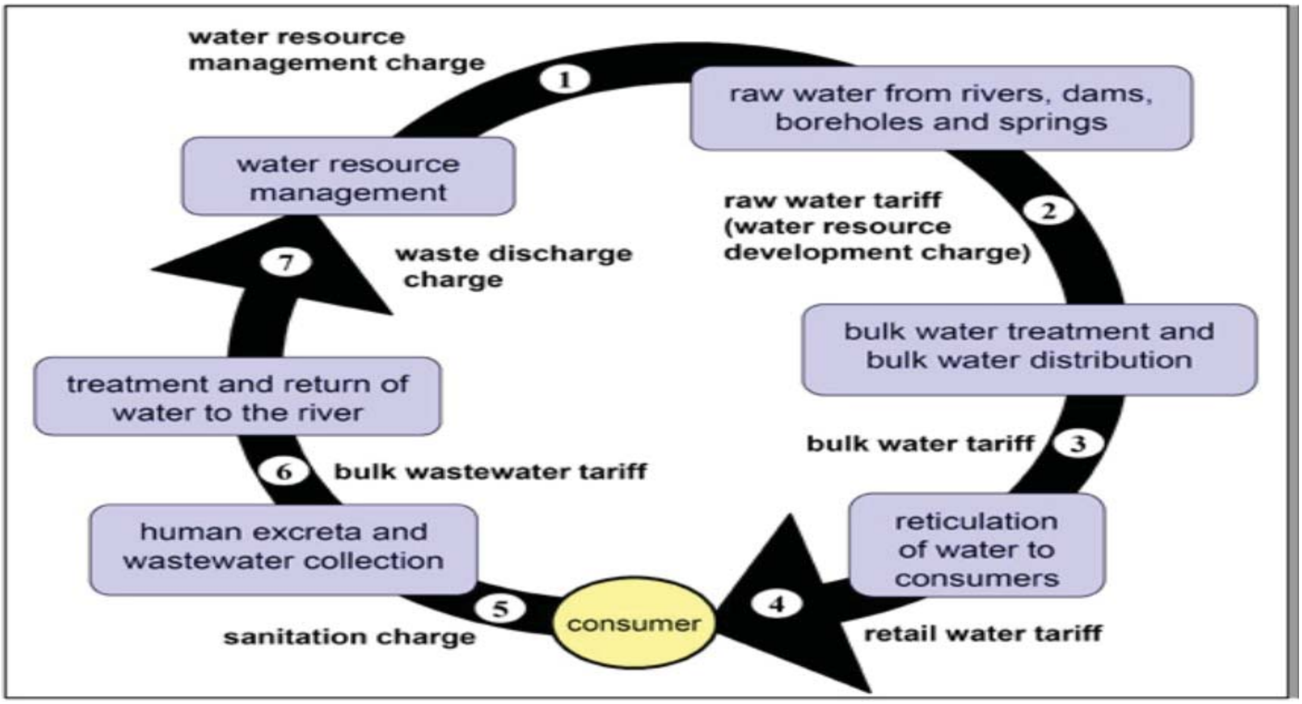


Figure 8.1: Elements of Determining Water Tariffs

Source: Strategic Framework for Water Services. Department of Water & Sanitation 2003

According to the 2007 Revised Water Pricing Strategy for Raw Water III, the water tariffs that the user of water pays consist mainly of three elements namely:

- Water Resources Management Charges, which cover the charges required to manage water resources within the nine water management areas determined in the NWRS-2;
- A Water Resource Infrastructure Charge, which includes charges relating to the development of and use of waterworks (a system of pipes and structures through which water is obtained and distributed, including but not limited to wells and well structures, intakes and cribs, pumping stations, treatment plants, storage tanks, pipelines and appurtenances, or a combination thereof), which cover the charges related to planning, capital costs, operation and maintenance, depreciation, and future infrastructure build on government water schemes; and
- Waste Discharge Mitigation Charges, which cover the discharge of water containing waste into a water resource or onto land.

8.2.1 Financial Cost of Raw, Bulk and Municipal Water

In this section, the three different water tariffs are discussed, namely; raw water tariffs, bulk water tariffs and municipal water tariffs. These tariffs differ in terms of specific water users, as well as the quality of the water and the point of delivery.

8.2.1.1 Raw Water Tariff

Raw Water is sourced from rivers, dams, boreholes and springs. The raw water tariff is determined from the management of the country's water resources. This incorporates the operations, maintenance, refurbishment and betterment of existing Government water schemes, waterworks owned by water management institutions and the development of new user-funded schemes. It is important to note that it does not include the treatment costs required for potable water and the distribution of water through pipelines.

Table 8.1 provides an example of the calculation of water costs for various users in 2020 prices. It should be noted that this is only an example that is not to be used in actual CBA calculations.

Table 8.1: Summary of Calculation of the Water Costs for a Typical River Basin

Dam Unit Cost	Current 2020 Prices
Domestic and Industrial	
Return on asset cost c/m^3	16.18
Depreciation cost c/m^3	1.16
Betterments cost c/m^3	0.00
Operation and maintenance cost c/m^3	2.15
Functional support cost c/m^3	0.00
Infrastructure cost c/m3	**19.49**
Catchment management cost c/m3	0.09
Working for water cost c/m^3	0.06
Afforestation/Abstraction cost c/m^3	0.03
Total unit cost c/m^3	**19.67**
Irrigation (full quota: 11000m^3/ha)	0.00
Betterments cost R/ha	0.00
Operation and maintenance cost R/ha	321.21
Functional support cost R/ha	0.00
Infrastructure cost R/ha	**321.21**
Catchment management cost R/ha	4.25
Working for water cost R/ha	0.80
Afforestation/Abstraction cost R/ha	3.45
Sub Total	330.15
10% increase into SAAU Agreement	32.97
Total unit cost R/ha	**363.12**
Total unit cost c/m^3	**3.30**

Information pertaining to raw water charges can be obtained from the Department of Water and Sanitation (Source: https://www.dws.gov.za/niwis2/RW).These figures should be used by the analyst when conducting a financial evaluation of water resource development projects. The raw water charges pertain to the following:

- Water Resource Management (WRM) charges to plan, manage, protect, allocate and control water use and water quality, which functions, in future, will be undertaken by Catchment Management Agencies (CMAs) and Water Management Agencies (WMAs); and
- Water Resource Infrastructure charges to finance the operation maintenance, refurbishment cost of Government Water Schemes (GWS).

Figure 8.2 presents the Raw water Tariffs per Catchment.

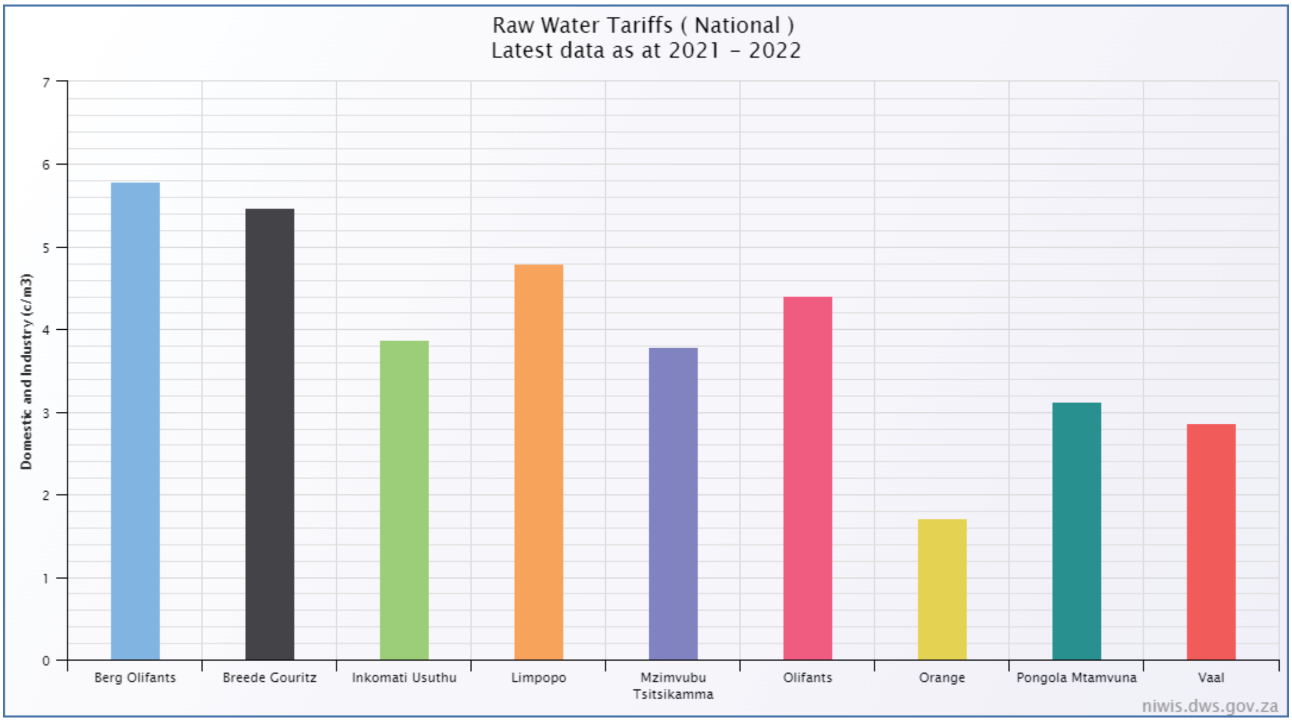


Figure 8.2: Raw Water Tariffs for Domestic and Industry per CMA, 2021-2022 Prices, [c/m^3]

Source: https://www.dws.gov.za/niwis2/RW

Figure 8.3 presents the Raw water Tariffs for irrigation

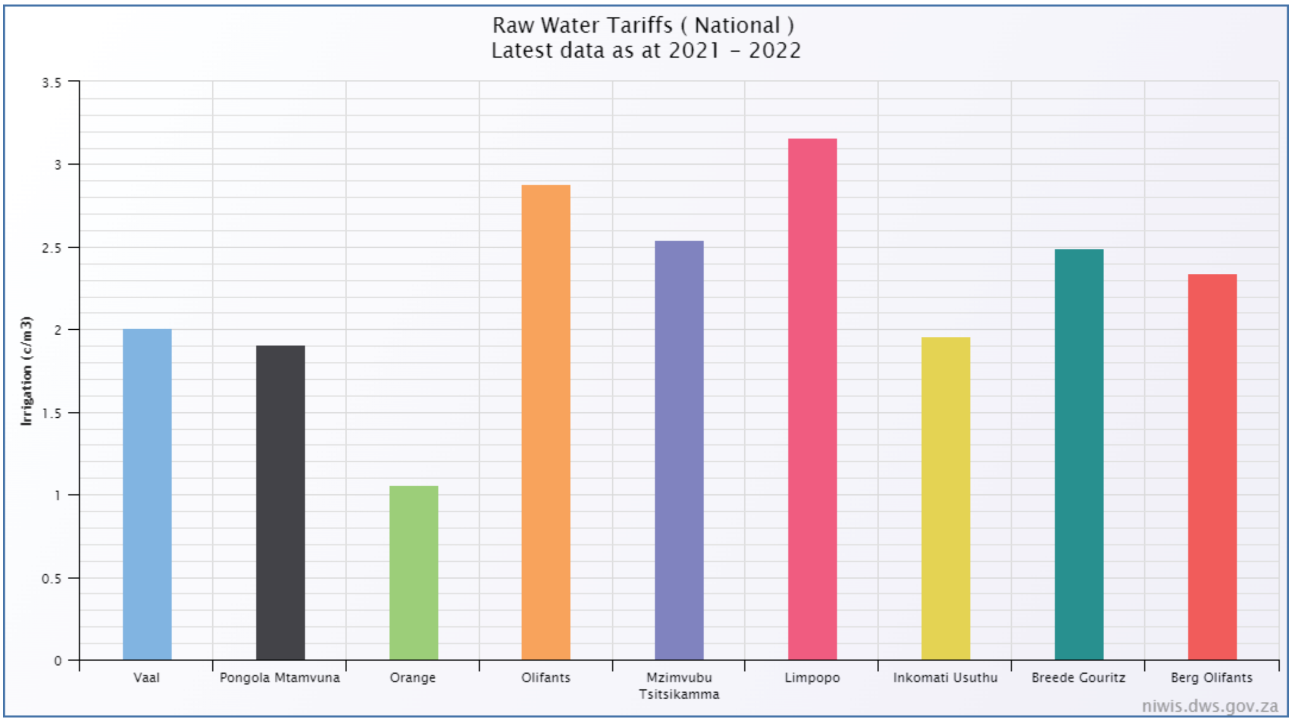
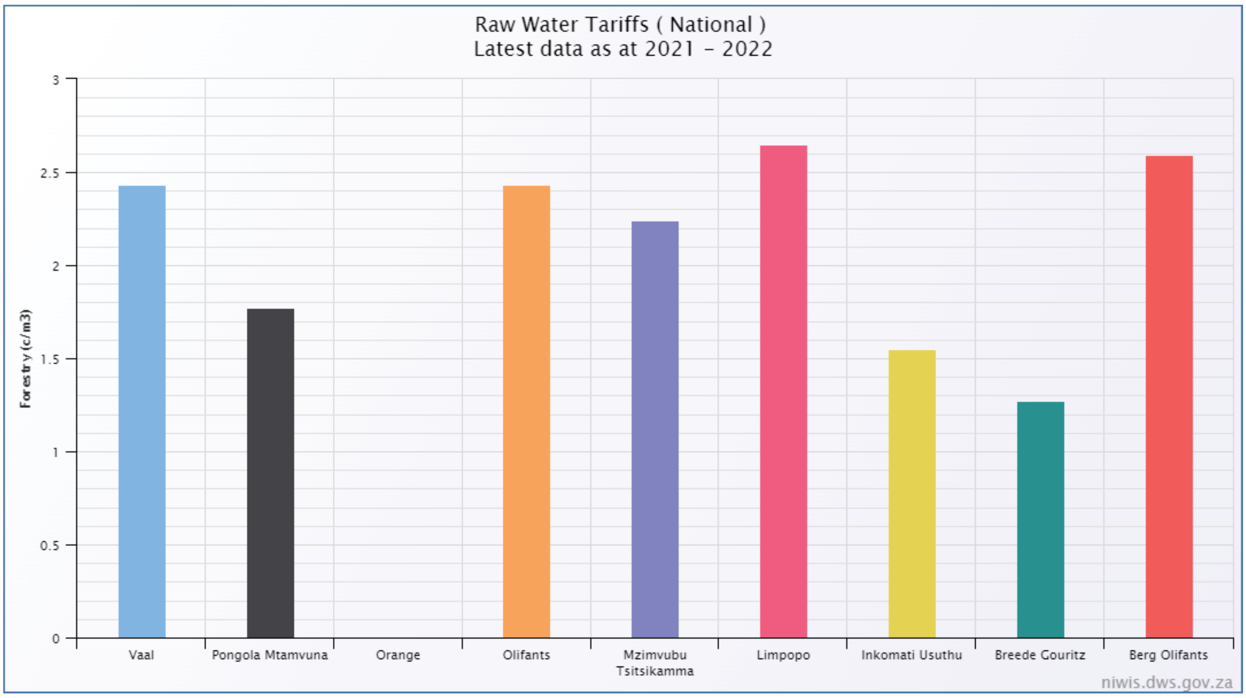


Figure 8.3: Raw Water Tariffs for irrigation per CMA, 2021-2022 Prices, [c/m^3]

Source: https://www.dws.gov.za/niwis2/RW

Figure 8.4 presents the Raw water Tariffs for Forestry

Figure 8.4: Raw Water Tariffs for Forestry per CMA, 2021-2022 Prices, [c/m^3]



Source : https://www.dws.gov.za/niwis2/RW

Detailed Raw Water Tariffs are also provided for Irrigation Agriculture, Domestic and Industrial per Province and per scheme on an Excel Spreadsheet accompanying this report. The information on Raw Water Tariffs is also available from both the National and Regional Offices of the Department of Water and Sanitation (DWS).

