VALUING THE SOCIAL COST OF AIR-POLLUTION IN BOPHELONG TOWNSHIP

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DECLARATION

I declare that:

VALUING THE SOCIAL COST OF AIR-POLLUTION IN BOPHELONG TOWNSHIP

is my own work, that all the sources used or quoted have been identified and acknowledged by means of complete references, and that this dissertation has not previously been submitted by me or any other person for a degree at any other university.

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OPSOMMING

Die doel van hierdie studie is om die sosiale koste van lugbesoedeling in die Bophelong-dorpsgemeenskap te kwantifiseer.

Bophelong is ’n grootliks Swart lae-inkomste nedersetting wat in die suid-westelike gedeelte van die Emfuleni Plaaslike Munisipaliteit in die Vaaldriehoek gevestig is. In 2006 was die Vaaldriehoek die eerste streek in die land wat tot Lugafwerpsel Prioriteitsarea ten opsigte van die Nasionale Omgewingsbeheer Wet (39/2004) verklaar is.

Ekonomiese literatuur toon aan dat daar ’n sterk positiewe verband tussen armoede en besoedeling is. Dit is op grond hiervan wat die studie ’n teoretiese agtergrond van armoede en besoedeling verskaf.

Die studie maak gebruik van ’n voorwaardelike waardasiemetode ten einde respondente se maksimum bereidwilligheid te ontlok om vir die vermindering van lugbesoedeling in die area te betaal. Die opname-vraelys dek drie breë sosio-ekonomiese kategorieë, naamlik die demografiese profiel, arbeidsmag-profiel en die inwoners se houdings teenoor sake rakende die omgewing. Die gedeelte van die vraelys waar waardasie ter sprake is, maak gebruik van ’n oop-antwoord-vraelys ten einde die respondente uit te lok ten opsigte van hulle maksimum bereidwilligheid om vir die vermindering van lugbesoedeling in Bophelong te betaal.

Die gemiddelde bereidwilligheid om vir die vermindering van lugbesoedeling in Bophelong te betaal word beraam teen R132 per jaar. Die jaarlikse sosiale koste van lugbesoedeling in Bophelong word bereken deur die gemiddelde bereidwilligheid om te betaal te vermenigvuldig met die beraamde totale bevolking. Bophelong se totale bevolking word op 49 408 geskat. Die jaarlikse sosiale koste van besoedeling word dus beraam teen R6 521 956.

Die regressie-analise toon dat verskeie faktore respondente se gewilligheid om te betaal positief beïnvloed. Die analise toon aan dat opvoeding, werksaanstelling en die vlak van inkomste positief korreleer met die

respondente se bereidwilligheid om te betaal. Die studie dui aan dat daar ’n positiewe korrelasie tussen armoede en besoedeling is.

Die meeste van die lugbesoedeling wat die bevolking van Bophelong raak, word deur huishoudelike bronne veroorsaak, soos steenkool wat gebrand word en biomassa-vuurmaakgoed vir verhittings- en kookdoeleindes. Om die negatiewe invloed van lugbesoedeling op die inwoners van Bophelong te elimineer, word in die studie aanbeveel dat owerhede begin deur die armoede-situasie in die area te die hoof te bied. Een van die hoofowerhede moet maatreëls instel wat die huishoudelike bronne van besoedeling teiken.

Van die maatreëls wat ingestel kan word om die impak van besoedeling te verlaag, kan die volgende insluit: (a) die aanmoediging van inwoners om ’n skoner bo-na-onder steenkool-ontbrandingmetode (bekend as “Basa-njengo-Magogo”) te gebruik, (b) die verskaffing van gratis basiese elektrisiteit aan arm huishoudings in die area, en (c) om te verseker dat huise gebou word met die inagname van termiese gerieflikheid, aangesien dit die behoefte aan ruimte-verhitting veral gedurende die wintermaande sal verminder.

SLEUTELWOORDE: lugbesoedeling, gebeurlike skatting, armoede, herwinbare energie, sosiale koste, volhoubare ontwikkeling, bereidwilligheid om te betaal

ABSTRACT

The aim of this study is to quantify the social cost of air pollution in Bophelong Township.

Bophelong is a dominantly Black low-income settlement located on the South-western part of the Emfuleni Local Municipality in the Vaal Triangle. In 2006 the Vaal Triangle was the first region in the country to be declared an Airshed Priority Area in terms of the National Environmental Management Act (39/2004).

Economic literature reveals that there is a strong positive correlation between poverty and pollution. It is on this basis that the study provides a theoretical background to poverty and pollution.

The study makes use of a Contingent valuation method to elicit respondents' maximum willingness to pay for the reduction of air-pollution in the area. The survey questionnaire covers three broad socio-economic categories namely, the demographic profile, labour force profile and the residents' attitudes towards environmental issues. The valuation part of the questionnaire makes use of an open-ended questionnaire to elicit the respondents' maximum willingness to pay for the reduction of air pollution in Bophelong.

The mean willingness to pay for the reduction of air-pollution in Bophelong is estimated at R132 per annum. The annual social cost of air-pollution in Bophelong is calculated by multiplying the mean willingness to pay with the estimated total population. Bophelong's total population was estimated at 49 408. The annual social cost of pollution is thus estimated at R6 521 856.

The regression analysis shows that several factors positively influence respondents' willingness to pay. The analysis shows that education, employment and level of income are positively correlated with the respondents' willingness to pay. This study indicates that there is a positive correlation between poverty and pollution.

Most of the air pollution that affects the population of Bophelong is generated from domestic sources such as the burning of coal and biomass fuels for

heating and cooking purposes. In order to eliminate the negative impacts of air pollution on the residents of Bophelong the study recommends that authorities must begin by ameliorating the poverty situation in the area. On the main authorities must introduce measures that target domestic sources of pollution.

Some of the measures that could be undertaken to reduce the impact of pollution could include: (a) encouraging residents to adopt the more cleaner top-down coal ignition method known as Basa-njengo-Magogo, (b) providing free basic electricity to poor households in the area and (c) ensuring that houses are constructed with thermal comfort in mind, as this will minimise the need for space heating particularly during winter months.

KEY WORDS: air pollution, contingent valuation, poverty, renewable energy, social cost, sustainable development, willingness to pay.

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LIST OF ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
ALRI	Acute Lower Respiratory Infection
BnM	Basa – njengo – Magogo
CBA	Cost-Benefit Analysis
CE	Choice Experiment
COPD	Chronic Obstructive Pulmonary Disease
CV	Contingent Valuation
DEAT	Department of Environmental Affairs and Tourism
DFID	Department for Foreign International Development
EEC	European Economic Commission
EIA	Environmental Impact Assessment
EKC	Environmental Kuznets Curve
EPA	Environmental Protection Agency
FGT	Foster, Greer and Thorbecke
GDP	Gross Domestic Product
GEAR	Growth, Employment And Redistribution
GNP	Gross National Product
HDI	Human Development Index
HEL	Household Effective Level
HIV	Human Immuno Virus
HP	Hedonic Pricing
HPI	Human Poverty Index
HSL	Household Subsistence Level
IDP	Integrated Development Plan
LED	Local Economic Development

MLL	Minimum Living Level
NEMA	National Environmental Management Act
NEPA	National Environmental Policy Act
NGOs	Non-Governmental Organisations
PDL	Poverty Datum Line
PM	Particulate Matter
RDP	Reconstruction and Development Programme
RSA	Republic of South Africa
SLL	Supplementing Living Level
SPII	Studies in Poverty and Inequality Institute
Stats SA	Statistics South Africa
TB	Tubercolosis
UN	United Nations
UNDP	United Nations Development Programme
USA	United States of America
WHO	World Health Organisation
WTA	Willingness to Accept
WTP	Willingnes to Pay

CHAPTER 1

INTRODUCTION AND BACKGROUND

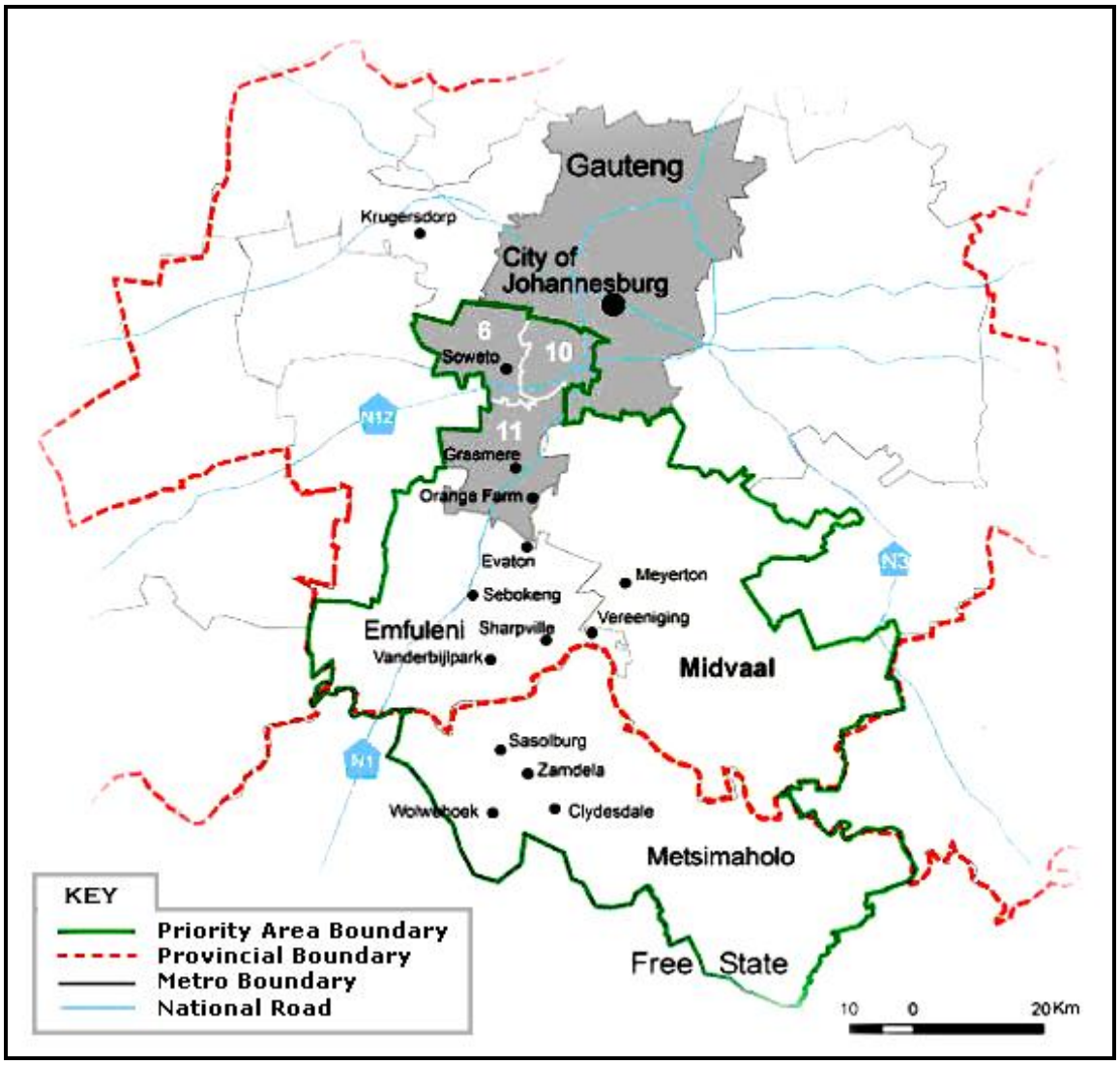
1.1 INTRODUCTION

Pollution is defined as a condition in which man-made activities reduce the ambient quality of a particular environment (Stephen *et al.,* 2002:133-136). The poor often possess inadequate resources that can enable them to afford cleaner sources of energy; as a result they tend to resort to using dirty fuels such as biomass and fossils. This expose them to air-pollution particularly indoor air-pollution, it is as a result of their low incomes that the poor are more likely to be vulnerable to pollution than the affluent members of society. Poverty is often associated with pollution, there is substantial literature that highlights the adverse effects of pollution on the health and welfare of the poor (Beall *et a*l., 2000:834-835). The endeavour to improve human welfare and raise standards of living cannot be divorced from the state of the natural environment. The issue of pollution is so intertwined with poverty that it cannot usefully be solved without addressing the latter. It is against this background that Chapter 2 of this study concentrates on a more in-depth discussion of poverty. Pollution is considered as a negative externality which means that its effects on society are not internalised into the production costs of producers. Producers tend to regard environmental goods such as air and water as free goods which do not represent a production cost to them. Chapter 3 of this study discusses pollution as an externality, and also discusses the various economic theories that have been developed over the years to address the issue of the social cost of externalities, – particularly negative externalities – to society. Two well-known theories which have been developed to deal with externality issues are the Pigouvian theory and the Coasean Theory. The main thrust of the Pigouvian theory and the Coasean theory is that a monetary value should be placed on environmental goods so that these goods can be regarded as part of production costs by producers. However these two theories do not provide the tools on how these goods should be valued. It is on this basis that economists have developed various valuation techniques

that can be used to assist in attaching a monetary value to environmental goods. Some of these techniques are discussed in this study as well. Amongst some of the techniques discussed are Cost-benefit analysis, indirect valuation techniques such as Hedonic pricing and direct valuation techniques such as Contingent valuation. This study makes use of the Contingent valuation method to determine the social cost of air-pollution to the residents of Bophelong.

This study focuses on the social cost of air-pollution on the population of Bophelong Township. Bophelong is located within the Emfuleni municipality which forms part of the Vaal Triangle. The Vaal Triangle stretches beyond the local provincial boundaries of Gauteng and extends into the Free State province. It is formed by three industrial towns, namely Vanderbijlpark, Vereeniging and Sasolburg. Vanderbijlpark and Vereeniging fall within the boundary of the Emfuleni Local Municipality – which is the largest local municipality in the Vaal Triangle, and in the Gauteng province, while Sasolburg falls within the adjacent Metsimaholo Local municipality in the Free State province. Together these three towns form one of the largest industrial hubs in the country. In April 2006 the Minister of Environmental Affairs and Tourism declared the Vaal Triangle an Airshed priority area, making Vaal Triangle the first region in the country to be declared a priority area in terms of the National Environmental Management Act (39/2004). As shown in Figure 1.1 below the priority area extends beyond the Vaal Triangle and includes the southern parts of Johannesburg such as some parts of Soweto, Lenasia, Ennerdale and Orange Farm.

Figure 1.1: Vaal Triangle airshed priority areas



Source: National Environmental Management Act (39/2004)

1.2 THE RESEARCH PROBLEM

The metal and metal products industry is the dominant economic sector in the Emfuleni economy, according to Slabbert (2001:43). It constitutes 80.6 percent of manufacturing activities in the region, while the chemical and chemical processing industry is the dominant economic activity in the Metsimaholo municipality. The Vaal Triangle is a heavily industrialised region, owing its origins to the discovery of coal deposits in the area in 1878. Commercial and mining activities in the Witwatersrand resulted in an increased demand for coal and steel. Several studies have identified significant health impacts occurring in the region due to air-pollution

originating from various sources including industrial and domestic emissions (GroundWork Report, 2006:19).

Whilst the Vaal Triangle area is heavily industrialised, and industries contribute significantly to air pollution, the largest contribution in the area comes from domestic sources (Friedl *et al.*, 2008). In a study conducted by Friedl *et al.* (2008), 94 percent of the respondents expressed a general concern about air pollution in the area, and the majority of the respondents felt that industries are the main culprits. The study by Friedl *et al.* (2008), however, proved that domestic sources are by far the largest contributors, accounting for 69 percent of the health impact levels.

A study conducted in the United States of America by Pope III *et al*. (2002) found that air pollution is an important environmental risk factor for the existence of cardiopulmonary illnesses for people residing in areas surrounding the polluting industries. Another study conducted by Oldewag-Theron *et al.* (2005) in an informal settlement in the Vaal Triangle found that 42 percent of the respondents suffer from chronic cough. The study further established that 72 percent of the respondents did not smoke; thereby suggesting that air pollution could be a leading cause of such ailments in the area.

It is essential that producers compensate communities who are negatively affected by the production process. The compensation can be obtained through the levying of Pigouvian taxes on the producers. Whilst Pigouvian taxes can be used to compensate the victims of pollution, determining the efficient level of tax poses a challenge to economists. The compensation must be adequate to cover costs such as hospital admissions. In order to receive adequate compensation, residents have to be adequately diagnosed for emission related illnesses, thereby also calling for properly trained health workers (Kisting *et al.,* 2004). Kisting *et al.* (2004) indicate that compensation amounts for asbestos related illnesses in Limpopo have largely been inadequate. It is of high importance therefore that higher penalties be imposed to offenders to encourage preventive measures such as adhering to the government prescribed emission quotas. The magnitude of air pollution in the

Emfuleni region requires that companies pay adequate compensation for the true cost of polluting the environment. Alternatively, the government can incentivise industries through the carbon trading system. According to this system, if companies fund programmes to decrease pollution they can get carbon credits, thereby allowing them to reduce their own pollution control costs. The Basa- njengo- Magogo (BnM) project is an example of how carbon credits can be used to expedite an air quality improvement project. The implementation of the BnM method has proved that coal burning through the BnM method results in coal that burns cleaner, thereby leading to a significant reduction in the negative impacts of air pollution on residents (Friedl *et al*., 2008).

According to Kidd (2004:152) and Beall *et al.* (2000:835), environmental ills are closely associated with a person's socio-economic status. The poorer you are, the more likely you are to be exposed to environmental hazards. Just over half of the population in Emfuleni lives in poverty. Approximately 96 percent of the poor in this area live in the townships (Slabbert, 2001). There is therefore a need to formulate and implement environmental intervention strategies to alleviate the impact of environmental degradation on the lives of the poor. It is imperative that a holistic approach including all stakeholders be considered when dealing with issues related to air pollution.

The duty of government in market economies is to intervene (in the interest of its citizens) and to correct market failures such as imperfect competition, inability to provide public goods and air-pollution which is probably the worst externality in urban areas (Nas, 1996:3). The South African government has in its bid to fulfil this function promulgated the National Environmental Management Act (39/2004) which states the following, amongst others, as its objective:-

To protect the environment by providing reasonable measures for,

- The protection of quality of air in the Republic
- The promotion of quality of air; and

- Securing ecologically sustainable development while promoting justifiable economic and social development.

1.3 AIM OF THE STUDY

According to Ezzati and Kammen (2002:1057) three billion people in the world rely on biomass and coal as their primary sources of domestic energy. These energy sources contain dangerous toxins such as particulate matter, carbon monoxide, nitrogen dioxide and other toxins which have been found to be major causes of respiratory and pulmonary ailments. Ezzati and Kammen (2002:1057), furthermore indicate that exposure to indoor air-pollution is responsible for three to four percent of global mortalities annually.

There is a general lack of data and information available at municipal level to enable decision-makers to make informed decisions on matters pertaining to the impacts of air pollution (Mokgoro, 2000). This study analyses the social cost of air pollution and provides information to decision makers to enable them to make appropriate decisions when formulating environmental policies. This study is based on the following premises:-

- Air-pollution has adverse impacts on the health of the population and the environment; and

- The social cost of air-pollution can be quantified that is, recognition that proposed environmental policies must be subjected to an intense cost-benefit analysis study in order to ensure that costly mistakes are avoided and scarce resources are utilised wisely.

There are many valuation techniques such as cost-benefit analysis, environmental impact assessment, scenario analysis and contingent valuation that can be used to evaluate policies and projects (Hanley & Spash, 1993:3). These methods are discussed in Chapter 5. The objectives of this study are carried out mainly through:

- Investigating methods that can be used to alleviate the negative impact of air pollution in Bophelong;

- Collecting and analysing data; related to the socio-economic profile and estimation of the social cost of air-pollution in Bophelong, and
- Making recommendations with regard to air pollution control in the area.

1.4 RESEARCH HYPOTHESIS

The introduction and implementation of appropriate air-quality control strategies such as appropriate air-pollution control technologies will reduce the social costs of air-pollution to residents of Bophelong.

1.5 IMPORTANCE OF THE STUDY

Economics provides economists with valuation instruments that can be used to quantify and place a monetary value of human actions on the environment. The results of economic valuation can be used in different ways (WHO, 2006:3). Firstly, they can be used as a project analysis tool, to inform decision-makers choosing between alternatives under consideration for large scale projects; secondly they can be used as a government policy-making tool, assisting government to choose cost-effective or cost beneficial interventions into public policy or into government planning or abandon cost-inefficient interventions; thirdly, they can also be used as a tool for assessing social impacts of interventions, by identifying parts of the population that are benefitting or losing and designing a policy intervention to target such groups and lastly, they can be used as a decision tool by an implementing agency, such as hospitals, companies and non-governmental organisations (NGOs).

1.6 RESEARCH METHODOLOGY

This study incorporated both elements of qualitative and quantitative research which comprise a literature review, field surveys and in-depth interviews with experts in the field of environmental economics.

1.6.1 Literature review

A variety of sources were consulted for this study, namely books, journal articles, thesis and dissertations.

1.6.2 Empirical study

There are several approaches that can be used to evaluate policies and projects that have an impact on the environment. These approaches are discussed in detail in chapter 5. This study makes use of Contingent Valuation method as it is most suitable for this study given the unavailability of data on air pollution in the area. Furthermore, Contingent Valuation is widely used and accepted as a scientific way to determine the social cost of different commodities. In line with the contingent valuation technique this study makes use of field surveys. The study also makes use of other available survey results of other similar studies conducted in the field to determine the nature of problems associated with poor air quality in the area of study. With reference to the survey conducted in this study, person-to-person interviews were conducted with respondents in their own homes. Home-based interviews provide respondents with an opportunity to reflect and present a well-thought-out opinion (Hanemann, 1994:22).

The following methodology was used, firstly maps were obtained for the area under study; secondly a sample stratification was designed based on how the population of Bophelong Township is geographically distributed and concentrated, thirdly a questionnaire was designed for obtaining the desired information; fourthly the area under study was divided into different sections and the questionnaires were pre-apportioned evenly among the inhabited sites; and lastly trained field workers were commissioned to conduct the survey. Information was obtained from the head of the household or the spouse.

1.7 OUTLINE OF THE STUDY

This study is divided into different chapters. A brief outline of contents is provided below.

Chapter 1 introduces the field of study and indicates the geographical position of Bophelong. The chapter further introduces the aim of the study, the research hypothesis and methodology. This chapter also provides a clear and

concise layout of the study and shows all the relevant topics that are discussed.