8.2.2 Economic value of water

This section provides guidelines for determining the economic value of water for different categories of water users. As already indicated in the introduction of this chapter, the Pella drift economic price/value of water is equivalent to the value that the end-user places on water. Economic CBA analyses the development of water resources from the point of view of the community, and uses the value that the end-user places on the water resource as its price.

The value of water is loosely defined as the maximum amount the user would be willing to pay for the use of an amount of water. In the absence of market clearing prices, there are a number of alternate means of estimating this value (See Gibbons (1986)[34]).

Firstly, there may be some evidence of market-like transactions within a given sector, and payment of this level for water indicates that the user is willing to pay at least a certain amount, which points to a lower limit for the value for water in that sector. However, more complete demand information may be required to plot a formal demand curve for a particular use. If enough tariff and quantity data are available, a consumer – or producer – water demand curve can be estimated, from which, in turn, estimates can be made of marginal values/benefits of the resource use at different levels of demand.

Financial budget information on a single productive process can also be used to impute a share of total product value to the water input. If all factors of production are remunerated in terms of their marginal returns, the residual, after subtraction of all other intermediate inputs, is assumed to be the maximum economic value of the water input.

Without actually studying demand relationships, the concept of alternate cost can also be used to determine the economic value of water, where the cost of the least expensive alternative to water serves as a proxy for the maximum amount the user might be willing to pay for water.

8.2.3 Urban households

The first step in the calculation of the economic value of water here is to derive a price demand function based on consumer demand from which price elasticities can be calculated. This price demand function can be calculated for urban households in total or for various income groups. The function could even be further broken down and calculated for indoor and outdoor use. Methods available in this regard are the following:

Contingent Valuation

For contingent valuation, information is typically obtained by means of questionnaires. The first step is to establish a typical user profile and then determine the effect that a price increase would have on these consumption patterns.

[34] Gibbons, D.C., 1986, "The Economic Value of Water", A Study from Resources for the Future, Washington DC, the Johns Hopkins University Press.

A shortcoming of this method is that outcomes are not actually observed, but are based on expectations. This method, amongst others, was used by Veck and Bill (1998)[35] to determine the price elasticity of demand for water.

Time Series Analysis

Here, tariff and demand quantity data are compared over time (at least 15 observations) in order to determine a relationship between them.

A shortcoming in terms of South Africa is that there is very little variance of the tariff structure in the past. During periods of drought, when the tariff was used to regulate volumes of water, it was done mostly in conjunction with direct control measures.

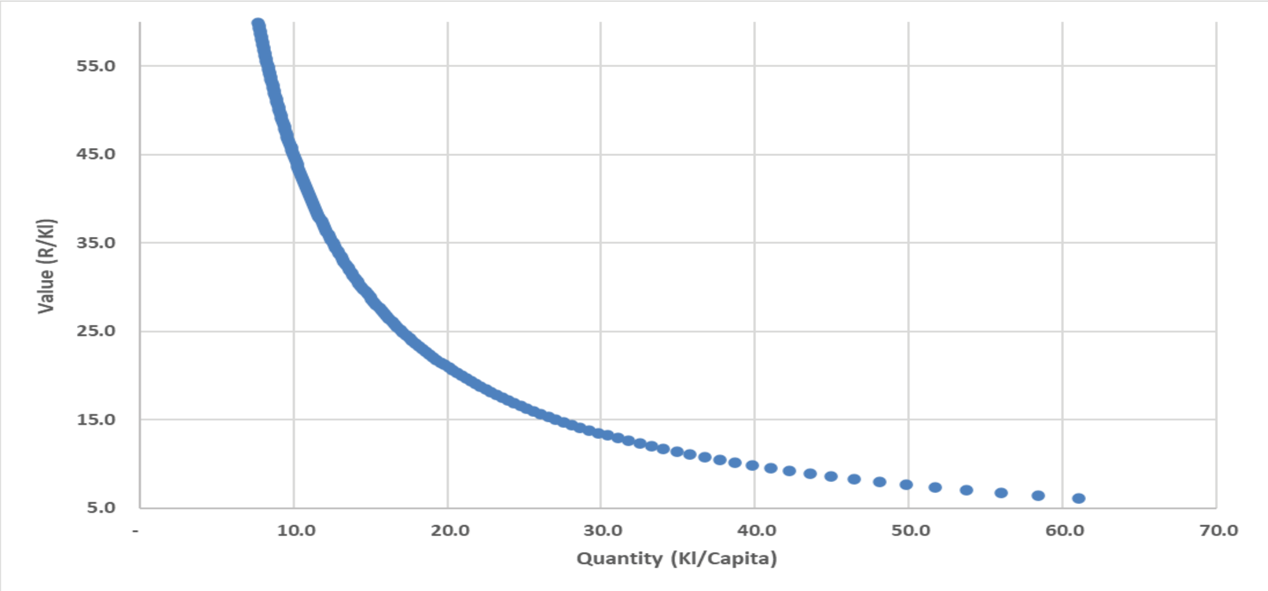
Cross Sectional Analysis

In cross sectional analysis, the reaction of different water users to tariff levels at the same point in time is investigated. An example of this is where a relationship is being determined between consumption and tariff data for different municipalities. An advantage of this method is that many factors influencing water consumption can be simultaneously analysed through multi-regression analysis.

8.2.3.1 Calculation of economic value

For CBA purposes, it is important to calculate the value of the total amount of water consumed by a specific urban household category. This can be derived from the demand schedules referred to above. Graph 8.1 is an example of the price demand schedule for the category: Urban households: High income: Outdoor[36].

Graph 8.1: Demand Curve: Households: High Income: Outdoor



In most cases, the CBA analyst will not estimate the tariff demand schedule her/himself, but will make use of secondary information. To construct a price demand schedule for her/his specific project, (s)he needs the current tariff and the average consumption per month of the category of households for a specific period. Furthermore, (s) he also needs the price elasticity for that specific category.

[35] Veck, A, and Bill, M., 2000, Estimation of the residential price elasticity of demand for water by means of a contingent valuation approach. Report 790/1/00. Water Research Commission.
[36] This is only a hypothetical case and the figures do not have any practical application.

The demand curve is constructed by assuming that the value of the last unit of water consumed is equal to the tariff paid by the consumer. The highest-quantity-lowest-value represents the current tariff. In the case of the example in Graph 8.1, this equals R6.14, which is a CPI-adjusted figure that reflects 2020 prices.

The economic value of water (per-capita per annum) can be defined as the total area under the curve. The value can be derived by calculating the integral under the price demand curve. To obtain the value per cubic metre of water, the total value should be divided by the volume of water use. In regard to this graph, the quantity of water consumed totals 60 kilolitre per-capita per annum.

It is important to note that, for medium and high-income households, it is recommended that the prevailing municipal tariff for water in the applicable municipality be applied.

8.2.4 Rural households

8.2.4.1 Introduction

It is very difficult to assign an economic value to household water use in general, and more particularly, a value for rural households.

Water is a good that has a value when it is consumed. However, if water is not available or unsuitable for human consumption, it has wider implications for society. In theory, the benefits of private goods are fully divisible and excludable, and the benefits of public goods are indivisible and non-excludable. Industrial water is a private good, but household water can provide broader health benefits and is, therefore, neither a purely private nor public good.

On the spectrum of private to public goods, household water lies between the two extremes, probably closer to pure private goods. Although this argument also applies with regard to urban household water, rural household water could probably be viewed as closer to a public good. This is also in line with current government policy where a certain amount of water is supplied free to the indigent communities.

Public or collective benefits are generally considered difficult to quantify and are intangible. The current practice in South Africa[37], and also by the World Bank[38], is to make use of the willingness-to-pay concept to calculate the economic value of water used by households in developing areas. By definition, this means that rural water is regarded as a private good. However, it will be recognised from the methodology that the pure willingness-to-pay principle in the true sense is only partially applied.

8.2.4.2 Methodology

The economic value of water is determined in two components. The first component deals with the social (public) portion of 25 litres of water per-capita/per day. This portion is in accordance with the government's policy on minimum water requirements for urban and rural households.

The second component deals with the volume of water consumed above the 25 litres per-capita/per day. This water is regarded as a pure private good.

[37] Internal Documentation of DBSA.
[38] World Bank. Operations Evaluation Department. May 1997. Report no. 146.

Social Portion of Water Consumption

The DBSA currently uses the following percentages for the social portion of water consumption for households with household income representing the amount of a household's willingness-to-pay for the social portion of the water.

	Potable Water	Sanitation
Low Income	4.0%	3%
Medium Income	2.7%	2.0%
High Income	1.3%	1.0%

The methodology to calculate the economic value for the social portion per kl for low-income households in a specific rural area is as follows:

Economic value of water = 4% of actual household income
monthly water consumption per household
= R197/month/household
4, 56 kl/month/household
= R43.19 per kl Where:

The monthly income of a rural/non-urban household consisting of six persons is R4 931. This is the average wage for unskilled labour in rural areas/ non-metro for all provinces. See Table 7.3.

and:

Monthly Water Consumption
per household = 25 litres per-capita per day
x 6 persons x 30, 44 days
= 4,565.63 kl per month

Private Portion of Water Consumption

The economic value of the balance of consumption is estimated by using the current tariff for water, taking into account the surplus value of that water. This is done by using the average of the current tariff per kl and the economic value of the social component per kl as calculated above. An example of this methodology for calculating the economic value of the private portion of water consumption is as follows:

Value Social portion
in R/kl + current
tariff in R/kl
2

Economic value of water per kl = R13.85 + R37.87
2
= R25.86

Consequently, the economic value for water is as follows:

Economic Value: Social portion = R43.19 per kl
Private portion = R25.86 per kl

The total value of water for a specific rural area is the weighted economic value of the social and private portion. An example of this for a household consuming 15 kl per month is as follows:

4565.63 kl x R43.19/kl	=	R197.22
10 431.25 kl x R25.86/kl	=	R269.75
Total monthly value		R466.97
Value per kl	=	R466.97/15 kl
	=	R31.14/kl

8.2.5 Irrigation agriculture[39]

The basic methodologies for estimating water values are crop-water production function analysis and farm crop budget analysis (including linear programming).

8.2.5.1 Crop-Water production function analysis

The relationship between inputs and outputs of crop production can be expressed mathematically as the crop production function. If all other inputs are held constant, the marginal physical productivity of water for each unit of water used on the crop can be calculated, where the marginal value of each unit of water is the marginal physical product times the crop price.

This procedure relies on the assumption that applications of different amounts of water incur the same labour, fertilizer, and other non-water input costs. Since these marginal values are not dependent on the economics of crop production, they are not related to fixed or variable costs, but only to the crop selling price and the physical productivity of the water unit. In addition, they reflect the value of on-site irrigation water.

Although the theory underpinning the crop-water production function method is sound, it is not often used to calculate the economic value of irrigation water as, in most places and for most crops, the actual physical productivity of water is not known. Crop-water production functions have not been scientifically established and the share of yield contributed by the water input has not been determined.

8.2.5.2 Farm crop budget analysis

A more popular method of estimating the economic value of irrigation agriculture is farm crop budget analysis. It is calculated as the total crop revenue, less non-water input costs. This residual can be defined as the maximum amount the farmer could pay for water and still cover costs of production. It thus represents the on-site value of water. If water procurement costs are further subtracted, the net value for irrigation is then comparable to in-stream water values. This monetary value, divided by the total quantity of water used on the crop, determines a maximum average value, or willingness-to-pay, for water for that crop. Depending on whether or not fixed costs are included, such values can be short-run or long-run average values.

8.2.5.3 Linear Programming (LP) Analysis

For calculating the economic value of a single crop, the method explained above is sufficient. However, it is accepted that a farm consists of more than one crop option, and switching can take place between products as the supply of water increases or decreases. In instances like this, more sophisticated methods to calculate the economic value of water with regard to irrigation agriculture will have to be applied. Probably the most important one is Linear Programming (LP) Analysis.

[39] The theory regarding valuation methods of water is taken from Gibbons Diana C (1985).

For the calculation of irrigation water values, the LP objective is to maximise net returns for a farm of specified hectares subject to constraints that may be economic or physical, such as hectares limitations for each crop, input cost per unit, available technology, constant water requirements set for each crop, crop prices, and so forth. In the LP solution, limiting the hectares of certain risky crops is one way to incorporate the desired level of risk to the farmer.

LP analysis can also be used to estimate marginal values for irrigation water on a representative farm, but not by crop. Instead of water cost, water supply is varied and an LP solution is found for each quantity of water available to the farm, all other constraints remaining constant. When the supply of water is low, the programme solution allocates water to its highest-valued uses, but as supply increases other less valuable or more water-intensive crops are added, and the marginal value of additional units of water falls. The set of shadow prices derived at various levels of water supply forms a water demand schedule for the farm.

8.2.6 Electricity

The economic value of hydropower is frequently recognised all over the world. However, in the case of South Africa, coal-based power stations generate most of the electricity consumed in the country. As such, this section pays specific attention to the development of a demand curve for coal-based power stations. From this the economic value of water used for electricity generation by coal-based power stations, can be deduced[40].

The main aim of the methodology is to calculate the economic value of water used in coal-based power stations, and to minimise the cost of water utilised in the process[41]. Two cooling systems are used in these South African power stations, namely wet and dry cooling systems.

A wet cooling system uses much more water than a dry cooling system in order to generate the same amount of electricity. In a wet cooling system 2.23 litres of water are used to generate 1kWh of electricity compared with the 0.22 litres of water per kWh of electricity in a dry cooled system.

However, a dry cooling system is much more costly than a wet one, and the running costs are also slightly higher. It is also difficult – and very costly – to convert a power station from a wet to a dry cooling system. The demand schedule for water is therefore very inelastic.