Chapter 2 provides a theoretical background to the study of poverty. The chapter discusses the different meanings and measures of poverty as well as different strategies that can be used to alleviate poverty. Economic literature suggests a very strong positive correlation between poverty and pollution.

Chapter 3 discusses the theoretical background to pollution and social cost. The chapter defines the meaning of pollution and describes the impact that pollution can have on the environment as well as on human health. The chapter concludes by discussing the theory of social cost.

Chapter 4 discusses different methods that can be used to evaluate policies and projects that have an impact on the environment. Some of the methods discussed in this chapter include environmental impact assessment, scenario analysis, cost-benefit analysis, and contingent valuation. Whilst the theory of social cost provides a theoretical basis for the measurement of social cost, the different evaluation techniques provide the tools for doing so.

Chapter 5 discusses the different strategies for pollution control and continues to discuss the related concepts of renewable energy and sustainable development.

Chapter 6 analyses the impact of air-pollution in Bophelong in terms of social cost to residents. The aim of this chapter is to provide knowledge to interested stakeholders, among them, the local government by providing an estimate of the social cost of pollution as perceived by the residents of Bophelong.

Chapter 7 summarises and concludes the study, and makes recommendations.

CHAPTER 2

THEORETICAL BACKGROUND TO POVERTY

2.1 INTRODUCTION

Poverty is considered to contribute to pollution as the poor are more likely to pollute than the affluent members of society (Beall *et a*l., 2000:833). The higher the per capita income of a particular nation the lower is the ambient concentration of water and air-pollution (Hilton, 2005:130).This chapter aims to give a proper understanding of poverty. Poverty can be explained both in absolute and relative terms.

Todaro and Smith (2003:52) describe absolute poverty as an inability to attain a specific minimum level of income deemed necessary for continued survival in a given society. According to this definition people whose incomes tend to fall below a certain pre-determined real income threshold are considered to be poor. Relative poverty on the other hand is defined in terms of the average resources available in society. According to this definition a person is considered to be poor on the basis of possession or lack thereof of resources deemed to be acceptable, relative to what is taken to be the norm in his or her society (Rio, 2006:73). Furthermore Rio (2006:36) describes subjective poverty. According to this approach, the people's perception of what constitute poverty is taken into account. When using this approach a survey of a representative sample is conducted to establish people's perception of a poverty line (Rio, 2006:30). This approach is in line with what Laderchi *et al.*, (2003:244) describe as a participatory approach in which the poor are involved in defining who is poor and what poverty actually means. In addition Laderchi *et al.,* (2003:244) describe four different approaches to the definition of poverty. Firstly, the monetary approach describes poverty in the context of a shortfall in income related to a pre-determined figure referred to as the poverty line. Any individual whose income fall below this predetermined figure is regarded as being poor. Secondly, the capability approach defines poverty as a lack of ability to attain a certain minimum of basic capabilities such as nutrition. Thirdly, the social exclusion approach views poverty as a state of

affairs where an individual or groups are totally or partially excluded from full participation in the community in which they stay. Lastly, the participatory approach promotes the involvement of the poor in defining poverty (Laderchi *et al.,* 2003:244).

2.2 POVERTY

Poverty can be measured in both absolute and relative terms. Absolute measures of poverty measure it in terms of the inability on an individual to attain a certain minimum level of income whereas relative poverty measures concentrate on other non-income determinants of poverty such as lack of access to basic services. This section begins by describing the different definitions of poverty and proceeds by discussing the different determinants of poverty as identified by the World Bank (2005:132). Furthermore, the section also describes the different approaches used to measure poverty namely, poverty lines and poverty indices and concludes by discussing various poverty alleviation strategies.

2.2.1 Definitions of poverty

Poverty can mean different things to different people. Hagenaars and de Vos (1988:212) divides the definitions of poverty into three basic categories namely, the absolute approach, the relative approach and the subjective approach. Absolute approach refers to a situation where people have less than a predefined absolute minimum of income. The relative approach refers to a situation where a person possesses less than what is regarded as the standard norm in the society in which he / she lives. The subjective approach refers to a situation where a person expresses his /her own feelings about being poor. The three categories of poverty described above can be further subdivided into several sub-categories as discussed below (Hagenaars & de Vos, 1988:212).

2.2.1.1 Absolute poverty

The basic needs approach defines poverty in terms of a certain minimum threshold of income required to meet basic needs such as food clothing and

housing. Measuring poverty according to the basic needs approach involves the pre-selection of a poverty line according to which households will be identified as being poor on the basis of a shortfall in income related to this figure. Different types of ratios can be used to measure poverty though the basic needs approach; these ratios can be described as follows (Hagenaars & de Vos, 1988:212):

- Food/income ratio – this definition of poverty states that the ratio of food expenditure to income declines as income rises. The pre-selected minimum threshold of income would then be linked to this ratio. For instance, if the ratio is stated as one third (i.e. 0.33), it would mean that a household which spends more than one third of their income on food is regarded as poor.

- Fixed cost /income ratio – according to this definition poverty is expressed as the ratio of fixed cost to total household income, and

- Total/expenditure income ratio – a person is defined as poor if his / her total current expenditure exceeds his / her total current income.

2.2.1.2 Relative poverty

Hagenaars and de Vos (1988:212) describe relative poverty in terms of commodity deprivation. A person is considered as poor when he / she lacks certain commodities which are considered to be the norm in the society in which he / she lives. Laderchi et al. (2003:244) describe this type of poverty as social exclusion that is, the process through which individuals or groups are wholly or partially excluded from full participation in the society in which they live. Alcock (1993:59) describes relative poverty as being multi-dimensional in nature and involves some comparison of the standards of living between members of society. According to the definition by Alcock (1993:59) a household is considered as poor if its resources fall below those of the rest of the community.

2.2.1.3 Subjective poverty

The subjective approach involves taking into account the views of the poor in defining who is poor or what poverty actually means (Laderchi *et al*., 2003:244). This category can be subdivided into the following income and consumption related definitions:-

- Subjective minimum income – this approach makes use of survey questions to determine the level of income that household consider to be sufficient for their survival;

- Subjective minimum consumption – this approach also makes use of survey questions to ask people what they regard as basic needs and let them indicate the amount that they deem sufficient to meet these basic needs, and

- Official minimum – according to this definition the government would set a certain threshold minimum, any household whose income is lower than the set minimum is then regarded as poor.

2.3 DETERMINANTS OF POVERTY

Table 2.1 below provides a summary of some of the determinants of poverty as identified by the World Bank (2005:132).

Table 2.1: Main determinants of poverty

MAIN DETERMINANTS OF POVERTY	
Regional characteristics	• Isolation/remoteness, including less infrastructure and poorer access to markets and services • Resource base, including land availability and quality. • Weather (e.g. are typhoons or droughts common) and environmental conditions (e.g. frequency of earthquakes) • Regional governance and management
Community characteristics	• Infrastructure (e.g. is there piped water, access to a tarred road) • Land distribution • Access to public goods and services (e.g. proximity of schools, clinics) • Social structure and social capital
Household characteristics	• Size of household • Dependency ratio (i.e. unemployed old and young relative to working age adults) • Gender of head; or of household adults on average • Assets (typically including land, tools and other means of production, housing) • Employment and income structure (i.e. proportion of adults employed; type of work – wage labour or self-employment; remittance inflows) • Health and education of household members on average
Individual characteristics	• Age • Education • Employment • Health status • Ethnicity

Source: World Bank, 2005:132

2.4 MEASURES OF POVERTY

Poverty can be measured in the form of poverty lines and poverty indices. A poverty line indicates the level of income required to attain the minimum subsistence level. It is used to distinguish households whose incomes are too low compared to that of the general population (Mokoena, 2001:41). The sub-section that follows will provide an overview of the different poverty lines that can be used to measure poverty.

2.4.1 Poverty Lines

Classification of how poverty is defined is extremely important as different definitions imply the use of different indicators for measurement (Laderchi *et al*., 2003:244). The most common approach to measuring poverty is the household income approach, or absolute poverty line. According to this approach a household is considered poor if its income or expenditure is below a specified minimum level of real income (Todaro & Smith, 2003:205). There are other non-income measures of poverty which use indicators such as infant mortality rates, life expectancy, the proportion of income devoted to food housing conditions and child-schooling (World Bank Institute, 2005:38). These types of non-income poverty lines are also known as relative poverty lines. A relative poverty line refers to the average resources available in a given society (Rio, 2006:33). **Table 2.2** below indicates the different types of relative poverty lines developed by the United Nations Development Programme (UNDP).

Table 2.2: UNDP Indexes of Human Development and Poverty (UNDP 2000)

Index	Longevity	Knowledge	Decent Standard of Living
Human Development Index (HDI)	Life-expectancy at birth	Adult literacy rate Combined enrolment rate	Adjusted income per capita PPP$
Gender Development Index (GDI)	Female and male life-expectancy at birth	Female and male adult literacy rate Female and male combined enrolment rate	Female and male income equal
Human Poverty Index-1(HPI-1) Developing countries	Percentage of people not expected to live to 40.	Adult literacy rate	Percentage of people without access to safe water Percentage of people without access to health services Percentage of undernourished children under the age of five
Human Poverty Index -2 (HPI-2) Develop countries	Percentage of people not expected to live to 60	Functional literacy rate	Percentage of people living below nationally defined income poverty lines (= fifty percent of median disposable income) Social exclusion – percentage of people with more than twelve months of unemployment

Source: DFID, 2002:25

A good poverty line should display several characteristics (also referred to as axioms) namely, (Rio, 2006:95):

- Focal axiom: the poverty measure should disregard information pertaining to the incomes of the non-poor;
- Monotonicity axiom: a poverty measure should increase when the income of a poor person decreases;

- Transfer axiom: a transfer of income from any given person to a less poor person should increase the poverty index i.e. the poverty line should reflect how incomes are distributed amongst the poor, and

- Subgroup Monotonicity: if a given population subgroup's poverty measure increases, ceteris paribus, and then the poverty measure for the whole population should increase (Rio, 2006:95):

Table 2.3 below shows examples of poverty lines used in South Africa. The Poverty Datum Line (PDL) was the first money-based absolute poverty line used in South Africa. It consisted of two components, namely, the Primary Poverty Datum Line and the Secondary Poverty Datum Line. The Primary Poverty Datum Line consisted solely of the cost of food, clothing, cleansing materials and fuel and light whilst the Secondary Poverty Datum Line also made provision for the cost of accommodation, transport for the breadwinner and taxation (SPII, 2007:30).

The Minimum Living Level (MLL) was described as the minimum level at which a non-white family would be able to maintain the health of its members and conform to Western standards of decency. The MLL was expanded through the introduction of a secondary poverty line known as the Supplemental Living Level (SLL) which incorporated a wider variety of basic necessities than the MLL. The use of these poverty lines was abandoned in 2002 (SPII, 2007:30). The Household Subsistence Level (HSL) is an estimate of the theoretical income needed by an individual household to maintain a defined minimum level of health and decency in the short-term and is calculated at the lowest retail cost of a basket of necessities of adequate quality (Slabbert, 1997:42-43).

According to Potgieter (1980:7) in Sekhampu (2009:86) the HSL was not effective in enabling households to maintain sufficient standards of long-term decency. To address this short-coming, the Household Effective Level (HEL) was developed. The HEL raised the HSL cut-off point by 50 percent. The Upper and Lower Bound poverty line was developed by Hoogeveen and Ozler in 2004. At the introduction of this poverty line the upper bound was R593 per

capita per month and the lower bound was R322 per capita per month using 2000 as the base year (SPII, 2007:31). The Food Insecurity Poverty Line measures the cost of a nutritionally balanced minimum diet for a household. The Food Insecurity Poverty Line is also referred to as the calorific approach (SPII, 2007:31).

The United Nations Development Programme (UNDP) makes use of a variety of indices to measure poverty. These indices were explained in **Table 2.2**. Lastly, the Multiple Deprivation Indices combines the various dimensions of deprivation as shown in **Table 2.3** into one measure and assign an equal weighting for each to provide a weighted aggregate of the specific domains of deprivation (SPII, 2007:32).

Poverty lines do, however, have their own disadvantages. The DFID (2002:17) lists the following disadvantages of poverty lines:

- They tend to pay less attention to non-income measures of poverty,
- The mostly focus on the reduction of absolute poverty and tend to ignore social inequality which may lead to political and social instability;
- They tend to concentrate more on economic rather than social development,
- They tend to disregard human development capabilities;
- They do not take into account the depth or severity of poverty, and
- The cut-off lines are often chosen arbitrarily.

Table 2.3: Poverty Lines

POVERTY LINE	COVERAGE
Poverty Datum Line (PDL)	Food, Clothing, Fuel/lighting, Washing/cleaning, Rent, Transport
Minimum Living Level (MLL)	PDL plus: Tax, Medical Expenses, Education, Household Equipment Replacement
Supplementary Living Level (SLL)	MLL plus: More of each item plus Recreation, Personal Care, Pension, Unemployment Insurance Fund, Medical Aid, Burial Contributions. Approximately MLL + 30 percent
Household Subsistence Level (HSL)	As for PDL
Household Effective Level (HEL)	HSL + 50 percent
Upper and Lower Bound Poverty Line	Upper and lower bound consumption-based poverty line using the cost of basic needs approach.
Food Insecurity Poverty Line	Very low cost food ration scale for food items included in the HSL
United Nations Development Programme (UNDP) Indices	Human Development Index, Human Poverty Index, Gender Empowerment Index and Service Deprivation Index (See **Table 2.2**)
Multiple Deprivation Indices	Measures deprivations in terms of Income, Employment, Health, Education and Living Environment

Source: Mokoena, 2004:22 and SPII, 2007:31-32 (adapted)

2.4.2 Poverty Indices

A poverty index, such as the headcount index can be obtained by expressing the number of the poor as a fraction of the total population (Todaro & Smith, 2011:212). The sub-section that follows provides an overview of the different poverty indices that can be used to measure poverty.

2.4.2.1 Headcount Index

The headcount index measures the proportion of the population below the poverty line. The headcount index can be expressed as follows (World Bank Institute, 2005:70):

$P_o = \frac{1}{N}\sum_{i=1}^{N} I(y_1 < z)$,

Where P_o= the fraction of the population below the poverty line

I(.) = the indicator function that takes the value of 1 if the bracketed expression is true and 0 otherwise

y_1 = household income

z = poverty line

N = total number of the poor

The headcount index has however, been criticised for not taking into account the extent of poverty **Table 2.4** below shows the shortcomings of the headcount index as a measure of the extent of poverty (World Bank Institute, 2005:70). According to **Table 2.4** the headcount index fails to capture the magnitude of poverty in two countries. The poverty rate is indicated as 50 percent for both countries, but as the table shows, poverty is more 'deeper' in country A (World Bank Institute, 2005:70).

Table 2.4: Headcount Index (Example)

Headcount Poverty Rates in A and B, assuming a poverty line of 125					
	Expenditure for each individual in country				Headcount poverty rate (P_o)
Expenditure Country A	100	100	150	150	50%
Expenditure Country B	124	124	150	150	50%

Source: World Bank Institute, 2005:70

2.4.2.2 Poverty Gap Index

In order to address the shortcomings associated with the headcount index, the poverty gap index is used. The poverty gap index measures the extent of the shortfall of income below the poverty line and expresses it as a percentage of the poverty line (World Bank Institute, 2005:72).

The poverty gap ratio can be expressed as follows (Slabbert, 2004:43):

$$R(y,z) = \sum_{i=1}^{M}(z - y)/z$$

Where R = mean income shortfall of the poor expressed as a proportion of the poverty line

y = the income of the household

z = the poverty line

M = the number of households with income equal to the poverty line

Table 2.5: Poverty Gap Index (Example)

Calculating the poverty gap index, assuming a poverty line of 125					
	Expenditure for each individual in country				**Poverty gap index (P_i)**
Expenditure Country C	100	110	150	160	
Poverty gap	25	15	0	0	
G_i/z	0.20	0.12	0	0	0.08 [=0.32/4]

Source: World Bank Institute, 2006:72

The poverty gap can only be eliminated by increasing household income. The poverty gap index shows how much would have to be transferred to the poor to bring their income or expenditure up to the poverty line (World Bank Institute, 2005:72).

2.4.2.3 The Forster-Greer-Thorbecke (FGT) Index

The Forster-Greer-Thorbecke index (also known as the squared poverty gap) concentrates on the degree of poverty among the poor. It measures the distribution of income among the poor (Todaro &Smith, 2003:208). The FGT index is a weighted sum of the poverty gap (World Bank, 2006:73). According to this index the observations that fall way below the poverty line are given more weight thus indicating the severity of their poverty. The FGT index can be expressed as follows (Todaro & Smith, 2003:208):

$$P_\alpha = \frac{I}{N} \quad \sum_{i=1}^{H} \left(\frac{yp - y1}{yp}\right) \alpha$$

Where y_1= the income of the i^{th} poor person

y_p= the poverty line

α = the severity of the index to poverty

N = population

if α = 0, normal headcount index

if α = 1, normal poverty gap index

if α = 2 poverty severity gap index

The poverty gap index and the poverty severity index complement each other in providing information on the depth and severity of poverty and thereby contribute towards the adoption of more appropriate policies (World Bank Institute, 2005:72).

2.4.2.4 The Human Development Index (HDI)

This index was developed by the United Nations Development Programme (UNDP) in 1997 to counteract the shortcomings of the income measures of poverty (Todaro & Smith, 2003:209). The HDI is a relative measure of poverty which measures poverty along three key deprivations namely, life-expectancy, basic education, and access to basic services such as health facilities and sanitation. The HDI is positively correlated with levels of deprivation. A higher HDI mean a higher level of deprivation (Todaro & Smith, 2003:209).

2.5 POVERTY REDUCTION POLICIES

Poverty reduction strategies are very important in ensuring that the poor are protected against threats to their economic well-being. **Table 2.6** below presents the intervention models related to concepts of poverty.

In addition Mankiw and Taylor (2006:410-411) believe that there is a need for government intervention in the distribution of income. Some of the intervention strategies they describe are discussed in the following sub-section.

Table 2.6: Intervention Model related to Poverty Concepts

Poverty Concept	Time Scale	Needs addressed	Livelihood strategy
Survival (abject poverty, absolute deprivation.	Minimum, short-term needs only.	Providing for basic nutrition.	Livelihood provisioning.
Subsistence.	Long-term survival, health and physical efficiency; increased security, reduced vulnerability.	Providing for food, clothing, shelter, fuel and access to basic health-care.	Livelihood-protection.
Basic needs.	As for subsistence but with more emphasis on human development as a component of longer-term security.	As for subsistence but with a much wider coverage. Also includes education, water sanitation, power, transport and participation in political decision-making.	Livelihood, promotion; longer-term development and empowerment-improving the resilience of households.
Social exclusion and multi-dimensional approach.	Increased security, reduced vulnerability, empowerment and inclusion.	As for basic needs but much wider and includes access to child-care, training, communications and information, legal rights and means to enforce them.	

Source: DFID, 2002:33 (Adapted)

2.5.1 Minimum-wages

Advocates of minimum wage laws consider this policy as a way of helping the poor without putting any burden on the government. Critics of this policy on the other hand maintain that setting wages above the equilibrium level raises the quantity of labour supplied and reduces the quantity of labour demanded thereby hurting the same people it is intended to help. Advocates of this policy insist that the demand for unskilled labour is relatively inelastic and the raising of wages above the equilibrium level will not necessarily depress employment (Mankiw & Taylor, 2006:410).

2.5.2 Social Security

Social security systems are systems of protection that are aimed at advancing the welfare and security of the citizens of a particular country through protecting them from vulnerability to deprivation (Garcia & Gruat, 2003:1). The government can also assist the poor through social security. Social security can be in the form of a variety of government benefits such as child-support grants, disability grants, old-age pensions etc. (Mankiw & Taylor, 2006:411).

2.5.3 Negative Income Tax

According to this policy every family is required to declare its income. High income families will then be charged a tax based on their income whilst lower income families would receive a subsidy i.e. negative tax. The main disadvantage with this policy is that it creates a disincentive to work; people undeserving of government support may benefit. The advantage of this policy is that it does not encourage social ills like illegitimate births (Mankiw & Taylor, 2006:411).

2.5.4 In-Kind Transfers

Advocates of the in-kind transfers maintain that the poor get what they need most. This policy prevents the abuse of cash transfers as the poor are more vulnerable to social ills such as alcohol and drug-dependence. Critics of this policy on the other hand maintain that it is inefficient and disrespectful of the

poor. Despite their unfortunate position the poor are well positioned to decide how to raise their own standards of living (Mankiw & Taylor, 2006:411)

2.6 SUMMARY ANDCONCLUSION

An extensive array of literature studies indicates that there is a strong link between poverty and pollution. These studies suggest that without an improvement in the poor nations' Gross Domestic Product (GDP), these nations are unlikely to reduce their levels of pollution. Friedl *et al*., (2002:2) states that main source of air-pollution that has by far the highest impact in South Africa is from domestic sources, largely through the burning of biomass and fossil fuels by poor households. The link between poverty and pollution provided the rationale for a more in-depth discussion of poverty as a way of bringing- about a proper understanding of this concept.

The discussion on poverty covered a variety of poverty concepts such as the different definitions of poverty, the measurement of poverty as well as poverty reduction policies and strategies. Poverty can be defined in absolute terms and in relative terms. The absolute measure of poverty is the most commonly used. Absolute poverty defines poverty in terms of lack of material resources. An individual or household is considered to be poor if he lacks the basic resources necessary for survival. Relative poverty on the other hand, considers the non-income aspects of poverty. An individual will be considered to be poor if he / she cannot function effectively in the society in which he / she lives. One form of relative poverty that was discussed in this chapter is the social exclusion approach where people are deemed to be poor on the basis of being excluded or marginalised from mainstream economic, social and political life.

The different definitions of poverty also serve as a guideline to measuring poverty. Poverty lines can also be divided into absolute and relative poverty lines. An absolute poverty line deems a household to be poor if it fails to attain a certain pre-selected minimum threshold of income. A relative poverty line on the other hand, considers the non-income measures of poverty. Relative

poverty lines are multi-dimensional in nature and can include other non-income aspects of poverty such as infant mortality rates and life-expectancy.