In a CBA study undertaken by Conningarth Consultants for the WRC in 1999[42] on dry cooling, it was established that, at a water tariff of R3.90 per kl, the dry cooling process becomes the cheaper of the two processes. This figure was updated with a CPI index using a series from 1999 to 2020 sourced from the South African Reserve Bank CPI Database. The adjusted figure reflecting the water tariff for dry cooling power stations in 2020 prices is R12.15 per kl.

8.2.7 Industry

With regard to the economic value of water used in industrial processes, it is notable that the cost of water is only a small percentage of the total cost of production. Even for industries that use huge quantities of water, the cost of water will be dwarfed by other production inputs, such as labour, energy, capital and raw materials utilised. It is thus clear that decisions on locality, technologies used, and scale of operations to maximise profits are more important than that of effective water utilisation.

[40] For calculation of the economic value of water for electricity generation by hydropower stations (See Gibbons Ibid, p. 86).
[41] A similar approach is also discussed in Gibbons Ibid p. 50.
[42] Conningarth Consultants Evaluating the Impact of Selected Water Research Commission Projects – A Cost-Benefit Analysis – A CBA Approach, 2000.

Theoretically, the demand and value of water used in industries could be derived from statistical industrial production functions or using the residual imputation method. However, in view of the importance of water, these methods are not often used. Instead, the economic value of water for industrial usage has been calculated by using the so-called second-best cost alternative, that is the cost to recirculate water within the production process. This means that industry will normally only be willing to pay for new water supply equal to the cost to produce water of adequate quality through treatment and reuse[43].

Currently the residual imputation method, also known as the budget approach, is applied to analyse various industries in South Africa in order to derive a demand curve for industrial water. This methodology was also used by Urban-Econ[44] in a report for the Department of Water Affairs some years back.

8.3 ECONOMIC COST OF WATER ADJUSTMENTS

In performing an Economic CBA, it is important that two additional cost items should be included in this analysis, namely the opportunity cost of water, and the environmental cost of water development. In calculating the cost of water in an economic analysis, the financial cost (capital as well as operational costs) forms the basis of these economic cost calculations. However, the financial costs must be adjusted in terms of shadow prices, opportunity costs and the environmental cost of water.

8.3.1 Adjustment for Shadow Prices

As is the case with CBA in general, the financial cost of water development should also be adjusted in terms of shadow prices to reflect the true costs for the community. See Chapter 7 for the conversion factors for these adjustments.

8.3.2 Opportunity Cost of Water

Water is a scarce resource in South Africa. In most of the drainage regions, an additional demand for water implies that there is not only storage and transfer costs involved, but also an economic cost (opportunity cost). This is due to the fact that this additional water demand in some cases deprives a current or a future user of water. For example, in a few water catchments in South Africa, where water in the low-flow periods is still adequate, are forestry permits readily issued, which attest to the scarcity of water. This example supports the opportunity cost argument.

In addition to the cost calculations proposed by the above-mentioned raw water pricing strategy, the opportunity cost of water should also be taken into consideration. However, in South Africa this aspect is not at this stage adequately taken into account. In theory the opportunity cost of water in a specific catchment is equal to the application with the highest economic use of water. This will differ from catchment area to catchment area.

Internationally, and also in South Africa, the economic value of water for industrial and urban use is much higher than the economic value of water for irrigation and forestry. The practical implication of this is that, in the event of a shortage of water for industrial and urban use, water will be channelled away from irrigation and forestry in favour of industrial and urban water use. In such cases, the economic value of water for industrial and urban use should at least be equal to the economic cost to the country (the so-called opportunity cost) of reduced forestry and/or irrigation activity.

[43] See Gibbons, Ibid, for more explanations.
[44] Urban-Econ. The determination of Economic Value of Water for the Vaal River System Area. A report by Urban-Econ for Department of Water Affairs. PC 000/00/10291. May 1991.

CHAPTER 9: DETERMINING ENVIRONMENTAL VALUES AND COSTS

9.1 INTRODUCTION

Achieving water security requires an integrated approach whilst, at the same time, recognising and accepting that economic trade-offs may be required. Given that development and policy decisions impact on the environment, it is important that these decisions are informed by a knowledge of the value of such impacts (Turpie, 2018). Thus, understanding economic trade-offs is an important part of sustainable water resource management.

Indeed, maintaining a certain level of environmental quality and quantity requires that stakeholders and decision-makers are exposed to comprehensive evaluations of the potential impacts of alternative environmental strategies so as to be able to determine appropriate environmental allocations that will best serve long-term societal interests (Turpie, 2018). Conducting CBA is one way of achieving this.

Interventions to address water security may include the restoration or protection of aquatic ecosystems as a stated objective, as an indirect consequence of improved environmental standards. Alternatively, interventions may lead to the degradation of ecosystems, for example due to increased abstraction from freshwater systems to increase urban or agricultural water supply. These positive or negative changes to the health and functioning of natural ecosystems lead to changes in the supply of ecosystem services, which can have both financial and welfare implications.

Understanding these impacts requires understanding which ecosystem services are supplied, how this is affected by the proposed development, and how to value that change. Measuring this change is highly context-specific though, as ecosystem services and their values vary geographically with factors that influence both supply and demand.

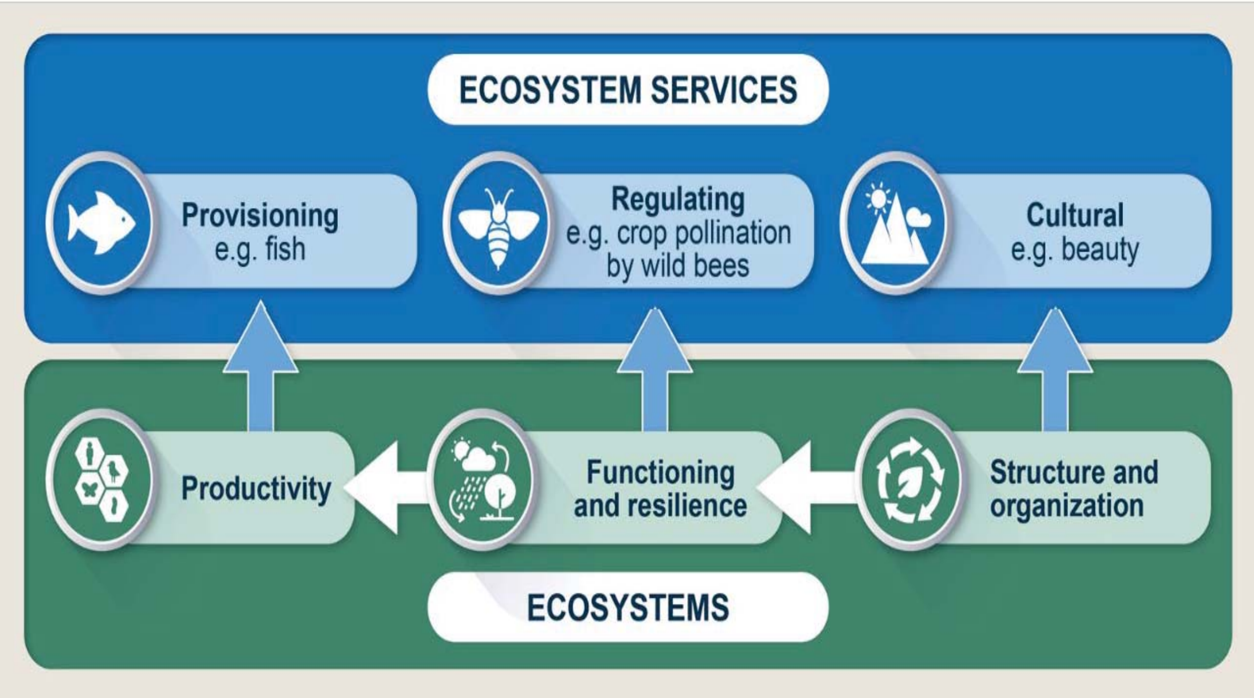
This chapter first discusses the role of biodiversity and ecosystems and the concept of ecosystem services. Following this, the role of the environment in achieving water security is presented, and key terminology and measures to address key issues are identified. The chapter then provides an overview of how economics can be applied to evaluate and address environmental problems through valuation and CBA.

9.2 BIODIVERSITY, ECOSYSTEMS AND ECOSYSTEM SERVICES

Ecosystem services are broadly defined as “the benefits people obtain from ecosystems” (Millennium Ecosystem Assessment, 2003, 2005), where these benefits depend on the nature of the ecosystems and their biodiversity. An ecosystem is defined as a community of living organisms in conjunction with non-living components of their environment, interacting as a system. The biotic and abiotic components are linked together through nutrient and energy flows. Ecosystems can be defined in space, and range in size, i.e. from wetlands to a large rainforest.

Ecosystem services were originally conceptualised in terms of “goods” (such as fish), “services” (such as pollination of crops by wild bees) and “attributes” (such as beauty and rarity), which determine how they are used or appreciated for purposes such as recreation, religious ceremonies, or sense of place (Barbier, 1994).

The attributes of ecosystems and their capacity to supply goods and services are strongly linked to ecosystem condition. The concepts of ecosystem goods, services and attributes are now more commonly referred to as provisioning, regulating and cultural services, respectively. Supporting services, a term coined by the MEA (2003), are services that are necessary for the production of all other ecosystem services, and include biomass production, soil formation, nutrient cycling, water cycling, and provisioning of habitat. These are now considered to be underlying processes that enable the supply of provisioning, regulating and cultural services. These services are described in more detail in the following sections.



Source: Turpie, unpublished

Ecosystem services are fundamentally linked to biodiversity, which is the variability among living organisms and the ecological complexes of which they are part. This includes diversity within species, between species, and of ecosystems. The biological diversity found within an ecosystem is critically important to its functioning and value. In particular, an ecosystem's composition determines its productivity and resilience.

Diversity within functional groups also helps to maintain ecosystem structure and functioning, such as its trophic balance (the ratios of predators to prey, etc.). Therefore, biodiversity plays the same role in ecosystems as diversity in a financial portfolio, in that it reduces variability (uncertainty) in yield. This is known as the "portfolio effect". In this way, biodiversity acts as "insurance" against climate change and other shocks. Biodiversity is the foundation of the vast array of ecosystem services that critically contribute to human well-being. Thus, decisions humans make that influence biodiversity affect the well-being of themselves and others.

9.2.1 Provisioning services

Provisioning services are the harvestable resources supplied by ecosystems, such as wild foods, raw materials, and the land inputs to agricultural and livestock production. Resource availability is linked to both ecosystem characteristics and property rights; whilst demand is influenced by the socio-economic circumstances of households and the prices of alternatives. Rural households in South Africa depend on subsistence agriculture and harvest a wide variety of wild plant and animal resources for nutrition, health, energy, and raw materials, particularly where there are limited economic opportunities (Turpie *et al.*, 2006;

Barnes *et al.*, 2009). Importantly, the use of provisioning services reduces the opportunities to obtain cultural and regulating services. The uses of these services often have to be limited or modified in order to secure regulating and/or cultural ecosystem services.

9.2.2 Regulating Services

Regulating services are the functions that ecosystems and their biota perform that benefit people in surrounding or downstream areas or even distant areas. These services include carbon sequestration – the active removal of carbon from the atmosphere by vegetation growth – reducing the potential impacts of climate change, or the passive benefit of retaining the carbon stored in the landscape by avoiding deforestation and hence avoiding causing further climate change damages both locally and in the rest of the world. Other greenhouse gases are also regulated in situ if the natural habitats are healthy i.e. leaching of ammonia and other substances is controlled. This category also includes the pollination of crops in nearby fields by insect pollinators that are supported by natural habitats. This is important in low-input, small-scale production systems.

Three types of regulating services are strongly linked to the way in which catchment hydrology is mediated by vegetative cover and ecosystem condition. These are the regulation of water flows, the control of sediments, and the removal of excess nutrients that affect water quality (Ekka *et al.*, 2020). Natural vegetation regulates the flow of water by facilitating the infiltration and temporary storage of rainwater before it enters streamflow. This reduces the seasonal variation in flows and helps to maintain base flows during the dry season, which, in turn, reduces the need to store water during the wet season for use in the dry season.

Natural vegetation also helps to slow down floodwaters during storm events, reducing potential damage (Nedkov & Burkhard, 2012). In addition, natural vegetation prevents erosion by stabilizing soil and intercepting rainfall, thereby reducing its erosivity, and can also trap eroded sediments that are transported from upstream (Conte et al., 2011). Stabilizing soil protects downstream areas from sedimentation, which can include impacts on water storage capacity, hydropower generation, and navigability of rivers. In addition, some of the nutrients in nutrient-enriched runoff can be removed when it passes through natural vegetation and wetlands in the landscape, mitigating downstream eutrophication, toxic algal blooms, deoxygenation, and fish kills that affect human health, water-treatment costs, and fisheries (Conte et al., 2011). All of these services help to save on grey infrastructure costs.

9.2.3 Cultural services

Cultural services are the ecosystem attributes (i.e. beauty, species diversity) that give rise to the “use values” gained through any type of activity ranging from adventure sports to birdwatching, religious or cultural ceremonies or just passive observation, or the “non-use values” gained from knowing that they exist and can be enjoyed by future generations. These values can be observed through local use, domestic and international tourism, and the premiums paid for properties that are close to natural amenities, or they can be investigated through stated-preference surveys, in which society’s willingness to pay to secure the biodiversity in question is estimated.

9.3 THE ROLE OF THE ENVIRONMENT IN ACHIEVING WATER-SECURITY

9.3.1 The challenge

To achieve water security, there is a need to restore and protect important water source areas and manage water resources in an integrated way. More so than ever before, natural ecosystems and the services they provide are increasingly being recognised as important for addressing water-security challenges. Healthy, functioning ecosystems increase water availability through improved soil retention and groundwater recharge, improve water quality by reducing sediment and nutrient loads into river systems, and reduce water-related disasters and climate change risks, such as floods and landslides. In other words, intact ecosystems play an important role in the movement of water through the landscape, its storage, and its transformation (Mishra et al., 2021).

At the extreme, ecosystem functioning can be completely lost through irreversible degradation or the intentional conversion to alternative land uses. When this happens, landscapes lack the functionality and resilience to sustain the delivery of ecosystem services. Not only does this affect livelihoods and quality of life of the people that are reliant on these services but it also increases the costs of water supply (Blignaut *et al.*, 2008).

Thus, achieving sustainable water management, in which water resources are used and allocated efficiently to achieve positive economic and social returns, requires investing in the restoration and conservation of critical catchment areas and finding sustainable "green" solutions to achieve cost savings and reduce environmental impacts. Such approaches are termed green infrastructure and ecological infrastructure and are described in the following sections.

9.3.2 Green (environmentally friendly) infrastructure

Engineers are continually improving their designs in order to reduce the environmental impacts associated with conventional grey infrastructure. For example, they have come up with ways to retard water flows from urban structures such as buildings, paved areas and drainage systems, by improving their capacity for infiltration and storage. These reduce environmental impacts indirectly in that they reduce the need for more conveyance infrastructure.