CHAPTER 3

BACKGROUND TO POLLUTION AND SOCIAL COST THEORIES

3.1 INTRODUCTION

Pollution is defined as the introduction into the environment of substances or energy liable to cause hazards to human health, harm to living resources, and ecological systems, damage to structure or amenity, or interference with legitimate use of the environment (Kidd, 1997:121). In addition, the National Environmental Management Act 39 of 2004 defines air-pollution as any change in the composition of air caused by smoke, soot, dust (including fly ash), cinders, solid particles of any kind, gases, fumes, aerosols and odorous substances. Human beings exist in an environmental space. The environment offers a great deal of services to mankind; firstly, the environment acts as a form of a consumption good by offering services to humankind in the form of air to breath and space; secondly, the environment supply resources such as water, sun and oil; thirdly, the environment is a recipient for waste through the atmosphere, land and water and lastly, the environment acts as a geographical location for economic activities (Bella, 2003:4).

This chapter begins by providing a historical overview of air-pollution and continues to discuss the relationship between economic growth and pollution and confirms the assertion that economic growth is negatively correlated with pollution. The negative correlation between economic growth and pollution is further confirmed by various researches conducted by the World Health Organisation (WHO, 2002:5), which indicates that more than three billion – mostly poor - people in the world who do not possess sufficient resources to afford cleaner forms of energy still use wood, dung, coal and other solid fuels for cooking. More than one and half million people die annually as a result of pollution originating from the use of biomass and fossil fuels (WHO, 2002:5).

The chapter proceeds by discussing different types and sources of air-pollution such as particulates, sulphur oxides, ozone, carbon monoxide,

nitrogen oxides and lead. In addition, the chapter also discusses air-pollution in terms of factors that make people more vulnerable to pollution. The factors discussed in this chapter are environmental factors, health factors and socio-economic factors. The chapter concludes by discussing the link between air-pollution and energy choice and shows that the poor's energy choices are by a variety of factors such as prices of commodities like oil, housing and electricity. These factors may influence the poor to choose dirty fuels such as biomass fuels instead of the cleaner fuels such as electricity thereby worsening the problem of air-pollution both indoors and outdoors. The second part of the chapter deals with the problem of social cost.

Air pollution is regarded as a negative externality to production. Producers treat environmental goods such as air and water as free goods and consequently do not internalise them in their production processes. It is in this light that economists saw the need to develop theories that will force producers to be more responsible in the process of producing goods and services. Two main theories that deal with the issue of externalities and social cost are the Pigouvian theory and the Coasean theory. Pigou preferred government intervention to address the issue of market failure. Pigou's theory advocates for the levying of taxes to close the divergence that exist between marginal private net benefits and marginal social costs. Coase on the other hand was in favour of the market mechanism to deal with the issue of externality. The main thrust of his argument is that in cases where property rights are well defined and transaction costs are minimal, the market system will produce an optimal level of production regardless of who owns the property rights.

3.2 HISTORICAL OVERVIEW OF AIR POLLUTION

The London fog of 1952 is one of the well-known air-pollution episodes to occur anywhere in the world. This fog killed more than 4 000 people and led to a public outcry which culminated in the enactment in England of the Clean-Air Act of 1956 (Fenger, 2009:14). In addition to the most well-known London fog incident of 1952, there are other well-known fog incidents which took place around the world, two of these incidents are discussed in this section. Firstly,

the Meuse valley fog which occurred in Belgium in 1930. This fog was caused by temperature inversions and heavy sulphur dioxide emissions generated by the combustion of coal for domestic and industrial purposes. The Meuse valley fog led to more than 63 deaths, mainly among the elderly and people with pre-existing cardiopulmonary problems. Approximately 6 000 people fell sick and suffered from a variety of ailments such as coughs, chest pains eye irritations and short-breath.

Secondly, another fog incident took place in Donora, Pennsylvania in the USA in the1940s. Unlike the London fog and the Meuse valley fogs which were of a shorter duration the Donora fog was of a longer duration and resulted mainly from photochemical smog. In 1943 the fog was so thick that visibility was reduced to only 3 city blocks. In the European continent most of the abatement legislation is established by the European Union although national reductions in emissions also have a role to play.

The first of several air-pollution abatement directives was issued by the European Economic Community (EEC) in 1980. The directive issued then specified limit values and guide values for sulphur dioxide and suspended particles to protect human health against environmental damage. In 1982 and 1985, the EEC followed with limit values and guide values for lead and nitrogen dioxide respectively. In 1999 the Gothenburg Protocol was signed, the aim of this protocol was to reduce acidification, eutrophication and damages from tropospheric ozone. The existing limit and guide values were strengthened in accordance with the terms agreed upon in the protocol (Fenger, 2009:15).

In the United States of America, various pieces of air-pollution legislation were passed during the first half of the 20th century. One of the legislations was passed in 1943 as a response to the Donora fog. This legislation banned the emission of dense smoke. In 1970, the administration of air-pollution related matters was transferred to the new Environmental Protection Agency (EPA). EPA introduced and passed the National Environmental Policy Act (NEPA) of 1969 which came into effect on the 01st of January 1970 (Mokhehle & Diab, 2001:10).

Developing countries also followed with their own attempts at regulating environmental protection, but on the main they tended to lack far behind the developed world. In developing countries, economic growth is considered as being more of a priority than environmental issues; hence the next section discusses the relationship between economic growth and pollution. Indoor air-pollution tends to be the main problem but is also exacerbated by polluting firms which escape stricter regulation in developed countries to take advantage of the more lax environmental policies of the developing countries (Mokhehle & Diab, 2001:10).

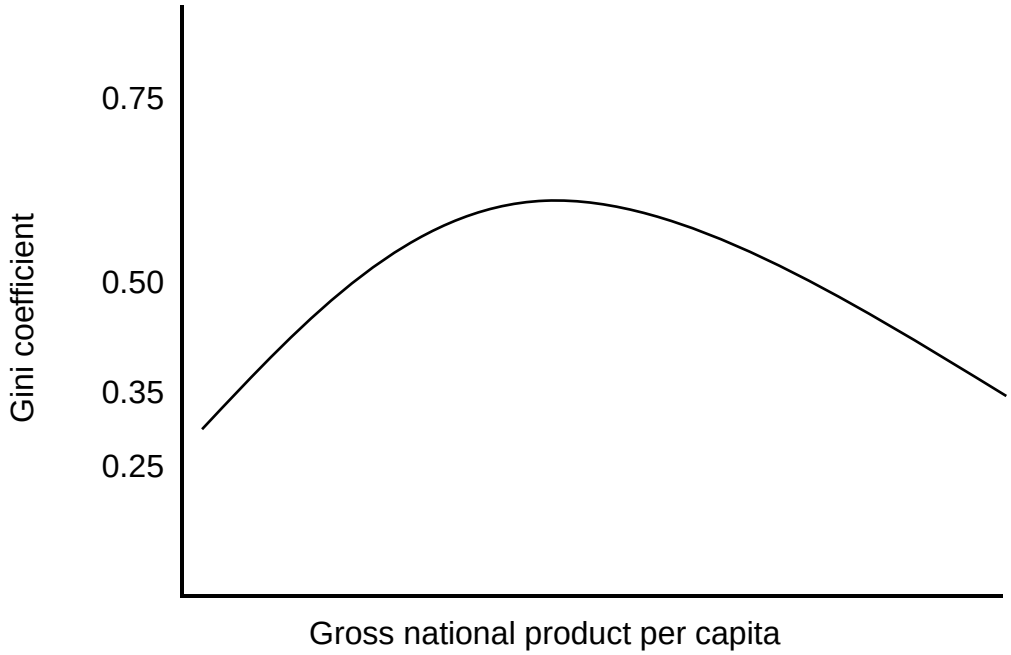
3.3 ECONOMIC GROWTH AND POLLUTION

Pollution is considered to be more a product of poverty than affluence (Beall *et al*., 2000:833). Raising national income will help to alleviate pollution as more people turn towards the use of cleaner energy e.g. electricity. **Figure 3.1** below illustrates an Environmental Kuznets Curve (EKC). According to this model, earlier stages of economic growth will lead to a rise in income inequality and consequently more environmental degradation, but inequality will fall during the later stages of economic growth thereby indicating that economic growth and reduction of income inequality and pollution are not mutually conflicting in the long-run (Todaro & Smith, 2003:215).

As nations prosper, the inhabitants tend to demand that more attention be paid to aspects of their lives which are non-economic in nature. This explains why richer nations which have already attained the critical threshold level of income beyond which pollution begins to fall have lower levels of emissions than poorer countries. The critical level of income from which pollution begins to fall will however, vary from country to country (Bella, 2003:11). Income growth does not however, automatically lead to a reduction of environmental problems. Firstly, not all pollutants follow the inverted 'U' shape of the Environmental Kuznets Curve. Secondly, many nations are still well below the critical threshold level of income required to induce a fall in pollution levels, implying that pollution levels will continue to intensify over an extended period of time. Thirdly, the reduction of pollution in richer countries does not necessarily mean that on a global scale pollution has decreased. Enforcement

of stricter environmental legislation in richer countries may encourage pollution intensive industries to move to low-income countries where such legislation may be non-existent or not strictly enforced (Bella, 2003:11). Lastly, it needs to be taken into account that Environmental Kuznets Curves only explain the relationship between pollution and levels of income, and pollution is but only one of the environmental problems. Empirical evidence suggest that other than on pollution many developed countries score low on other environmental measures such as biodiversity and ecosystem stress (Lee & Chung, 2005:4). It can be concluded therefore, that increase in income levels may lead to a decrease in pollution but it can also have a more damaging impact on other measures of the environment (Lee & Chung, 2005:4).

Figure 3.1: The "inverted U" Kuznets curve



Source: Todaro & Smith, 2003:215

Although the Environmental Kuznets Curve suggests a positive relationship between economic growth and environmental quality, this relationship largely relates to economic growth and pollution. Pollution is but one aspect of environmental quality. On the whole the negative relationship between economic growth and other environmental quality measures persists (Chu *et al.*, 2005:1). Economic growth will continue to degrade the environment as long as appropriate policy measures that take into account other

environmental quality measures are not adopted. Nunberger (1999:85) describes the following ecological concerns resulting from economic growth:

- The greenhouse effect: The greenhouse effect is caused by increasing levels of gases such as carbon dioxide, carbon monoxide, methane, nitrous oxide and chlorofluorocarbons. These gases prevent the heat generated by sun on earth from escaping into space in the form of infra-red radiation thereby altering climatic behaviour e.g. decline in average annual rainfall, rise in sea levels etc.;

- Destruction of the ozone layer. Ozone is a gas that filters out significant amounts of ultra-violet rays from the sun. Depletion of this gas may lead to harmful consequences to organic life e.g. skin cancer and weakening of the immune system;

- Acid rain: Emissions of gases such as sulphur dioxide and nitrogen oxide can lead to the formation of acid rain. Although acid rain does not seem to have any noticeable short-run effects on humans its long-run effects can be quite daunting.

- Waste disposal. It is becoming more and more difficult to find waste disposal sites, including disposal of nuclear waste, wherever is deposited, nuclear waste continue to emit radio-active radiation for thousands of years (Nunberger, 1999:85).

3.4 AIR POLLUTION

There are many different forms of pollution but this study concentrates only on air-pollution as it is its main object. The National Environmental Management Act 39 of 2004 defines air-pollution as any change in the composition of air caused by smoke, soot, dust (including fly ash), cinders, solid particles of any kind, gases, fumes, aerosols and odorous substances. The pollutants described in this section relate to a discharge of residual material that occurs during industrial and domestic processes such as energy generation and cooking and indoor-space heating respectively. These pollutants can be broadly classified according to factors that affect their economic

characteristics. The pollutants described below tend to be cumulative in nature as opposed to being non-cumulative, they tend to have a more regionalised and global impact as opposed to just having a local impact, they are mostly point-source in nature as opposed to non-point-source are generally continuous as opposed to being just episodic (Field & Field, 2009:37-40). The sub-section below provides a description of the characteristics described above.

3.4.1 Cumulative versus non-cumulative pollutants

A cumulative pollutant is a type of pollutant that accumulates over time. Such pollutants may decay over time but their rate of decay is so slow that they can, for all intents and purposes, be regarded as being permanent. A non-cumulative pollutant on the other hand will disappear soon after being discharged. A more common example of a non-cumulative pollutant is noise. Noise will disappear once the source of the noise is shut down. Unlike non-cumulative pollutants, cumulative pollutants are generally difficult to content with as they tend to distort the cause and effect relationship. The distortion of the cause and effect relationship tends to dissuade people from attending to damages caused by emissions as today's ambient air quality levels may not necessarily be linked to today's emissions (Field & Field, 2009:37-38).

3.4.2 Local versus regional and global pollutants

The pollutants described in this sub-section are more regional and global in nature as their impact is not limited to their locality. This means their impact may extend far beyond the borders of a country, for instance, emission in South Africa may affect neighbouring countries such as Lesotho and Botswana. Ozone depletion can have an even wider impact affecting countries that are fur-flung from the source of pollution thereby being truly a global scale. This can make the pollutants much difficult to deal with as countries will not necessarily act altruistically with regards to the reduction of pollution (Field & Field, 2009:37-38).

3.4.3 Point source versus non-point source

Point source pollutants are defined as those types of pollutants where the point of discharge can easily be identified. Non-point source pollutants on the other hand are those that the point of discharge is not well defined. Point source pollutants are much easier to deal with since the source of pollution can be easily identified. It will not be difficult therefore to develop, administer and monitor policies relating to such pollutants (Field & Field, 2009:37-39).

3.4.4 Continuous versus episodic pollutants

Most pollutants such as those emanating from industrial processes tend to be more continuous in nature. On the other hand, some pollutants such as chemical spills may be more episodic in nature. Continuous pollutants are easier to deal with especially in instances where the emissions are not subject to highly volatile fluctuations (Field & Field, 2009:37-38).

3.5 TYPES AND SOURCES OF AIR POLLUTION

A wide variety of pollutants exist in indoor and outdoor air. These pollutants include particulates, sulphur dioxide, ozone carbon monoxide, nitrogen oxide and lead. The main source of air-pollution emanate from the burning of fuels for the generation of electricity, transportation, industrial processes, space-heating and cooking (McGranahan & Murray, 2003:5).

3.5.1 Particulates

Particulates refer to small solid and liquid particles found in the air. These particles vary in physical dimension and chemical properties. The concentration of particulates varies from place to place and from time to time. During winter towns and cities may experience high concentrations of particulates associated with smoke and sulphur dioxide (McGranahan & Murray, 2003:6). The application of different concepts and measuring techniques makes it difficult to evaluate the development of pollution levels related to particulates. Furthermore the chemical composition of particles cannot be established, this implies that the health impacts resulting from

particulates can actually be from other pollutants which are absorbed in the particles. Despite these problems emissions can still be reduced through better combustion techniques and impaction technologies (Fenger, 1999:4881).

3.5.2 Sulphur Oxides

The main source of this type of pollutant is the combustion of fossil fuels. Sulphur dioxide generally occurs as a local pollutant although it can be transported over large distances as particulate if it is in the form of oxide (McGranahan & Murray, 2003:6). Reduction of sulphur dioxide emission can be achieved by using fuels with low sulphur content for instance oil which has low sulphur content can be used instead of coal which generally has high sulphur content (Fenger, 1999:4881).

3.5.3 Ozone

Ozone is a result of photochemical reaction of sunlight on nitrogen oxides and volatile organic compounds. The main oxidant produced by this photochemical reaction is ozone. Plants and crops exposed to ozone cab suffer damage as a result of the stimulation of an oxidation burst in leaves of sensitive plants. Continued exposure to ozone ultimately leads to plant and crop death thereby resulting in poor harvests and food shortages (Wohlgemuth *et al*., 2002:717). High concentrations of ozone are usually found in hot summer afternoons (McGranahan & Murray, 2003:5).

3.5.4 Carbon Monoxide

Carbon monoxide is generated by the incomplete combustion of carbon based fuels. Its main source is emissions from petrol-powered vehicles. It is mostly prevalent in the ambient air of cities. Cigarette smoke also contains large amouns of carbon monoxide and can be a major source of indoor-air pollution (McGranahan & Murray, 2003:7). Carbon monoxide can be reduced through the use of catalytic convertors (Fenger, 1999:4881).

3.5.5 Nitrogen Oxides

Nitrogen oxides can be found in a variety of chemical forms, but the most relevant from the perspective of human health is nitrogen dioxide. This pollutant is formed by the oxidation of atmospheric nitrogen during combustion processes (Fenger, 1999:4881). These chemicals mainly emanate from the same source as carbon monoxide, namely, vehicle emissions and industrial processes. Nitrogen oxide tends to be highly concentrated during peak traffic (McGranahan & Murray, 2003:7). Reduction of emission for this source can be achieved through the optimisation of the combustion process and installing catalytic convertors in exhausts (Fenger, 1999:4881).

3.5.6 Lead

Lead is generated by mining and industrial processes such as the mining of ore and metal processing (McGranahan & Murray, 2003:7). Lead is used as an additive to petrol and can be found in exhaust fumes. Although the use of leaded fuel has been outlawed in many industrialised countries, many developing countries still continue to use lead as an additive in petrol and also in industrial processes such as the manufacture of paint (Fenger, 1999:4881).

3.6 CLASSIFICATION OF AIR POLLUTANTS

Air-pollutants can be classified into various categories, namely, primary, secondary, indoor, outdoor, gaseous and particulate pollutants (Bernstein *et al.,* 2004:1117). **Table 3.1** below provides a summary and description of these pollutants.

Table 3.1: Classification of air-pollutants

Type of pollutant	Description
Primary pollutants	Pollutants emitted directly into the atmosphere e.g. sulphur dioxides, nitrogen oxides and particulate matter.
Secondary pollutants	Pollutants that are generated in the air due to chemical reactions with other pollutants and gases e.g. ozone.
Indoor pollutants	Indoor pollutants can be generated by a variety of sources such as combustion of fossil fuels and biomass for cooking and heating, building materials, smoking etc.
Outdoor pollutants	Pollutants generated by industrial and domestic processes, vehicles, agricultural practices etc. Examples include sulphur dioxides, ozone and particulate matter (PM).
Gaseous pollutants	Pollutants such as sulphur dioxides, nitrogen oxides, benzene etc.
Particulate matter (PM)	Consists of coarse particulate matter $PM_{2.5-10}$ micrograms and, fine particulate matter $PM_{0.1-2.5}$ micrograms.

Source: Bernstein *et al.,* 2004:1117 (adapted)

3.7 NATIONAL AND REGIONAL SOURCES OF AIR POLLUTION

Air-pollution in South Africa is generated by a variety of activities. The sub-section below describes the general activities that generate air pollution on a national level followed by a sub-section that discusses these air pollution generating activities in the context of the Vaal Triangle. Fuggle and Rabie, (1996:417-418) identify the following five activities that generate air pollution in South Africa:

- Fuel combustion and gasification from stationary sources. Processes which fall into this category include the combustion of oil and coal or oil for

electrical power generation, steam generation and industrial energy requirements, coal gasification for the production of metallurgical coke, and domestic coal combustion for space heating.

- Fuel combustion in mobile sources. This category is dominated by the transport sector. Pollutants include unburned fuel and volatile lead species.

- Industrial and chemical processes. Pollutants such as alkali metals and fluorides from the ferro-alloy industries, nitrogen and phosphorus compounds from fertilizer production, and organic vapours from chemical production are classified under this category. The category caters for pollution generated by processes other than gasification or combustion.

- Solid waste disposal. Incineration of industrial, residential and hospital wastes contribute significantly to air-pollution.

- Land surface disturbances. Mining and construction activities and waste dumps are classified under this category (Fuggle & Rabie, 1996:417-418).

The common characteristic in all of the pollutants described above is that they produce carbon dioxide. Carbon dioxide is considered a contributor to climate change (Fuggle & Rabie, 1996:418).

The Vaal Triangle area in which Bophelong is situated is a densely populated region consisting of industrial activities which are dominated by the metal and metal products industry, followed by mining activities (mainly coal mining), agricultural activities and residential areas in close proximity to one another. This situation makes residents in the region (including the residents of Bophelong) to be highly vulnerable to toxic air pollutants. Scorgie *et al.* (2003) describe the sources of air pollution in the Vaal Triangle as being the following:

- Industrial and commercial activities. This type of pollution occurs as a result of non-domestic fuel burning by businesses, hospitals and schools.

- Waste treatment and disposal. This is a result of burning of waste material, landfills and waste water treatment.

- Residential/domestic. This occurs as a result of domestic coal-burning, paraffin lube and gas use, wood-burning etc.

- Transport. Emissions by petrol and diesel powered vehicles.

- Mining. Emissions from industrial combustion, mining dust etc. (Scorgie *et al.,* 2003)

3.8 ENVIRONMENTAL EFFECTS OF AIR POLLUTION

This section discusses the environmental effects of air pollution. Fuggle and Rabie (1996:418) identify several environmental effects of air pollution. These effects are discussed below.

3.8.1 Acidic disposition

Acid disposition refers to a process whereby sulphur and nitrogen compounds are transported to ground through either one of the following three ways (Fuggle & Rabie, 1996:418):

- Dry deposition. Sulphur and nitrogen compounds are deposited directly through an expanded pollution plume;

- Wet deposition. Sulphur and nitrogen compounds are washed out by rain, and

- Occult deposition. This occurs through capturing by impaction on aerosols.

All of these three processes described above lead to the occurrence of acid rain, which is destructive to the environment and has negative impact on human health.

In addition Reis (2005:18-19) describes the impact of acid deposition on the environment as follows:

- Heavy metals such as aluminium travel more easily in acidified soils, causing damage to roots and interfering with the absorption of nutrients such as magnesium and potassium.

- Reduced pH in soil inhibits the germination process and stifles the growth of seedlings.

- Low pH levels can lead to the death of important soil organisms thereby retarding the decomposition process.

- Acid precipitation especially in the form of fog or cloud water (which is more acidic) can lead to direct damage to the foliage on plants (Reis, 2005:18-19).

3.8.2 Visibility reduction

Poor visibility can result from smog which is emitted during the combustion of solid fuels such as coal, and also from the dispersion of light by fly ash particulates and aerosol particles (Fuggle & Rabie, 1996:418-427). The photochemical smog that affected Donora in Pennsylvania (USA) in the 1940s reduced visibility to only 3 city blocks.