Whilst these can be purely structural innovations, they often involve the use of vegetation, especially where doing so can also help to address water quality issues. These measures are examples of green infrastructure, where the "green" is used in the sense of lower environmental impacts. Another example is the construction of artificial treatment wetlands to further improve the quality of treated wastewater.

Such investments can lead to considerable cost savings, particularly for the management of downstream environmental issues in urban environments, although in the case of their contribution to water quality, they tend to be most effective when the fundamentals (sanitation measures) are already in place (Turpie et al., 2017a). Note that the term "green infrastructure" is often used to include both the engineering innovations described here and ecological infrastructure, which we describe separately below.

9.3.3 Ecological infrastructure

Investments are also needed in restoring and maintaining the natural ecosystems that play an important role in complementing and supporting grey and green infrastructure investments. These ecosystems are known as ecological infrastructure. In the context of climate change and growing populations, traditional built infrastructure implemented alone is unlikely to be sufficient in addressing water supply challenges, and the importance of ecological infrastructure is becoming increasingly clear.

Natural systems such as forests, grasslands, wetlands and floodplains, have a direct influence on catchment hydrology, contributing towards a clean and reliable supply of water (see section 9.2.2). The ecosystem services provided by healthy ecosystems – the regulation of water flows, the control of sediments, and the removal of excess nutrients that affect water quality – all help to save on grey infrastructure costs and offer some of the most effective ways to improve water security. However, the extent and condition of these ecosystems are threatened by increasing levels of degradation (i.e. soil erosion, wetland drainage, land use change).

The protection and/or restoration of these ecosystems is increasingly being shown to be critical to meeting water resources management challenges. Similarly, the management of cultivated lands is also important in this regard. Indeed, whilst investment in built infrastructure is a primary element of achieving water security, even the best-built infrastructure will not be able to supply sufficient water without maintaining the integrity of natural systems and cultivated land. Securing ecological infrastructure can be a cost-effective way to enhance service delivery and ensure resilience (WWAP, 2018; Browder et al., 2019).

By investing in ecological infrastructure, the existing lifespan of conventional grey infrastructure can be lengthened or the need for additional built structures can be reduced, usually with significant cost savings. In addition, whilst the investments might be focused on water security, they also have the added advantage of a range of co-benefits associated with having healthier ecosystems.

9.4 VALUATION OF ENVIRONMENTAL CHANGES

9.4.1 The Total Economic Value concept

The values produced by ecosystem services are categorised into different types. The Total Economic Value of an environmental asset or an ecosystem comprises Direct Use, Indirect Use, Option and Non-Use values as reflected in Figure 9.1 below.

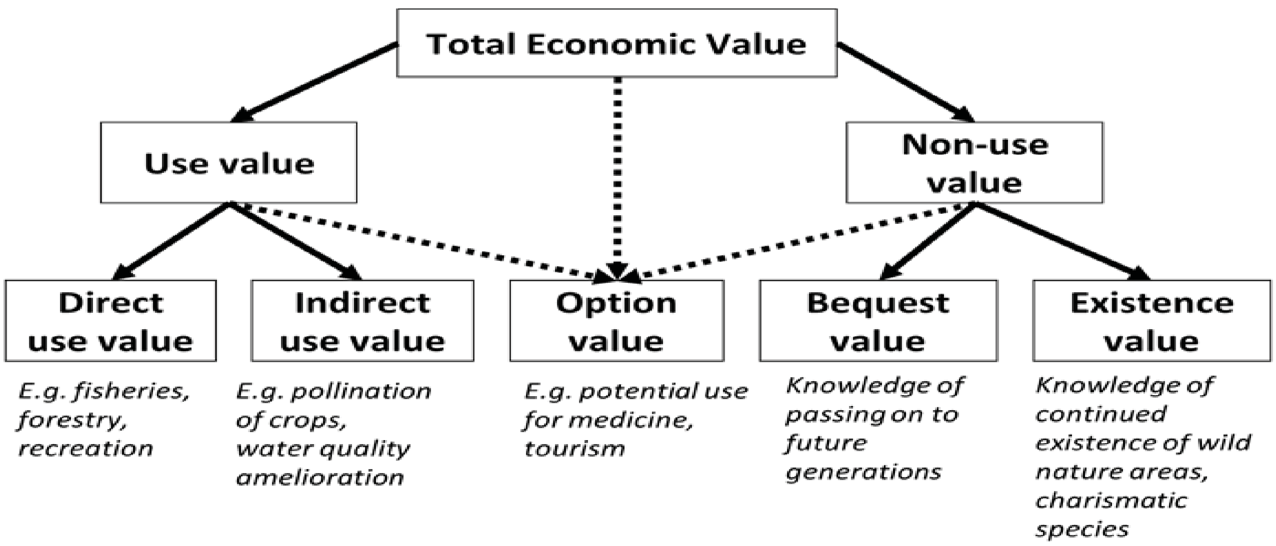


Figure 9.1: The components of Total Economic Value. Source: Turpie (2018)

Direct use values may be generated through the consumptive or non-consumptive use of resources. These values are more likely to be straightforward to estimate because there are often well-functioning markets.

Indirect use values are values generated by outputs from ecosystems that form inputs into production by other sectors of the economy, or that contribute to net economic outputs elsewhere in the economy by saving on costs. These outputs are derived from ecosystem functioning such as water purification and nursery functions.

Option value is the value of retaining the option to use something in the future. Non-use value includes 'existence value', which is the value derived from knowing that something exists or is protected, without necessarily having any intention of using it, and 'bequest value', which is the value of knowing that your descendants or other members of society will have the opportunity to use it. Although far less tangible than the above values, option and non-use values are reflected in society's willingness to pay to conserve these resources, sometimes expressed in the form of donations.

9.4.2 Valuation methods

9.4.2.1 Overview

The various different approaches, developed for the valuation of ecosystem services over the last few decades are typically classified into (a) market-based approaches, (b) revealed preference approaches, and (c) stated preference approaches (Table 9.1).

Table 9.1: Valuation approaches and the types of value that they are used to measure. Source: Turpie (2018).

Approach	Method	Direct use values	Indirect use values	Option & non-use values
Market value approaches	**Observed market prices**	X	X	
	Production functions	X	X	
	Damage/replacement cost		X	
Revealed preference approaches	**Travel cost**	X		
	Hedonic pricing	X		
	Averting behaviour		X	
Stated preference approaches	**Contingent valuation**	X		X
	Conjoint/choice experiments	X		X

Market-based approaches include the use of directly observed market prices, deriving prices from production functions, or estimating cost savings. The latter can be the avoided damages that would occur in the absence of the service, or what it would cost to replace the service using an engineering solution.

Revealed preference approaches involve the analysis of expenditures that people make either to protect against a bad environment or to take advantage of a good environment. Commonly used methods include the averting behaviour method, travel cost method, and hedonic pricing method.

Stated preference approaches involve asking people directly how they value environmental changes. Methods include contingent valuation and choice experiments. Table 9.1 shows which approaches and methods might be used in eliciting which value sets. Typically, the more intangible a value or type of value is, the fewer approaches and methods there are available for deriving and estimating values.

9.4.2.2 Market-based approaches

Market-based approaches can be applied to the measurement of direct or indirect use values. Observed market prices are most often used for valuing provisioning services (such as for fish or timber) where there is available data on the prices of these resources that are collected directly from natural ecosystems. Where the costs of production are negligible then the use of market prices is acceptable. However, for provisioning services that are harvested from managed ecosystems or using significant human inputs, or for any ecosystem service that has significant human inputs, then it is more accurate to use residual value or resource rent methods.

Residual value is the gross value of a marketed good to which the ecosystem service provides an input, minus the costs of all other inputs including the unit costs of labour, produced assets and intermediate inputs. Residual value is similar to resource rent as described and applied in SEEA ecosystem accounting (SEEA Experimental Ecosystem Accounting, UN 2017). However, a number of market conditions must be in place for this price to accurately reflect the value of the resource. For example, if markets are not competitive or there are externalities, then the value will need to be corrected, which can be done using shadow pricing.

Production functions can be used to reveal the marginal benefits of environmental inputs. It is a statistical model that shows how much of the output of a marketed good will change as a result of a change in an environmental variable. For example, a statistical analysis can be undertaken to relate changes in relative water quality in a river or water supply dam to changes in water-treatment costs. This requires collecting detailed data on the production system. Either time series data from a single locality or data from multiple localities (cross-sectional data), or preferably panel data, which is time series data from multiple localities is needed. However, such data can be difficult to obtain. Without such data it is difficult to show the cause-and-effect relationships.

Alternatively, replacement or damage cost methods can be used to estimate the costs that are being avoided as a result of the service being there. These methods are typically used to value regulating services and it is the lesser of the two that is used. The indirect nature of these services means that their values are usually not immediately obvious to people. Estimating the expected damage costs involves estimating what damages could happen in the absence of the ecosystem providing the service, such as the flood damages that might occur if a channel was dug through an upstream wetland.

This usually involves complex biophysical modelling and costing. The replacement cost method, which is sometimes referred to as the damage prevention cost method, involves estimating what measures or interventions can be taken or implemented to replicate the service, or protect society from the damages that could be incurred without the ecosystem service being there. In the flood example provided above, this might be the cost of building flood protection levees.

Another example where these methods are used would be in valuing erosion control. Without natural systems providing erosion control in catchment areas, alternative conventional infrastructure would need to be implemented to prevent the loss of storage capacity and sedimentation of downstream aquatic environments. The costs of the alternative conventional infrastructure represents either the replacement cost or the damage costs avoided and is used to value the erosion control service provided by the natural systems. The replacement cost of lost storage capacity (i.e. through raising the dam wall, constructing a substitute dam at a new site to make up the reduction in capacity, or constructing sediment check dams) estimates the amount of storage that would have to be constructed to prevent a similar amount of sediment from reaching downstream aquatic environments, using an average capital replacement cost.

9.4.2.3 Revealed preference approaches

Revealed preference approaches use actual consumer behaviour to estimate values. These include averting behaviour, travel cost, and hedonic pricing methods (Turpie, 2018). These methods are based on people's actual expenditures to use an environmental good or to avoid pollution.

The averting behaviour method estimates damage costs of pollution by assessing people's expenditure to mitigate damages that are caused by environmental impacts. Examples include purchasing of bottled water because of heightened health risks associated with polluted water, or installing double-glazed windows because of traffic noise, or installing air conditioning units to avoid polluted air. This method typically provides an underestimate of actual value, as not all of the impacts are eliminated and people tend to adapt by changing their behaviour, for example.

The travel cost method uses people's expenditure on travelling to a site to estimate its recreational value. The relationship between the costs of travel to a site and the number of trips taken by people from different distances away is used to derive a demand curve in order to estimate not only total spend, but also consumer surplus. These data are typically collected using visitor surveys. The travel cost method is well established, ranging from simple models to complex models of peoples' choices. This method can be difficult to apply in situations where people are on multiple destination trips.

In the context of environmental valuation, the hedonic pricing method is typically used to estimate how much the presence of views or proximity to positive or negative environmental features increases or decreases property values. This is estimated using regression analysis in which property sales prices are analysed in respect to the environmental attribute of interest, whilst controlling for the other factors that influence property price such as the size or condition of the property or proximity to schools and shopping centres. For example, the method can be used to estimate whether green open spaces or the planting of street trees in cities improve property values in an area.

The method is very well established and with quality data, is considered reliable. However, obtaining quality datasets on prices and property characteristics can be challenging. Furthermore, the method will only work where there are competitive property markets and identifying all variables that influence property values is often difficult to do. The method can be difficult to use for economic analysis because a complicated second stage of analysis is required to estimate consumer surplus.

9.4.2.4 Stated preference approaches

Stated preference approaches use survey-based methods to directly ask people about their preferences. These methods provide the only means of estimating changes in option and non-use values. They can, however, also be used to estimate changes in some direct use values such as recreational value but are not reliable for valuing regulating services.

Contingent valuation methods involve the use of survey questionnaires where respondents are either asked about their willingness to pay either for a positive change, such as restoration of a wetland or protection of biodiversity, or their willingness to accept compensation for a negative change, such as the loss of access to an area that they make use of or for putting up with living with elephants. The questions are phrased and directed at the respondent in a careful manner by skilfully crafting a hypothetical scenario and using a payment mechanism (such as a payment card) to elicit willingness to pay. This method was specifically designed to estimate the non-use values associated with ecosystems but has also been used to estimate other types of value. This is a well-established method that is relatively straightforward to undertake and does not require large amounts of data. However, it can be an expensive undertaking and is prone to a number of potential biases and so requires very careful design and testing.

Choice experiments are also survey-based methods, using questionnaires, but instead of asking a question about a specific change, respondents are asked to choose from a set of alternative options that vary in terms of their characteristics and costs (9.2). Their choices reveal how they trade off the different attributes with cost. For example, respondents can be presented with options in which the quantity or quality of an environmental feature varies, such as having more family parks in a city, but with higher taxes to cover the cost of having the additional parks. Based on the choices that people make, the value of an additional park can be estimated.

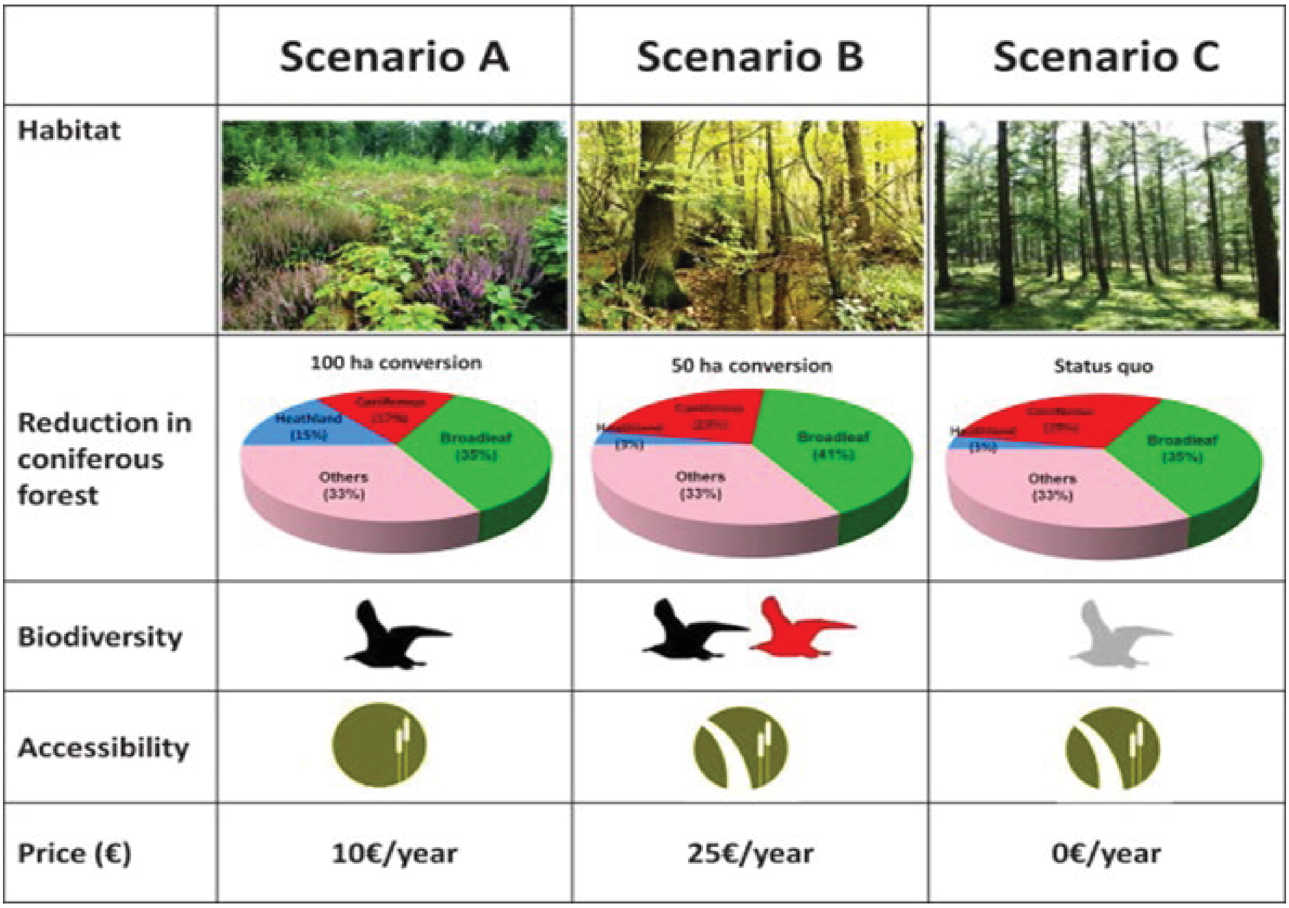


Figure 9.2: An example choice set. Source: De Valck et al., 2014.