3.8.3 Hazardous air pollutants

Air-pollutants such as lead, mercury, arsenic, benzene, furans and dioxins have a negative impact on human health (Fuggle & Rabie, 1996:418-427). The existence of these pollutants in the air can lead to health problems such as eye and respiratory irritations in the short-term and increased risk of cancer in the long term. The pollutants also have the potential of polluting groundwater particularly in areas where petrol filling stations are located (Fenger, 1999:4881).

3.8.4 Stratosphere ozone depletion

The stratospheric ozone layer is being continually depleted by chlorofluorocarbons, halons nitrous oxide, which is released into the atmosphere by a variety of natural and industrial processes. This depletes the

ozone layer leading to increased levels of harmful ultraviolet radiation reaching the earth surface (Fuggle & Rabie, 1996:418). A depleted ozone layer can lead to an increase in the rates of diseases such as skin cancer, eye irritations and other damage to other forms of biological species (Dincer, 1999:163).

3.8.5 Global climate change

Global climate change occurs as a result of the greenhouse effect. The main pollutants contributing to climate change are carbon dioxide, methane, water vapour, nitrous oxide and halons. These gases allow short-wave radiation to come through to the earth's surface but trap outwardly radiated long-waves thus leading to global warming (Fuggle & Rabie, 1996:418-419). According to Dincer (1999:165) the surface temperature of the earth has increased by about 0.6° C over the last century. Increases in surface temperatures can have catastrophic consequences for the human race in that it can lead to the occurrence of natural disasters such as flooding particularly at settlement adjacent to the coast (Dincer, 1999:165).

As indicated in Chapter 1, the largest contribution to air pollution in the area emanates from the domestic sector. According to Friedl *et al.* (2008) pollution by domestic sources accounts for 69 percent of the health impact levels. This situation exists for the following reasons, firstly, the high rate of urbanisation and the rise of informal residential areas lead to backlogs in the provision of services such as electrification of dwellings, waste removal, sanitation etc., secondly, many electrified households continue to use coal due to its cost-effectiveness and variety of needs that it can satisfy e.g. space-heating and cooking.

3.9 AIR POLLUTION AND HEALTH

This section discusses the impact that air pollution can have on human health. The discussion in this section begins by giving a description of the possible impact of outdoor air pollution on health, and proceeds to discuss possible results of this type of pollution. Brunekreef (2008:6662) observed a six-dimensional relationship between ambient particulate matter (PM) and health.

Firstly, short-term exposure and mortality were examined and it was found that although the effects of day-to-day variations in PM were small, they were consistently associated with non-accidental cardiovascular and pulmonary mortality. Secondly, the association between long-term exposure and mortality was observed and it was found that long term exposure to PM does reduce the years of life of an individual. Thirdly, it was found that day-to-day variations in air-pollution are positively related to day-to-day variations in number of mortalities, hospital admissions and number of patients presenting with symptoms. Fourthly, it was shown that exposure to PM does not respect any set thresholds .That is, even at lower levels of exposure, a positive relationship still exists between exposure and mortality. Fifthly, the observations revealed that exposure to PM leads to more than just respiratory diseases. Many of the people who died in the aftermath of the London fog of 1952 died of cardiovascular problems. Lastly, it was shown that excessive exposure can lead to vascular problems which may manifest in the form of cardiovascular disease and eventually death (Brunekreef, 2008:6662).

Environmental concerns before the 1960s were primarily concerned with indoor air-quality. Since the early 1960s, however, there was a move away from indoor air-quality to pollution generated by industries. It was only in the late 1960s and early 1970s that there was a move back to the issues that relate to indoor air quality. Indoor air quality can be affected by various factors. Construction-related factors can have an influence on indoor air-pollution. Dampness in houses is positively related to bad health and may lead to conditions such as coughing, wheezing, allergies and asthma. Damp houses may also lead to irritations and constriction of airways. Poor ventilation is positively related with respiratory conditions such as wheezing and coughing. One of the causes of poor ventilation in houses is the desire to save energy. High energy costs may motivate households to reduce ventilation in their homes as an energy saving measure. Building materials, particularly new building materials emit substances that may be dangerous to human health. The emission from building materials can be divided into two categories namely, primary emissions and secondary emissions. Primary emissions are those that come from the actual building materials whilst secondary emissions

are generated by actions such as moisture and alkali in the building structure. Secondary emissions are also generated by the use of household detergents and aerosols. There have been efforts to solve the primary emission through the development of building materials that generate fewer emissions (Sundell, 2004:51-55).

3.10 FACTORS AFFECTING VULNERABILITY TO AIR POLLUTION

The effects of air-pollution on communities tend to be more intense in developing countries. This is so because developing countries face unfavourable socio-economic conditions in terms of population size and structure, levels of nutrition and exposure to different types of pollutants (Matooane *et al*., 2004:1). This sub-section discusses vulnerability to air-pollution in terms of health factors - which are categorised into respiratory and non-respiratory diseases - and socio-economic factors.

3.10.1 Health factors

Researchers widely agree that exposure to smoke from the combustion of fossil and biomass fuels have an adverse health impact for both children and adults. Excessive exposure can lead to both respiratory as well as non-respiratory diseases as discussed below. According to WHO (2002:9) people suffering from respiratory conditions are more susceptible to the effects of air pollution. Respiration related ailments tend to be more pronounced amongst people of low socio-economic status due to their likelihood of being exposed for extended periods of time particularly during cooking and space heating. Another factor leading to extended exposure is the communities' close proximity to industrial emissions (Matooane *et a*l., 2004:3). Exposure to these emissions can lead to serious diseases such as Childhood Acute Lower Respiratory Infection (ALRI), Chronic Obstructive Pulmonary Disease, and Cancer. The section that follows provides a brief overview of the various diseases that could result from excessive exposure to air pollution (WHO, 2002:9).

3.10.1.1 Childhood Acute Lower Respiratory Infection (ALRI)

Exposure to urban air-pollution and indoor tobacco smoke can lead to acute lower respiratory infections (ALRI) such as pneumonia which is the most important cause of deaths in the world in children under five years. ALRI is responsible for approximately two million deaths annually in children under five years (WHO, 2002:9).

3.10.1.2 Chronic Obstructive Pulmonary Disease (COPD)

COPD is a consequence of excessive exposure to air-pollution such as exposure to coal smoke. This exposure may lead to the development of chronic bronchitis and COPD. In some patents excessive exposure can lead to the over-inflation of air-sacs (emphysema) and right heart failure (cor pulmonale) (WHO, 2002:10).

3.10.1.3 Tuberculosis (TB)

Several studies such as the Indian National Health Survey conducted during 1992-1993 have found that persons living in households using coal and biomass as sources of energy are more at risk of contracting TB compared to persons living in households that use cleaner fuels (WHO, 2002:12).

3.10.1.4 Cancer

Biomass and coal smoke consist of significant amounts of carcinogens which may cause cancer. There is a strong correlation between exposure to coal smoke and the development of lung cancer (WHO, 2002:11).

3.10.1.5 Hypertension

People with high blood pressure (i.e. blood pressure equal to or above 140/mm/HG) tend to be highly vulnerable to the effects of air-pollution. This is likely because their immune system is less likely to effectively eliminate toxins from the body (Matooane *et al*., 2004:3).

3.10.1.6 Diabetes

Diabetes may lead to cardiovascular problems and other related problems such as poor metabolism. People suffering from diabetes are more prone to be affected by even lower levels of exposure to air-pollution (Matooane *et al*., 2004:4).

3.10.1.7 HIV/AIDS

People with HIV/AIDS are more likely to suffer from the effects of air-pollution than those without HIV/AIDS. This is so because HIV/AIDS weakens the immune system thus making sufferers more susceptible to opportunistic infections such as TB (Matooane *et al*. 2004:4). People infected with HIV tend to suffer from mild obstruction of the airways, which can also accelerate the development of COPD (Bruce *et al.,* 2006:847).

3.10.1.8 Genetic factors

Genetic factors may lead to differences in vulnerability to diseases. Certain diseases tend to affect people with a certain genetic disposition than others. In South Africa, for instance, cardiovascular diseases tend to be more prevalent in white communities than in other races (Matooane *et al*., 2004:4).

3.10.1.9 Developmental Stage

Children are more likely to be highly vulnerable to the effects of air-pollution than adults. This is largely due to differences in lung capacity. Children tend to have a bigger lung surface area relative to their body size compared to adults. In addition metabolism and other physiological processes differ from those of adults due to their incomplete physiological development (Matooane *et al*., 2004:5). Furthermore, exposure to biomass and coal smoke can lead to adverse outcomes such as low birth weight and stillbirths (WHO, 2002:10).

3.10.1.10 Blindness

Biomass fuels can lead to the development of cataract which is the main source of blindness in developing countries (WHO, 2002:10). Smoke from

biomass fuels leads to the development of oxidative stress and the reduction of plasma ascorbate, carotenoids and glutathione, which are a source of antioxidant protection against the development of cataract (Bruce *et al*., 2006:847).

3.10.2 Socio-economic factors

Socio-economic factors such as employment status, level of education, access to health facilities and housing have a bearing on a person's vulnerability to pollution. As indicated in the introductory section, there is a positive correlation between poverty as explained by lack of access to the factors described above, and exposure to pollution.

3.10.2.1 Employment status and education levels

Unemployed people are more vulnerable to the effects of air pollution than those that are employed. Unemployment can be associated with stress-related illnesses such as cardiovascular diseases and hypertension (Matooane *et al*., 2004:5).Education also does have an impact on vulnerability to air-pollution. People with low levels of education are more prone to engage in activities that may compromise their good health and well-being. High levels of illiteracy can therefore lead to increase in exposure (Matooane *et al*., 2004:5).

3.10.2.2 Access to health facilities

Access to health-care is positively correlated to income and education. People of lower economic standing tend to struggle to access health-care. These people are more vulnerable to the effects of air pollution as compared to their counterparts of higher social standing (Matooane *et al*., 2004:5).

3.10.2.3 Housing

Access to proper housing has a say in whether people are exposed to air pollution or not. People staying in poorer communities tend to occupy houses that are overcrowded, poorly ventilated and often without electricity. People living in these conditions are compelled to make use of biomass fuels for

cooking and space heating thus increasing their exposure to air pollution (Matooane *et al*., 2004:5).

3.11 AIR POLLUTION AND ENERGY CHOICE

The poor's energy choices are influenced directly and indirectly by various factors such as the oil price, housing, electricity supply and income. The impact of these factors on the poor's energy choices is discussed below.

3.11.1 Oil price

Oil price has a significant influence in the energy choices of the poor. Oil prices have a direct bearing on the price of paraffin and also indirectly influence the price of coal and wood. Persistently high oil prices can therefore lead to an increase in the use of low grade biomass fuels (Friedl *et al.,* 2008:3).

3.11.2 Housing

The thermal comfort of a house has a direct bearing on energy use. Presently government subsidy houses are built without any consideration for thermal comfort thereby structurally entrenching the use of dirty fuels for space heating and cooking (Friedl *et al.,* 2008:3). Energy efficient housing has several benefits in that it improves the thermal comfort of the house throughout the year, secondly it minimises the need for space heating resulting in less emissions and smoke inhalations in cases where fossil fuels are used for space heating. Thirdly, the reduction in the usage of electricity leads to lower fuel bills. Lastly, these types of houses also lead to improved health and safety of household members due to improved indoor air quality (SA, 2005:19-20).