Choice experiments are more flexible than contingent valuation methods as a range of options can be assessed and the marginal changes in the quantity or quality of environmental assets can be valued. They are particularly well suited to situations where ecosystem services are multidimensional and where it is useful to know the value attached to different components of a package of services provided by an ecosystem. The more complex the choice sets are (i.e. a higher number of attributes and levels), the larger the sample size needs to be for the analysis to be sound. The statistical design and analysis of choice experiments requires complex statistics. However, there are software packages available to help with this.

9.4.2.5 Value transfer

The value transfer is the practice of using values from existing studies to estimate the value that would be applicable to other areas. This method is a shortcut that avoids commissioning new studies because primary data collection might be too expensive or too time-consuming. The major challenge with using value transfer is that values vary geographically with factors that influence both supply and demand. For example, the supply of ecosystem services could vary in an area depending on site characteristics like ecosystem type, extent or condition.

The demand could vary depending on the people living in that area, the distance between people and the ecosystem, and other socio-economic factors such as household income, culture and preferences, the institutional context such as land tenure rights and governance, and the context for beneficiaries in terms of availability of substitutes or complementary sites and services. There are four value transfer approaches; unadjusted value transfer, adjusted value transfer, value function transfer, and meta-analytic transfer.

- Unadjusted value transfer is the simplest approach whereby the mean willingness to pay value is taken from an existing study site (i.e. R100/hectare) and directly applied to the policy site which is being evaluated (i.e. R100/hectare). This is essentially a “look-up table” approach which is generally considered unacceptable as it ignores differences between the two sites in terms of socioeconomic and demographic characteristics, physical characteristics, market conditions, and differences in time.

- Adjusted value transfer takes the value from the study site (i.e. R100/hectare) and adjusts it for income differences between the two study sites using estimates of income, willingness to pay and income elasticity and then applies this adjusted value to the policy site (i.e. R500/hectare).

- The value function transfer approach considers a wider range of differences between the study and policy site. A value function is estimated for the study site and is used in conjunction with information about a number of variables at the policy site. The change in willingness to pay as a result of a marginal change in the corresponding variables at the policy site is estimated.

- Using a meta-analytic function transfer, a willingness to pay function is estimated using value functions from several sites to estimate values at the policy site. This allows consideration of greater variation of site and socioeconomic characteristics but is only robust when there are numerous quality studies available. Using this approach can be challenging when studies have used different methods in determining their values.

Whilst this method is generally considered unreliable, the increase in the number of valuation studies has increased the spatial variability of available data sets and derived values which has in turn led to increased accuracy of value estimates established through value transfer (Turpie, 2018).

9.4.3 Valuing impacts on the environment

In this section we look more closely at the types of environmental impacts that occur as a result of water resource developments and their costs to society as well as how valuation methods can be applied to valuing environmental changes (both positive and negative) and how CBA can be used to assess these changes.

Previously, analysts may not have included the environmental impacts of water development projects into their overall appraisal. This was largely because most environmental goods and services are not traded in the marketplace and thus do not have established prices. However, these goods and services do have a value to society, often significant, and their degradation or loss represents a cost which should be captured. Previously assessments may have focused solely on infrastructure costs, for example the capital and maintenance costs of building a new water supply dam and the water supply benefits that would be generated through its construction.

However, the construction of a large water supply dam or the development of largescale irrigation can have significant onsite and downstream environmental impacts, which are often overlooked. For example, the construction of a large water supply dam could result in reduced sediment loads downstream as the sediments being transported by the river end up in the dam, starving downstream aquatic ecosystems. The result is downstream channel erosion and coastal erosion whereby the morphology of estuaries, deltas and beaches changes with knock-on impacts on the ecology of the system.

The emergence of technology and biophysical and economic modelling and valuation techniques and tools over the past decade has enabled us to be able to predict the magnitude of the impact of a project on ecosystems more accurately, as well as determine their value to society. Typically, the environmental costs are incorporated into a CBA by valuing the development alternative as the change in net benefits attributable to the project less the cost of the infrastructure needed to develop the project. The value of the ecosystem services that are lost or degraded through the development would be included as a cost unless the project is being compared to an environmentally friendly alternative in which case the net values of the potential losses incurred through the project would be included as a benefit in the form of avoided losses or cost savings.

Examples of potential environmental impacts and their associated costs to society are shown in Table 9.2. The methods typically used to evaluate these costs are described in section 9.4.2 above.

Table 9.2: Examples of the main environmental costs associated with water resource development

Project	Environmental impact	Costs to society
Water supply / hydropower dam	• Loss of important/iconic fauna and flora and loss of land for alternative use (inundation). • Fragmentation of river ecosystem impacting the movement of migratory river animals. • Reduced sediment deposition leading to increased erosion of downstream aquatic habitats (i.e. coastal deltas, floodplains). • Hydrological alteration of flows downstream influencing flood regime and flows to estuaries.	• Loss of biodiversity, sense of place • Lost land use opportunities • Tourism losses • Loss of flood-dependent ecology and floodplain agriculture & fishing (losses in human uses of floodplains) • Loss of nursery value
Largescale irrigation	• Changes to floodplain land use and ecology • Worsening of downstream water quality through nutrient runoff from agricultural chemicals and fertilizers • Reduced river flow • Waterlogging and salinization	• Higher water-treatment costs • Loss of flood-dependent ecology and floodplain agriculture & fishing (losses in human uses of floodplains) • Loss of nursery value • Loss in agricultural productivity
Channelisation & canalisation of rivers	• Loss of aquatic habitats • Loss of river connectivity to floodplain • Changes in water quality • Increased levels of erosion and sedimentation	• Loss of flood-dependent ecology and floodplain agriculture & fishing (losses in human uses of floodplains) • Amenity losses

9.4.4 Cost reductions and economic co-benefits of ecological infrastructure

The nature and magnitude of the impact of a specific water resource development project can be improved significantly through the investment in ecological infrastructure. For example, degraded catchments lead to the reduced capacity and lifespan of water supply dams, increasing the cost of their maintenance, decreasing their ability to produce hydroelectric power, or reducing availability of water for irrigation and municipal use. The loss of vegetation from the catchment may increase flood risk, resulting in damage to downstream infrastructure such as roads and bridges. Therefore, it is generally more cost-effective to restore the ecosystems or integrate ecological infrastructure with engineered solutions than it is to keep repairing or replacing the built infrastructure. Improving the environment and having combined infrastructure approaches can thus enhance water development projects.

Table 9.3 provides a description of the ecological infrastructure interventions that can be employed to improve the nature and magnitude of the impact of water development projects and provides examples of the benefits that can be achieved in terms of water supply (or infrastructure cost reductions) as well as potential economic co-benefits that should also be included in a project’s economic evaluation. The environmental co-benefits associated with the implementation of ecological infrastructure interventions are often significant and can be a driving factor in the selection of the project for implementation, often attracting further investment from the private sector and international donors.

Table 9.3: Ecological infrastructure interventions and the benefits that they can provide

Ecological infrastructure intervention	Water supply benefit / infrastructure cost reduction	Potential economic co-benefits
Restoration of catchment areas to improve infiltration (i.e. clearing of invasive alien plants)	Increased water yields, flow regulation	Climate mitigation, biodiversity and recreational values
Active restoration of catchment areas to reduce erosion and soil loss (i.e. tree and/or grass planting, stabilisation)	Improved water quality, extended lifespan of the dam, reduce hydropower equipment and water-treatment plant operational and maintenance costs	Climate mitigation, biodiversity and recreational values
Incentives for better catchment management (Payments for Ecosystem Services) to improve land management practices that supply target ecosystem services such as soil retention	Improved water quality, extended lifespan of the dam, reduce hydropower equipment and water-treatment plant operational and maintenance costs	Climate mitigation, biodiversity and recreational values
Soil conservation measures on cultivated land to reduce erosion and soil loss (i.e. reduced tillage, contour ploughing, terracing, agroforestry, farmer-managed natural regeneration)	Improved water quality, extended lifespan of the dam, reduce hydropower equipment and water-treatment plant operational and maintenance costs, reduced irrigation requirements	Increased crop yields, climate mitigation, natural resources for subsistence use (i.e. wood)
Restoration or rehabilitation of wetlands	Improved water quality and flood protection	Climate mitigation, biodiversity and recreational values, natural resources for subsistence use (i.e. fish, medicinal plants, wild foods)
Protection and/or restoration of riparian zone to maintain a natural vegetative buffer along streams and rivers	Improved water quality and flood protection, extended lifespan of a dam through reduced sedimentation	Climate mitigation, biodiversity
Improved rangeland management to reduce soil erosion and maintain vegetative cover	Increased baseflows during the dry season (assurance of supply), extended lifespan of the dam, reduce hydropower equipment and water-treatment plant operational and maintenance costs	Climate mitigation, biodiversity
Maintain or reinstate natural vegetation buffers between agricultural crops and rivers and wetlands	Improved water quality, improved soil quality	Climate mitigation, biodiversity

The viability of such projects is usually evaluated using an approach where, the impacts of a development project, which would without any intervention follow a business-as-usual (BAU) approach, are compared with the impacts of following a more environmentally friendly development path where the scenario/s comprise measures that reduce the rate of loss of ecosystem services and/or reduce the cost of grey infrastructure components by either reducing capital costs, reducing operation and maintenance costs, or by increasing climate resilience.

The environmentally friendly scenario/s which include interventions to restore or conserve ecological infrastructure is then compared to the ‘do nothing’ BAU scenario. This is achieved by dividing the difference in benefits of the environmentally friendly scenario versus the BAU scenario by the costs of restoration interventions in achieving the conservation outcomes. This produces a benefit-cost ratio (BCR) or return on investment (ROI), which suggests how many units of benefit each unit of cost brings.

An example, taken from Turpie et al. (2021) is shown in Table 9.4 below, where the potential costs and benefits of addressing land degradation in the Thukela catchment (one of South Africa's most important catchments in terms of water supply and one that is severely degraded) were estimated using a scenario-based approach. The study estimated the costs and benefits of interventions under a fully restored catchment scenario and a land degradation neutrality scenario and compared these with a BAU scenario.

Table 9.4: Present value of the costs of interventions and ecosystem service benefits relative to BAU under the LDN and Full Restoration scenarios (2020 R millions, 3.66% discount rate, 25 years). Source: Turpie et al., 2021

	Present value (R millions)		
Costs relative to BAU	**LDN Scenario**		**Full restoration scenario**
	Upper bound costs	**Lower bound costs**	
Clearing IAPs	514.4	514.4	2 355.2
Addressing bush encroachment	507.2	237.6	691.1
Active restoration of grasslands, erosion	2 623.6	-	-
Sustainable land management	-	1 981.02	6 093.62
Total present value of costs	**3 645.18**	**2 733.09**	**9 139.98**
Water supply	2 591.4	2 591.4	10 757.2
Sediment retention	38.9	38.9	63.1
Tourism	121.8	121.8	243.6
Carbon storage (avoided national cost)	-274.91	-274.91	597.5
Harvested wild resources	70.6	70.6	2 391.3
Livestock production	620.7	620.7	1 476.9
Total present value of benefits	**3 168.6**	**3 168.6**	**15 529.6**
Net Present Value	**-476.6**	**435.5**	**6 389.6**
BCR	**0.9**	**1.2**	**1.7**

The Thukela catchment provides a range of ecosystem services which contribute to benefits used by the economy and to the provision of sustainable livelihoods. The study included the following ecosystem services: water retention (regulation of water supply); sediment retention (erosion control); carbon sequestration; provisioning of livestock products; provisioning of wood products; provisioning of non-wood products; and nature-based tourism.

The benefits were estimated as the difference in value of ecosystem services compared to the BAU outcome, and the costs of the interventions were based on the literature and previous studies undertaken in the catchment. The key finding from the study was that halting and reversing ecosystem degradation can have positive net economic benefits. The degradation of natural landscapes and ecological infrastructure has significant social, economic and environmental costs. Measures to slow, halt and reverse the net impacts of poor land management were in most estimations expected to have positive net benefits. Therefore, addressing land degradation could be justified in economic terms.

CHAPTER 10: PRACTICAL EXAMPLES

This chapter presents the practical case study applications. These practical examples are Excel spreadsheet format and accompany the report separately. They will also be made available on the WRC website.

10.1 EXAMPLE 1: DAM CONSTRUCTION 1

10.1.1 Objective

The objective of this example is to evaluate the feasibility of a project in the Limpopo Province with regard to the construction of a dam. It is planned that the water will be used to supply raw water to a nearby Municipality, 6 new coal mines and to game farms nearby. The dam will also be used for sailing, whilst a camping site will also be developed on the shores of the dam.

10.1.2 Features of Example

The model is a complete dynamic integrated model that makes provision for various discount rates covering a study period of 31 years. The example makes provision for:

- Consumption for household users
- The ecological and tourism benefits of the dam
- The use of water for mining activities
- Financial and economic analysis
- Various capital cost items
- Increases in number of connections and individual consumption over time.
- Operational and maintenance costs

10.1.3 Layout of Example

The model layout incorporates:

- Separate input and result sheets
- Financial Cost Benefit Analysis sheet
- Economic Cost Benefit sheet

10.1.4 Project Cost

Project costs include:

- Capital Cost:
  - Dam
  - Reservoir
  - Bulk Pipelines
  - Vehicles
- Professional Fees
- Contingencies
- Escalation
- Operating & maintenance cost of the dam – R/kl

10.1.5 Project Benefits

Project benefits include:

- Revenue from water sales to consumers and to the mine
- Revenue from tourism

10.1.6 CBA Evaluation Criteria

CBA evaluation criteria include:

- Internal Rate of Return (IRR)
- Net Present value (NPV)
- Benefit/Cost Ratio (BCR)
- (Definition of BCR: NPV of total benefits divided by NPV of total costs)

10.1.7 Economic Value of Water

Economic value of water criteria include:

- The willingness to pay (WTP) for water was used for consumers
- For mines the value of the water in the mining of coal was calculated.
- The ecological and economic benefits of tourism was calculated: These include:
  - Cultivated Floodplains
  - Provision of Stock Water
  - Recreational fishing, boating and camping
  - Contribution of the water to the consumer surplus of the Game Farms

10.1.8 CONVERSION FACTORS FOR PURPOSES OF SHADOW PRICES

See Sheet: ECON CBA – Column K

10.2 EXAMPLE 2: POTABLE WATER

10.2.1 Objective

The objective of this example is to evaluate the feasibility of a community project in KwaZulu-Natal with regard to the delivery of potable water. This is as a result of a community that had to be resettled due to the construction of a new dam for irrigation purposes. Raw water is purchased from the dam operator and then purified.

10.2.2 Features of Example

The model is a complete dynamic integrated model that makes provision for various discount rates covering a study period of 20 years. The example makes provision for:

- Consumption for household and commercial users
- Different income-levels
- Differentiated tariff structure
- Financial and economic analysis
- Various capital cost items
- Increases in number of connections and individual consumption over time.

- Operational and maintenance costs

Model includes shadow prices for capital and operational elements.

10.2.3 Layout of Example

- Separate input and result sheets
- Financial analysis sheet
- Economic analysis sheet

10.2.4 Project Cost

- Capital Cost:
  - Reservoirs
  - Treatment Works
  - Pump Stations
  - Bulk Pipelines
  - Telemetry
  - Reticulation
  - Computers
  - Vehicles
  - Contingencies
  - Professional Fees
  - Other Capital Expenditure
  - Annual Escalation
- Purchase of raw water from the bulk supplier – R/kl
- Operating & maintenance cost of water purification – R/kl
- Operating & maintenance cost of reticulation (including administration costs) – R/kl

10.2.5 Project Benefits

- Revenue from water sales
- Reduction in water losses
- Savings in operation & maintenance costs, if any

10.2.6 CBA Evaluation Criteria

- Internal Rate of Return (IRR)
- Net Present Value (NPV)
- Benefit/Cost Ratio (BCR) – (Definition of BCR: NPV of total benefits divided by NPV of total costs)

10.3 EXAMPLE 3: CBA OF USING ECOLOGICAL INFRASTRUCTURE IN SECURING AND AUGMENTING OF WATER PROVISION

10.3.1 Objective

Interventions to address water augmentation and security may include the restoration or protection of aquatic ecosystems. These positive or negative changes to the health and functioning of natural ecosystems lead to changes in the supply of ecosystem services, which can have both financial and welfare implications.

Understanding these impacts requires understanding which ecosystem services are supplied, how this is affected by the proposed development, and how to value that change. Measuring this change is highly context-specific though, as ecosystem services and their values vary geographically with factors that influence both supply and demand.

The objective of this example is to evaluate the financial and economic viability of Ecological Infrastructure in water provision. Ecological infrastructure can play an important role in complementing and supporting grey infrastructure investments in water provision.

Three interventions with different purposes are demonstrated in this example, namely;

- Reduction of sedimentation in dams
- Clearing of alien plants near streams; as well as
- The production of ecological goods and services following the clearing of alien plants.

10.3.2 Features of Example

The model covers a study period of 20 years, at various discount rates. The example makes provision for;

- Various capital cost items
- Operational and maintenance costs
- Shadow prices for capital and operational elements

10.3.3 Layout of Example

- Inputs
- Capital and operating cost sheets
- Revenue sheets
- Financial analysis sheet
- Economic analysis sheet

10.3.4 Project Cost

- Capital Cost:
  - Sedimentation
  - Clearing of alien invasive plants next to river streams
  - Production of ecological goods and services
- Operating and Maintenance Cost:
  - Operating & maintenance cost of Sedimentation
  - Operating & maintenance cost of clearing alien and invasive plants next to river streams
  - Operating & maintenance cost of production of ecological goods and services

10.3.5 Project Benefits

- Revenue from water savings from mitigating against sedimentation by constructing of a weir/small dam
- Revenue from the water savings from water saved through clearing plants that reduce stream flow
- Revenue from the production of ecological goods and services

10.3.6 CBA Evaluation Criteria

- Internal Rate of Return (IRR)
- Net Present Value (NPV)

- Benefit/Cost Ratio (BCR) – (Definition of BCR: NPV of total benefits divided by NPV of total costs)

10.4 EVALUATING THE POTENTIAL RETURNS FROM INVESTING IN GREEN URBAN DEVELOPMENT IN DURBAN, SOUTH AFRICA

Under a business-as-usual scenario, the continued growth of urban areas in Africa will result in further deterioration of the environment and living conditions, a loss of values associated with green open space areas, and increased costs in reducing risks to people that result from environmental problems. The environmental problems associated with increased hardened surfaces and the loss of natural areas are particularly acute in developing country cities, where a lack of regulation and resources has led to poor planning, the expansion of informal settlements in high-risk, marginal areas, and the inability to adequately manage the quantity and quality of surface water flows. Whilst conventional stormwater conveyance measures contribute to reducing flooding impacts, they have not been able to keep ahead of the problem and have also contributed to pollution and degradation of downstream aquatic systems.

The notion of Green Urban Development (GUD) is highly attractive, as it allows cities to grow in a way that maintains resilience and standards of living. A GUD strategy does not only focus on surface water issues but also involves the maintenance of natural open space areas for recreation which is essential for human health and wellbeing. One of the challenges of green urban development is to find the right balance between “green” and conventional “grey” infrastructure. Thus, understanding the costs and benefits associated with the different types of measures is important and requires careful consideration of their potential benefits and cost effectiveness in managing urban environmental problems.

A study was undertaken by Turpie et al. (2017a) to determine the economic costs and benefits associated with using a green urban development approach to addressing environmental issues in a well-developed quaternary catchment in the city of Durban. The study sought to find a suitable set of “green” measures that could be implemented in combination to address flooding and water quality problems in the study area, whilst also contributing to a green urban development path for the city. This study formed part of a larger study that provided an updated, spatial estimate of the value of natural capital in the eThekwini Municipality (Turpie et al., 2017b).

A hydrological and hydraulic model were used to determine the change in flooding and water quality under a series of hypothetical scenarios in which the development of the study area had involved different combinations and extents of GUD sanitation, stormwater management and conservation measures. The economic implications of these changes were assessed in terms of implications for aquatic ecosystem health as well as the infrastructure costs, and losses in property, tourism and fishery benefits that would have been avoided under these alternative scenarios. The relative costs and benefits of different scenarios were then evaluated using a cost-benefit approach. Inputs into the models included the extent and quality of natural areas, the extent, design and performance of a range of GUD engineering solutions for flood attenuation and water quality amelioration, and the amount and design capacity of conventional conveyance and wastewater-treatment infrastructure.

By comparing the modelled outputs for each scenario versus the baseline, it was possible to estimate the difference made by GUD interventions to the flood hydrograph, and to sediment and nutrient loads transported to Durban Bay. The water quality data were then used as inputs into a River Ecosystem Health assessment tool to evaluate river system changes, into an Estuarine Ecosystem Services model to estimate changes in the value of selected services, and into an assessment to determine dredging costs avoided in Durban Bay. Changes in the quantity and quality of green open space areas were inputs into a Tourism Value model and a Hedonic Pricing Model developed as part of the ecosystem services valuation study (Turpie et al., 2017b), which estimated differences in tourism and property values, respectively. A Cost-Benefit Analysis was then used to assess the overall impacts and benefits associated with the GUD approach. A time frame of 20 years was applied, and the flows of costs and benefits were discounted using a discount rate of 6%.

The results from the hydrological modelling confirmed that natural systems and structural GUD interventions could significantly reduce peak flows during small to medium return period floods, although their impact on large floods when implemented independently were much smaller. It was estimated that there could be a 6% capital cost saving in stormwater infrastructure for flood conveyance under the full GUD scenario. GUD interventions, particularly conservation areas and riparian buffers, were found to significantly reduce sediment loads into the harbour which resulted in a decrease in annual maintenance dredging costs associated with maintaining channel depths for ships. Furthermore, a reduction in nutrient and sediment loads into the rivers and Durban Bay resulted in a gain in estuarine and marine fishery values. The effect of a more compact but greener development approach on property and tourism values was also estimated to be significant.

The results suggested that the compact development options that allow for a higher proportion of green open space could be far more effective than using engineering measures alone. This was because the open space areas not only delivered ecosystem services relating to the primary stormwater management objectives but also directly provided amenity value that translated into property values and tourism values. It was concluded that compact development coupled with the other GUD interventions would create the greenest city, in terms of water quality and biodiversity conservation goals, and was an economically justifiable strategy in terms of overall costs and benefits. Furthermore, it generated other infrastructure and service cost savings associated with compact development that were not quantified, such as improvements in air quality, as well as intangible benefits such as the existence value of biodiversity.

10.5 EXAMPLE 4: HYDRO-ELECTRICITY MODEL

10.5.1 Objective

The main focus of the study is on the economic developmental impact of the generation of electricity with hydro-electricity. In respect of the economic impacts of electricity generation the emphasis is more on how the sales thereof to potential markets will benefit the users rather than on the capacity.

10.5.2 Features of Example

The model covers a study period of 40 years, at 10% discount rate. The example makes provision for:

- CO_2 emission for coal fired steam plant per 1000GWh (million tons of CO_2)
- CO_2 emission for gas fired combined cycle plant per 1000GWh (million tons of CO_2)
- CO_2 emission for average thermal plant per 1000GWh (million tons of CO_2)
- Value of CO_2/Ton (R)
- Percentage distribution between markets
- Quantity (GWh p.a)
- Price of second-best generating alternative (R/MWh)
- Distance from transmission lines to market (Km)
- Transmission cost (MWh/km)
- Infrastructure costs
- Operational and maintenance costs

10.5.3 Layout of Example

- Inputs
- Modelling Preparation
- Detailed modelling System

10.5.4 Project Cost

- Capital Cost:
  - Capital cost: Hydro-electricity
  - Capital cost: Water resources

10.5.5 Project Benefits

- Revenue from electricity sales
- Benefits from reduced CO2 emissions

10.5.6 CBA Evaluation Criteria

- Internal Rate of Return (IRR)
- Net Present Value (NPV)
- Benefit/Cost Ratio (BCR)

10.6 EXAMPLE 5: COAL MINING MODEL

10.6.1 Objective

The objective of this example is to evaluate the financial and economic viability of a coal mining project in Limpopo. The model covers a study period of 20 years, at various discount rates. The example makes provision for:

- Coal production tons
- Domestic and export saleable tons
- Domestic and export prices for coal
- Various capital cost items
- Operational and maintenance costs
- Shadow prices for capital and operational elements

10.6.2 Layout of Example

- Inputs
- Capital and operating cost sheets
- Revenue sheets
- Financial analysis sheet
- Economic analysis sheet

10.6.3 Project Cost

- Capital Cost:
  - Capital cost: Hydro-electricity
  - Capital cost: Water resources

- Operating & maintenance cost of total mine colliery
  - Operating & maintenance cost of rail infrastructure
  - Operating & maintenance cost of water infrastructure
- Externalities and rehabilitation
- Transport costs
- Water supply costs

10.6.4 Project Benefits

- Revenue from domestic sales
- Revenue from export sales

10.6.5 CBA Evaluation Criteria

- Internal Rate of Return (IRR)
- Net Present Value (NPV)
- Benefit/Cost Ratio (BCR)

10.7 EXAMPLE 6: INGONYAMA ROAD UPGRADE PROJECT IN DIEPSLOOT

10.7.1 Diepsloot Township

Diepsloot is located on the northern edge of the Metropolitan Council of the Johannesburg Area, some 30 km from the central business district and 20 km North of Sandton. The Diepsloot township has a population estimate of 350 000 and has a mixture of informal and formal settlements. Although Diepsloot 's location was once marginal, it is now relatively well located in Johannesburg because of an explosion of decentralised development to the north.

10.7.2 Project Description

The Diepsloot Ingonyama Road Upgrade project aimed at achieving the following:

- Creating formal roads that will unlock the provision of basic services in the area, i.e. ambulance, SAPS, PIKITUP, etc.
- Creating a safe and secure urban settlement that will attract investment and encourage sustainable community development
- Creating quality public spaces to enhance the sense of community and to conserve environmental and cultural places of interest
- Ensuring the legibility and identity of the precinct, and creating opportunities for community interaction such as informal trading

10.7.3 Definition of Benefits and Methodology

In performing a CBA of a project of this nature, a distinction has been made between the costs and revenue associated with the various components constituting the Ingonyama Road Upgrade Project.

The CBA for the different elements of the Ingonyama Road Upgrade Project has been performed as one entity. However, in order to calculate the benefits as well as the costs. The following benefits have been identified and calculated for the Ingonyama Road Upgrade project:

- Taxi Rank

- Pedestrian Bridges
- Ingonyama Road (improved road infrastructure)
- Additional Retail and Trade Facilities
- Advantage for the consumers

10.7.4 Definition of Costs and Methodology

The following categories of costs have been identified and calculated for the Ingonyama Road:

- Construction Costs
  - Costs associated with Ingonyama and internal roads;
  - Costs associated with formal and informal trading;
  - Costs of two pedestrian bridges; and
  - Costs of taxi rank facility

- Maintenance costs
  - Costs associated with Ingonyama and internal roads;
  - Costs associated with formal and informal trading;
  - Costs of two pedestrian bridges; and
  - Costs of taxi rank facility

10.7.5 Assumptions and Data

For purposes of the CBA analysis, the following data inputs were assumed for the analysis:

- Ingonyama road distance: approximately 5.0 kilometres
- Internal roads distance: approximately 1.3 kilometres
- Routine maintenance after construction: R2.2 million per annum
- Traffic Breakdown according to number of taxis, commercial vehicles, buses and motor vehicles using the Ingonyama road
- Estimated average daily vehicle counts: 4 300

The estimated operating and maintenance costs calculated for each element of the Ingonyama Road Upgrade Project. The total construction costs for the project amounts to R149,1 million in 2015 prices.

- Ingonyama and internal roads: R1.08 million
- Informal and Formal Traders: R0.07 million
- Construction of 2 Pedestrian Bridges: R0.25 million
- Taxi rank facility: R1.0 million

The construction, operating, and maintenance costs of the different elements have been derived from documents provided by JDA. It is important to note that the individual cost breakdowns for both the informal and formal traders as well as for the construction of pedestrian bridges are included in the construction of Ingonyama and internal roads.

The following assumptions have been made regarding the benefits derived by the formal and informal traders as well as the pedestrians crossing the pedestrian and road bridges. This is based on discussions with CoJ staff and own observations.

- No. Traders
- No. Customers/ evenue/Other Operating costs (excl. Rental)
- Net Operating Profit Month Customer
- Informal Traders
  - Total No. of Selling Stalls (informal) 66 4 620 R20.00 R13.00 R7.00
  - Total No. of Brick & Mortar Small Business (formal) 157 27 475 R30.00 R24.00 R6.00
  - Total No. of Selling Stalls made of Shacks & Nets (informal) 170 11 900 R12.00 R5.40 R6.60

The estimated benefits for pedestrians crossing the river are as follows:

- Ingonyama Road Benefits
- Potential No. of Lives lost due to directly crossing across river 3 per annum
- Effective Rate of Using Facilities 100%
- Value of a Life R394 186
- Annual Growth in Pedestrians 3%

The following assumptions were made regarding the future usage of the taxi rank facility.

•	Ingonyama Road Assumptions -	Taxi Rank Facility				
•	Potential No. taxis	60 per day parked at the facility outside traffic peak time				
•		Year 1	Year 2	Year 3	Year 4	Year 5
•	Effective Rate of Using Facilities	40%	45%	50%	50%	50%
•	Value of Parking Area	R70/7 hours and above				
•	No. of Weekdays per annum	249 days				
•	Weekends and Public Holidays	116 days				
•	Occupation during Weekends	50%				

10.7.6 Features of Example

The model is a complete dynamic integrated model that makes provision for various discount rates covering a study period of 31 years.

10.7.7 Layout of Example

- Separate input and result sheets
- Financial Cost Benefit Analysis sheet
- Economic Cost Benefit sheet

10.7.8 CBA Evaluation Criteria

- Internal Rate of Return (IRR)
- Net Present value (NPV)
- Benefit/Cost Ratio (BCR) – (Definition of BCR: NPV of total benefits divided by NPV of total costs)

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ANNEXURE 1: REVISED MAGISTERIAL DISTRICTS PER FUEL PRICE ZONE

MAGISTERIAL DISTRICT	PRICE ZONE
Aberdeen	**9B**
Adelaide	**5A**
Albany	**4A**
Albert (Burgersdorp)	**7A**
Alberton	**9C**
Alexandria	**4A**
Alfred	**5A**
Aliwal North	**7A**
Amersfoort	**8C**
Babanango	**6A**
Bafokeng	**10C**
Balfour	**8C**
Barberton	**10C**
Barkly East	**8A**
Barkly West	**11C**
Bathurst	**5A**
Beaufort West	**8B**
Bedford	**5A**
Belfast	**9C**
Bellville	**1A**
Benoni	**9C**
Bergville	**6C**
Bethal	**8C**
Bethlehem	**7C**
Bethulie	**8A**
Bizana	**7B**
Bloemfontein	**10C**
Bloemhof	**10C**
Bochum	**13C**
Boksburg	**9C**
Bolobedu	**13C**
Boshof	**10C**
Bothaville	**9C**
Botshabelo	**10C**
Brakpan	**9C**
Brandfort	**10C**
Bredasdorp	**6A**
Brits	**10C**
Britstown	**9A**
Bronkhorstspruit	**9C**
Bultfontein	**10C**
Cacadu (Glen Grey)	**6A**
Caledon	**5A**
Calitzdorp	**4A**
Calvinia (west of 20° longitude)	**12B**
Calvinia (east of 20° longitude)	**14B**
Camperdown	**2A**
Cape Town	**1A**
Carnarvon	**10B**
Carolina	**9C**
Cathcart	**5A**
Ceres	**5A**

MAGISTERIAL DISTRICT	PRICE ZONE
Chatsworth	**1A**
Christiana	**10C**
Clanwilliam	**7B**
Clocolan	**8C**
Cofimvaba	**5A**
Colesberg	**8A**
Coligny	**10C**
Cradock	**8B**
Cullinan	**9C**
Dannhauser	**6C**
De Aar	**8A**
Delareyville	**11C**
Delmas	**9C**
Dewetsdorp	**10C**
Ditsobotla	**12C**
Dundee	**6C**
Durban	**1A**
Dzanani Central	**13C**
Dzanani North	**14C**
Dzanani South	**13C**
East London	**1A**
Edenburg	**8A**
Eerstehoek	**9C**
Elliot	**8A**
Ellisras	**13C**
Embumbulu	**2A**
Engcobo	**7A**
Ermelo	**8C**
Eshowe	**4A**
Estcourt	**5C**
Excelsior	**9C**
Fauresmith	**9A**
Ficksburg	**8C**
Fort Beaufort	**5A**
Fouriesburg	**7C**
Frankfort	**8C**
Fraserburg	**8B**
Ganyesa	**15C**
Gatyana	**5A**
Gcuwa (Butterworth)	**5A**
George	**3A**
Germiston	**9C**
Giyani	**14C**
Glencoe	**6C**
Goodwood	**1A**
Gordonia (south of 28° latitude)	**13A**
Gordonia (between 27°30' and 28° latitude)	**17A**
Gordonia (north of 27°30' latitude)	**19A**
Graaff-Reinet	**9B**
Groblersdal	**10C**
Hankey	**3A**
Hanover	**8A**
Harrismith	**6C**
Hartswater	**11C**
Hay	**11A**
Heidelberg (Eastern Cape)	**4A**
Heidelberg (Gauteng)	**9C**
Heilbron	**8C**

MAGISTERIAL DISTRICT	PRICE ZONE
Henneman	**8C**
Herbert	**10C**
Hermanus	**5A**
Herschel	**8A**
Hewu	**5A**
Highveld Ridge	**8C**
Hlabisa	**5A**
Hofmeyr	**7A**
Hoopstad	**10C**
Hopefield	**5A**
Hopetown	**9A**
Humansdorp	**3B**
Idutywa	**5A**
Impendle	**5C**
Inanda	**1A**
Indwe	**7A**
Ingwavuma	**7A**
Ixopo	**4A**
Jacobsdal	**10C**
Jagersfontein	**8A**
Jansenville	**7B**
Johannesburg	**9C**
Joubertina	**7B**
Kamhlushwa	**10C**
Keiskammahoek	**4A**
Kempton Park	**9C**
Kenhardt (east of 20° longitude)	**15A**
Kenhardt (west of 20° longitude)	**19A**
Kentane	**5A**
Kimberley	**11C**
King William's Town	**3A**
Kirkwood	**3A**
Klerksdorp	**9C**
Kliprivier	**5C**
Knysna	**4A**
Koffiefontein	**9A**
Komga	**3A**
Koppies	**8C**
Koster	**10C**
Kranskop	**5A**
Kriel	**8C**
Kroonstad	**8C**
Krugersdorp	**9C**
Kudumane	**15C**
Kuils River	**1A**
Kuruman (south of 27° latitude)	**13C**
Kuruman (north of 27° latitude)	**17C**
Kwabhaca (Mount Frere)	**10B**
KwaMhlanga	**10C**
Ladismith (Cape)	**6B**
Lady Grey	**8A**
Ladybrand	**8C**
Lahurushe	**11C**
Laingsburg	**7B**
Letaba	**13C**
Lichtenburg	**11C**
Lindley	**8C**
Lions River	**4C**

MAGISTERIAL DISTRICT	PRICE ZONE
Lower Tugela	**3A**
Lower Umfolozi	**5A**
Lusikisiki	**10B**
Lydenburg	**10C**
Maclear	**8A**
Madikwe	**11C**
Mahlabatini	**6A**
Malamulele	**14C**
Malmesbury	**3A**
Malmesbury (south of 33°30' latitude)	**1A**
Maluki (Matatiele)	**7A**
Mankwe	**10C**
Mapulaneng	**11C**
Mapumulo	**3A**
Marico	**11C**
Marquard	**8C**
Maxesibeni (Mount Ayliff)	**8B**
Mbibana	**10C**
Mdutjana (Siyabuswa)	**10C**
Messina (east of 30° longitude)	**14C**
Messina (west of 30° longitude)	**16C**
Mdantsane	**1A**
Mhala	**11C**
Middelburg (Cape)	**7A**
Middelburg (Tvl.)	**10C**
Middledrift	**4A**
Mitchells Plain	**1A**
Mkobola	**10C**
Moanduli	**7A**
Mokerong 1	**16C**
Mokerong 2	**11C**
Mokerong 3	**11C**
Molopo	**11C**
Molteno	**6A**
Montagu	**5A**
Mooi River	**5C**
Moorreesburg	**4A**
Moretele 1	**9C**
Moretele 2	**9C**
Mossel Bay	**1A**
Mount Currie	**7A**
Mount Fletcher	**10B**
Moutse	**10C**
Mpofu (Stockenström)	**5A**
Msinga	**5C**
Mtonjaneni	**5A**
Mtunzini	**4A**
Murraysburg	**12B**
Mutale	**14C**
Namakgale	**12C**
Namakwaland (south of 30° latitude)	**31J**
Namakwaland (between 29°-30° lat. & 17°30'-18°30' long.)	**32J**
Namakwaland (north of 30° lat. & east of 18°30' long.)	**33J**
Namakwaland (north of 29° lat. & east of 17° long.)	**34J**
Namakwaland (south of 29° lat. & west of 17° long.)	**35J**
Namakwaland (between 29°-30° lat. & 17°-17°30' long.)	**36J**
Namakwaland (north of 29° lat. & west of 17° long.)	**37J**
Naphuno	**12C**

MAGISTERIAL DISTRICT	PRICE ZONE
Ndwedwe	**2A**
Nebo	**11C**
Nelspruit	**10C**
New Hanover	**5C**
Newcastle	**6C**
Ngotshe	**7A**
Ngqeleni	**7A**
Nigel	**9C**
Nkandla	**5A**
Nongoma	**6A**
Noupoort	**7A**
Nqamakwe	**5A**
Nqutu	**6C**
Nsikazi	**10C**
Oberholzer	**9C**
Odendaalsrus	**9C**
Odi	**9C**
Oudtshoorn	**4A**
Paarl	**2A**
Parys	**9C**
Paulpietersburg	**7C**
Pearston	**8B**
Peddie	**4A**
Petrusburg	**10C**
Phalaborwa	**12C**
Philipstown	**9A**
Philippolis	**8A**
Piet Retief	**8C**
Pietermaritzburg	**3C**
Pietersburg (south of Tropic of Capricorn)	**12C**
Pietersburg (north of Tropic of Capricorn)	**13C**
Piketberg	**6B**
Pilgrim’s Rest	**11C**
Pinetown	**1A**
Polela	**5C**
Port Elizabeth	**1A**
Port Shepstone	**4A**
Postmasburg	**13C**
Potchefstroom	**9C**
Potgietersrus (south of Tropic of Capricorn)	**11C**
Potgietersrus (north of Tropic of Capricorn)	**16C**
Pretoria	**9C**
Prieska	**10A**
Prince Albert	**7B**
Queenstown	**5A**
Qumbu	**7A**
Randburg	**9C**
Randfontein	**9C**
Reddersburg	**8A**
Reitz	**8C**
Richmond (Cape)	**8A**
Richmond (Natal)	**3A**
Ritavi	**13C**
Riversdale	**4A**
Robertson	**5A**
Roodepoort	**9C**
Rouxville	**8A**
Rustenburg	**10C**

MAGISTERIAL DISTRICT	PRICE ZONE
Sasolburg	**9C**
Schweizer-Reneke	**11C**
Sekgosese	**13C**
Sekhukhuneland	**11C**
Senekal	**8C**
Seshego	**12C**
Simon's Town	**1A**
Sipangeni (Flag Staff)	**8B**
Smithfield	**8A**
Somerset East	**7B**
Somerset West	**2A**
Soshanguve	**9C**
Soutpansberg (east of 29°30' longitude)	**13C**
Soutpansberg (west of 29°30' longitude)	**16C**
Springs	**9C**
Standerton	**8C**
Stellenbosch	**2A**
Sterkstroom	**5A**
Steynsburg	**7A**
Steytlerville	**7B**
Stockenström	**5A**
Strand	**2A**
Stutterheim	**4A**
Sutherland	**12B**
Swartruggens	**10C**
Swellendam	**5A**
Tabankulu	**10B**
Tarka	**5A**
Taung	**11C**
Thabamoopo	**12C**
Thaba 'Nchu	**10C**
Thabazimbi (east of 27° longitude)	**12C**
Thabazimbi (west of 27° longitude)	**13C**
Theunissen	**9C**
Thohoyandou East	**17C**
Thohoyandou West	**13C**
Trompsburg	**8A**
Tsolo	**7A**
Tsomo	**5A**
Tulbagh	**4A**
Ubombo	**7A**
Uitenhage	**2A**
Umlazi	**1A**
Umtata	**6A**
Umvoti	**5C**
Umzimkulu	**5A**
Umzimvubu	**10B**
Umzinto	**3A**
Underberg	**5C**
Uniondale	**6B**
Utrecht	**7C**
Vanderbijlpark	**9C**
Vanrhynsdorp	**9B**
Ventersburg	**8C**
Ventersdorp	**10C**
Venterstad	**8A**
Vereeniging	**9C**
Victoria East	**4A**

MAGISTERIAL DISTRICT	PRICE ZONE
Victoria West	**12B**
Viljoenskroon	**9C**
Virginia	**9C**
Volksrust	**7C**
Vrede	**8C**
Vredefort	**9C**
Vredenburg	**5A**
Vredendal	**9B**
Vryburg (south of 26°30' latitude)	**12C**
Vryburg (east of 24° long. & north of 26°30' lat)	**13C**
Vryburg (west of 24° longitude)	**17C**
Vryheid	**6C**
Vuwani	**13C**
Wakkerstroom	**8C**
Warm Baths	**10C**
Warrenton	**11C**
Waterberg	**11C**
Waterval Boven	**9C**
Weenen	**5C**
Welkom	**9C**
Wellington	**2A**
Wepener	**8A**
Wesselsbron	**9C**
Westonaria	**9C**
White River	**10C**
Williston	**10B**
Willowmore	**7B**
Winburg	**9C**
Witbank	**9C**
Witsieshoek	**7C**
Wodehouse	**6A**
Wolmaransstad	**10C**
Wonderboom	**9C**
Worcester	**5A**
Wynberg	**1A**
Xalanga	**7A**
Xhora (Elliotdale)	**7A**
Zastron	**8A**
Zwelitsha	**3A**

ANNEXURE 2: APPROACHES TO DETERMINE THE DISCOUNT RATE

The United States Environment Protection Agency (EPA) determines two major discounting approaches: intra-generational social discounting and inter-generational social discounting, depending on the impact of an investment over time.

Intra-generational Discounting

The intra-generational discounting is used when it comes to analyse a short- and medium-term project. Conventional intra-generational social discounting is rooted firmly in the view that the government is acting on behalf of its citizens in undertaking public projects and promulgating environment and other policies. Therefore, CBA of these actions should seek to estimate the costs and benefits experienced by all of the affected parties, and in so doing determine whether, in aggregate, the gainers under a policy would be able to compensate the losers.

This approach makes use of an exponential discounting which is based on converting the future costs and benefits of a given investment into net present values using a constant discount rate[45].

Inter-generational Discounting

From the mid-1990s, with the growing concerns over environment problems caused by climate changes, global warming, and other environmental issues, there has been a renewed interest on how discounting should be applied to long-term projects, the effects of which spread over more than one generation or even hundreds of years, and whose present values are extremely sensitive to the choice of discount rate[46].

Unlike the intra-generational approach, inter-generational approach makes use of a hyperbolic discounting which makes use of a variable discount rate.

The next section describes in detail the two different functional forms of discounting that the two approaches use.

a. Exponential Discounting

Luus and Mullins[47] (2008) state that exponential (conventional) discounting is based on converting the future costs and benefits of a given project into net present values using a constant, positive discount rate.

To calculate the net present value (PV) of any potential investment, the weighted sum of all future values (FV) is calculated. By using the exponential discounting, the future values will be discounted over time (t) using a constant, positive discount rate (r). Consistent with the notion of present value calculations, the discount factor is defined as:

$$d_t = 1/(1+r)^t = (1+r)^{-t} \qquad (1)$$

Thus, to calculate the net present value, the formula is:

[45] Luus, CW., and Mullins, D., 2008. Ibid. p. 11-14.
[46] 2Zhuang J., Liang Z., Lin T., and De Guzman F. 2007. Ibid. p14-15.
[47] Luus C.W. and Mullins D., 2008. Ibid. p 8.

$$PV = FV(1+r)^{-t} \quad (2)$$

Thus, the discount factor declines less in the short run than in the long run. Equation 2 could just be solved for FV, in which case the PV is compounded by the interest rate over the appropriate period:

$$FV = PV(1+r)^{t} \quad (3)$$

With exponential discounting the discount factor declines exponentially with time, thus attaching ever-declining values to future benefits and costs. However, recent work casts doubts on the conventional discounting method's ability to explain how individuals effectively make choices.

In particular a more general form of discounting that gained importance, in both applied and theoretical work, is hyperbolic discounting which captures phenomena such as procrastination and addiction.

b. Hyperbolic Discounting

Unlike the exponential discounting, hyperbolic discounting is based on converting the future costs and benefits of a given project into net present values using a variable discount rate, so equation 2 becomes:

$$PV = FV/(1+rt) \quad (4)$$

Thus, the discount factor falls more quickly in the short run than the long run.

There is a problem of time inconsistency in the use of hyperbolic discounting, despite the fact that hyperbolic discounting is the best way to calculate the cost and benefit of investment project. It is generally used in the case of investments that have impact on extremely long term.

Methods of calculating the Discount Rate

It is quite easy to determine the social discount rate under a perfectly competitive market model (market without distortions). Under this model, the market clears at a rate where the social rate of time preference (SRTP) for consumption equates the social opportunity cost (SOC) of capital. SRTP for consumption reflects the rate at which people are prepared to trade current consumption for future consumption. The SRTP is equal to households' supply of funds (saving) in the loanable funds market, whilst The SOC is equal to the demand of funds (investment) in the loanable funds market. In this case the market-clearing rate would be the appropriate social discount rate.

However, in real world were markets are distorted by factors such as government intervention, externality and asymmetric of information; there will be a gap between SRTP, which relates to the returns to savings, and SOC, which relates to the return to investment. It is unclear which one, if either, should be used (in the first place) as the discount rate .

Under imperfect competition market, there are various methods of calculating the discount rate for intra and inter-generational projects.

A. Method of discounting an intra-generational projects

Four conventional methods of discounting an intra-generational project can be put forward: (i) Social rate of time preference (SRTP), (ii) Social opportunity cost (SOC), (iii) Weighted average approach, and (iv) Shadow price of capital (SPC) approach.

i. Social Rate of Time Preference

The use of SRTP as the social discount rate is based on the argument that households prefer current consumption to future consumption. Consumers are generally "impatient" or "myopic". Therefore, the appropriate discount rate is the social opportunity cost of forgone present consumption.

The social rate of time preference is the rate at which households are willing to trade a unit of current consumption in exchange for more future consumption. Algebraically, SRTP can be represented as follow:

$$i = r + ug \qquad (5)$$

Where *i* is the consumption rate of interest, *r* captures the effect that higher interest rates are required to draw forth a given amount of savings when individuals expect consumption

There are two models of estimating the SRTP. One is the approximation of the SRTP after tax rate of return of the government bond or other low risk marketable securities. The other is the application of Ramsey formula. According to Ramsey's formula derived from a growth model, SRTP is the sum of two terms: the first is a utility discount rate reflecting the pure time preference and the second is the product of two parameters, the elasticity of the marginal utility of consumption and the annual rate of growth of per-capita real consumption (Ramsey, 1928) .

A major criticism on using SRTP as the social discount rate is that it is purely a measure of social opportunity cost in terms of forgone consumption and ignores the fact that public project investment can crowd out private project investment due to an increase in the market interest rate. In addition, since SRTP is generally lower than SOC because of the wedge created by market distortions such as taxes, this raises the possibility that too many low return investments in the public sector would be undertaken when SRTP is used as the social discount rate.

However, the SRTP is much more stable parameter than the social opportunity cost rate which tends to fluctuate sharply with the business cycle.

ii. Social Opportunity Cost

The social opportunity cost (SOC) is based on the argument that resources in any economy are scare; that government and private sector compete in the same pool of funds. Everything else being constant, an increase in the demand for public investment will crowd out the demand for private investment. Therefore, the social rate of discount will be the rate of return of the next best alternative use of funds. Generally, the next best alternative use of funds is thought to be the investment of private sector.

Luus and Mullins (2008)[48] sited four models for calculating the social opportunity cost which are: Capital asset pricing models (CAPM); Arbitrage pricing theory (APT), and Fama and French's multi-factor model.

[48] Luus, CW., and Mullins, D., 2008. Ibid. p. 19.

Despite the fact that CAPM currently dominates the other models, the other models are continually challenging this dominance. Lally, cited by Luus and Mullins (2008)[49] concluded that: “All versions of the CAPM along with APT suffer from considerable ambiguity in empirical testing. However, parameter estimation problems appear to be considerably less for the CAPM than for APT, multi-factor models (such as Fama-French) and the dividend growth model. These considerations do not favour any alternative to the CAPM, and this is consistent with the CAPM’s dominance in practice.”

A major criticism on using SOC as the social discount rate is that it is purely a measure of social opportunity cost of public investment. SOC as the social discount rate assumes that public investment only crowd out private investment and not private consumption, which is not realistic.

iii. Weighted Average Approach

Since SRTP does not take into account the social opportunity cost of public investment and SOC does not take into account the impact of public investment on consumption spending. Several Economists, including Broadman et al. (1996)[50], Sadmo and Dreze (1971)[51], have suggested that the social discount rate should defined as the weighted average of the SRTP (usually computed as the post-tax savings rate) and the SOC (usually computed as the pre-tax investment return).

The discount rate calculated using the weighted average approach could be represented as:

Social discount rate $= (\alpha)SOC + (1-\alpha)SRTP$ (6)

Where α is the proportion of resources or costs that crowd out private investment and $(1-\alpha)$ represent the proportion of resources or costs that crowd out consumption spending? Young (2002)[52] states that there is an issue about setting α, which is project dependent. It may not be clear what the impact will be on private investment and consumption levels.

A major criticism on the weighted average approach is that, whilst it recognises that costs of public investment can crowd out private investment, it assumes that benefits will be consumed immediately and ignores the fact that they could also be reinvested in private sector, generate future consumption, and bring more social value than crowd out consumption, whilst ignoring that higher social value of project benefits that are reinvested than immediately consumed, leads to over discounting of project benefits.

iv. Shadow Price of Capital Approach

The shadow price of capital (SPC) approach attempts to reconcile the SRTP approach with that of SOC and, at the same time, addresses the limitation of the weighted average approach. The SPC approach recognises that whilst costs of a public project can crowd out private investment, its benefits can also be reinvested in the private sector.

The SPC approach involves four steps. The first is estimating SPC, which is the present value of streams of future consumption forgone arising from displacing one unit of private investment or the present value of future consumption streams generated from reinvestment one unit of project benefits in the private sector. The second step involves, for each time period, converting all the costs and benefits that either displace or generate private investment into consumption equivalents by multiplying them by SPC. Third step is adding these cost

[49] Luus, CW., and Mullins, D., 2008. Ibid. p. 20.
[50] Boardman A.E. et al. 1996. CBA – Concepts and Practice; Prentice-Hall Inc; p28-29.
[51] Sadmo, A., and Dreze, J. 1971. “Discount Rates for Public Investments in Closed and Open Economies.” Economica 38:395-412.
[52] Young, L. 2002. Ibid. p. 6.

and benefits to the other portions of costs (in the form of directly displaced consumption) and of benefits (in the form of immediate consumption), respectively. Finally, discount the total cost and benefit streams at SRTP to calculate the net present value (NPV).

Bradford (1975) proposed the following formula for the case when investment returns are perpetual but a proportion of the annual return π is re-invested:

Shadow price $= \frac{(1-s)\gamma}{i - s\gamma}$ (7)

Where $\gamma = (1+\pi)/(1+i)$, is the marginal propensity to save, and $s\gamma < 1$. the shadow price increases with the fraction of re-invested.

The SPC approach, although theoretically attractive is difficult to implement. The value of SPC is very sensitive to the values of SRTP and SOC, to how depreciation and reinvestment are assumed, and to the length of life of a project.

What is common to the four approaches described above is that the discount rate, whatever it is, is time-invariant, implying that discounting would be exponential.

B. Method of discounting an inter-generational projects

Luus and Mullins (2007), distinguish between social welfare planner approach and approaches based on existing individual's preferences as methods of calculating social discount rate for extremely long-term projects, which involve unborn generations. The two methods can be described as follow:

- **Social welfare planner approach**

One popular recommendation is that social discounting for inter-generational policies should be based upon optimal growth analyses. In optimal growth models, the social rate of discount generally equals the sum of two factors. One is a discount rate for pure time preference, which measures the degree to which the social planner favours the utility of current and near future members of society over that of individuals in the more distance future. The other is an adjustment reflecting the fact that the marginal utility of consumption will decline over time as consumption per-capital increases (equal to the elasticity of marginal utility multiplied by the rate of increase of consumption over time).

- **Approaches based on existing individuals' preferences**

The major alternative to the social welfare planner approach for inter-generational discounting is to rely on the preferences of current individuals for an appropriate discount rate. At its core, this perspective rejects the view that the problem is one of balancing the interests of all humans who will live now and in the future. Instead, according to this perspective, it is fundamentally about individuals alive today allocating their scare resources to competing ends, one of which happens to be the welfare of future generations.

The two above methods mentioned make use of hyperbolic discounting when it comes to analyse cost and benefit that occurs in "far future".

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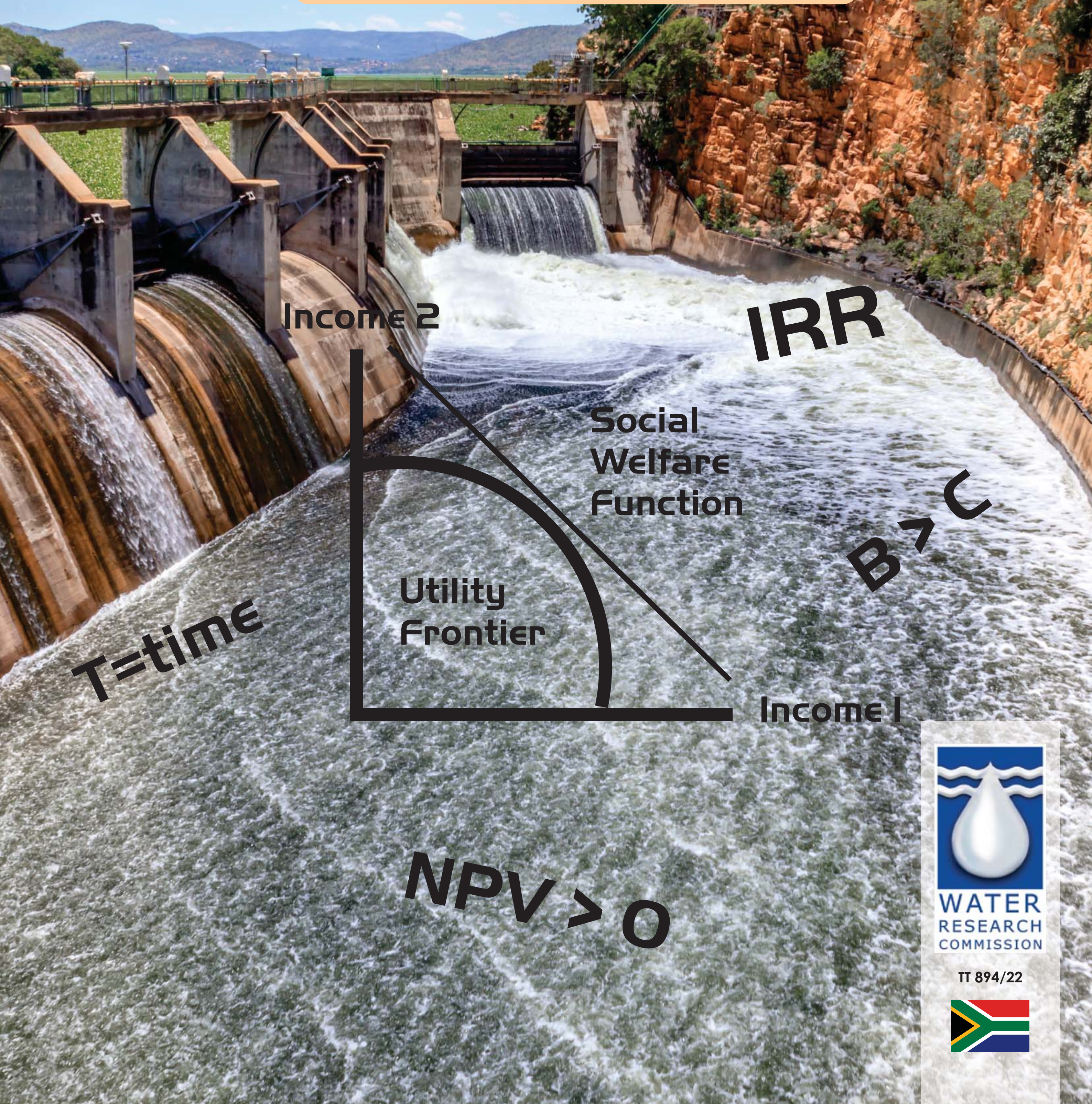

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