3.11.3 Electricity supply

Unreliable supply of electricity can encourage the use of dirty fuels. If electricity supply is frequently interrupted, people may resort to the use of dirty fuels as a form of back-up. In such situations power-cuts will be positively correlated with air-pollution. In the event of a more severe electricity supply

crisis, biomass fuels can become the energy of choice for the poor. Expensive electricity on the other hand can also inevitably lead to increased usage of bio-fuels. It is therefore, advisable to consider subsidised electricity supply for the poor (Friedl *et al.,* 2008:3).

3.11.4 Income

There is a negative correlation between income and the use of dirty fuels. Increase in income generally lead to a decrease in the use of dirty fuels (Friedl *et al.,* 2008:3). This is in line with the environmental Kuznets curve hypothesis which suggests a positive relationship between income and environmental degradation. This means that a rise in income will lead to a decline in the levels of environmental degradation, including air pollution.

3.12 THEORY OF SOCIAL COST

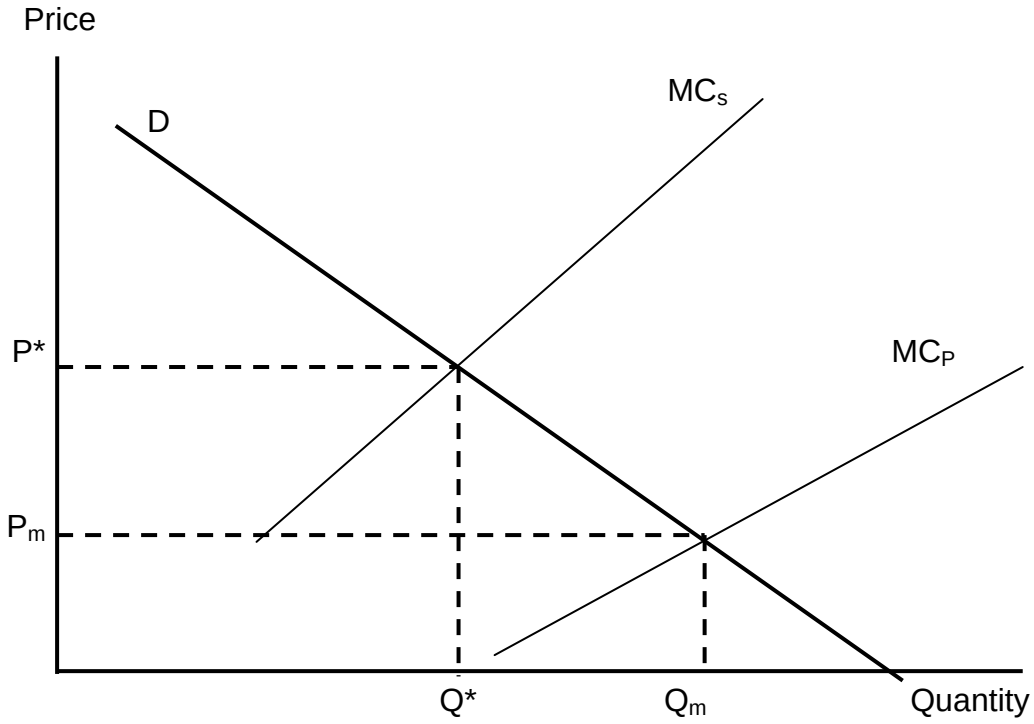
This section begins by describing the effects of externalities on production and then describes the different types of costs that are of importance to environmental economists as described by Field and Field (2009:163-165). The section concludes by discussing the social-cost theory as based on the two dominant schools of thought in this field, namely, the Pigouvian approach and the Coasian approach.

3.13 THE EFFECTS OF EXTERNAL COSTS ON PRODUCTION

An economy is regarded as efficient if it produces goods and services at the lowest possible cost. The existence of factors such as the impact of production activities on the environment will tend to alter this condition. It is important that factors relating to environmental degradation, which are regarded as a negative externality, be taken into account when addressing the issue of economic efficiency. **Figure 3.2** below illustrates the effects of externalities on production. In the hypothetical example below the producer manufactures steel. In the process of producing steel, the firm also generates pollution, but the pollution is not internalised into its cost structure. The demand for steel is indicated by the downward sloping curve D, the firm's private cost is indicated by $MC_{p,}$ but as stated above, the firm considers

pollution to be external to its costs. Society does consider both costs. The marginal social cost is represented by $MC_{s.}$ In the absence of control, steel production would be at Q_m, but this level of production is not economically efficient as it does not take into account the marginal social cost. The efficient level of output for society is at Q^* and not Q_m. The following can therefore be deduced from the above analysis, that is, if markets are left entirely on their own to allocate resources excessive levels of output will be produced at lower prices since the externality is not taken into account. From the above discussion it can be concluded therefore that government intervention is justified in order to bring the economy back to efficiency (Storfner, 2004:2-3).

Figure 3.2 The effects of external costs on production



Source: Storfner, 2004:2

3.14 CONCEPTS RELATED TO EXTERNALITIES

There are certain cost concepts which need to be considered when the issue of externalities is being addressed. The cost concepts discussed in this sub-section are, opportunity costs, private costs, social costs, environmental costs and enforcement costs. These are discussed in detail below:

- Opportunity cost of externalities - The most fundamental cost concept used by economists is opportunity cost. Opportunity cost refers to the best forgone alternative that is, the alternative that could have been chosen but was not. Resources used in one area for instance, air-pollution control legislation cannot be simultaneously used in other areas as well (Field & Field, 2009:163).

- Private costs and social costs - Private costs are described as costs that are incurred by individuals making the decision leading to a particular cost-bearing action, whereas social costs are those incurred by society as a whole irrespective of who made the decision leading to the action. For instance, the cost of running a vehicle such as fuel, oil and maintenance are borne by the operator whilst the congestion and the pollution emanating from the operation of the vehicle are borne by society. Private costs are included when undertaking financial analysis of a project and will therefore be reflected in financial statements. Social cost on the other hand forms part of a much broader economic analysis and is not shown in financial statements. Social cost is therefore expected to be much higher than private cost as it includes both private costs and external costs. External costs are costs such as pollution which are inflicted on third parties (Field & Field, 2009:164).

- Environmental costs - Pollution abatement programmes incur costs related to what Field and Field (2009:164) refer to as media switches. Emission abatement strategies are based on reducing emissions into a specific environmental medium such as water or air. Reduction of emissions from one medium may result in an increase into another medium.

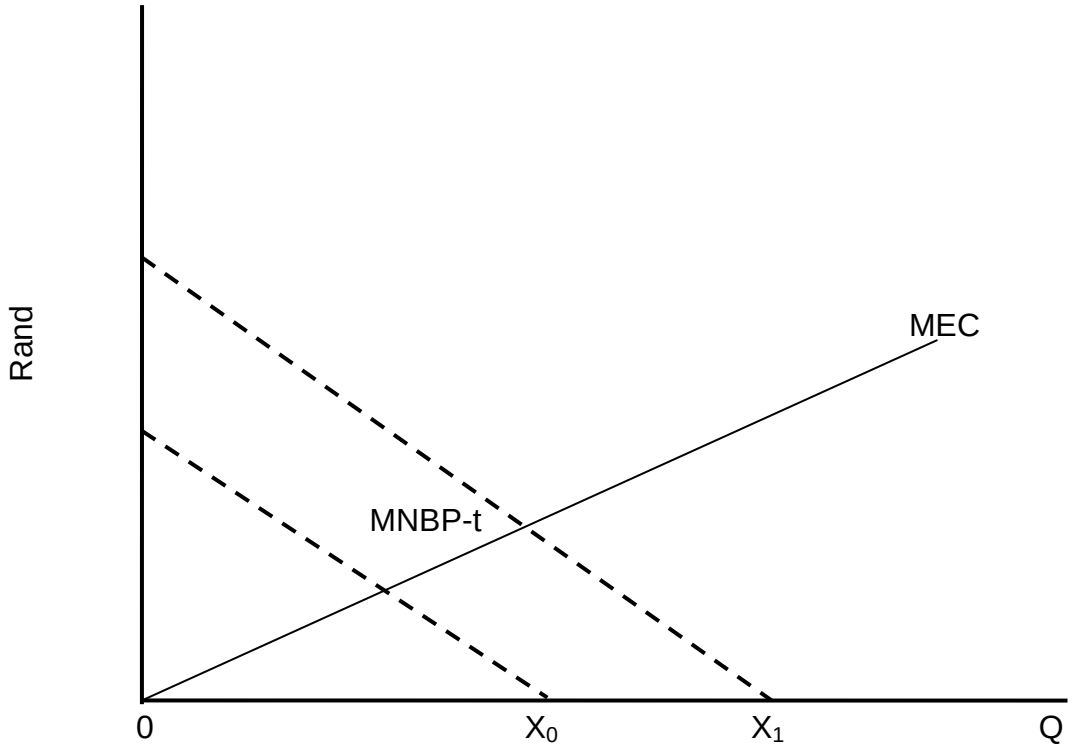
- Enforcement costs - Enforcing pollution control legislation requires resources. These resources will have to be sourced from somewhere. When new enforcement legislation is passed, agencies that are tasked with enforcement may find themselves being forced to switch funds from other areas of enforcement in order to accommodate the enforcement of the new laws. Thus the opportunity cost of the new enforcement will be in

the form of lower levels of enforcement and consequently compliance in those areas whose budgets were cut (Field & Field, 2009:165).

3.15 THE PIGOUVIAN APPROACH TO THE EXTERNALITY PROBLEM

The Pigouvian approach favours government intervention to rectify the distortions between private costs and marginal social costs. These distortions prevail as a result of market failure. Market failure is described as a situation where markets fail to clear, that is, markets fail to allocate resources efficiently. Markets can fail for a variety of reasons. Firstly, in instances where a firm has too much market power as in the case of a monopoly, market failure may result thereby necessitating government intervention. A monopolist would produce at the level of output where marginal revenue equal marginal cost and sell at higher price than would be the case had a competitive market existed. Secondly, information asymmetries about prices and product quality can also lead to inefficiencies. Thirdly, because public goods are non-exclusive and non-rival in nature, there is often an undersupply of public goods in a market economy. Government will therefore be expected to intervene through the provision of these goods or creating incentives for the private sector to produce such goods. Lastly, government intervention is warranted in cases where externalities exist. Externalities arise when an economic activity has an indirect effect on third parties. These externalities are usually not reflected in the market price (Pindyck & Rubenfeld, 2009:612-613).

Figure 3.3: Pigovian tax



Source: Storfner, 2004:5

According to the Pigouvian approach, externalities may be resolved through the implementation of taxes, regulations, standards and subsidies. In the case of market failure, that is, a situation where a divergence between marginal social costs and marginal private costs exist, a tax referred to as the Pigouvian tax must be levied on the user which is equal to the difference between marginal social costs and marginal private costs. Implementation of such a tax means priority is being accorded to the affected party who will now be protected from external cost (Dragun, 1985:113).

In **Figure 3.3** above, the Pigouvian tax is represented by t, the effect of this tax is to shift the marginal net private benefit (MNPB) to the left, thus reducing the marginal benefit of the firm from X_1 to X_0, X_1 is the competitive output whilst X_0 represents the socially efficient level of output (Storfner, 2004:5). Economists tend to be more in favour of Pigouvian taxes as they tend to be more reflective of free-market situations, for instance, a user must be charged for the use of a good such as water or air. In this way the user realises that there is a cost attached to the use of the good and will therefore be expected

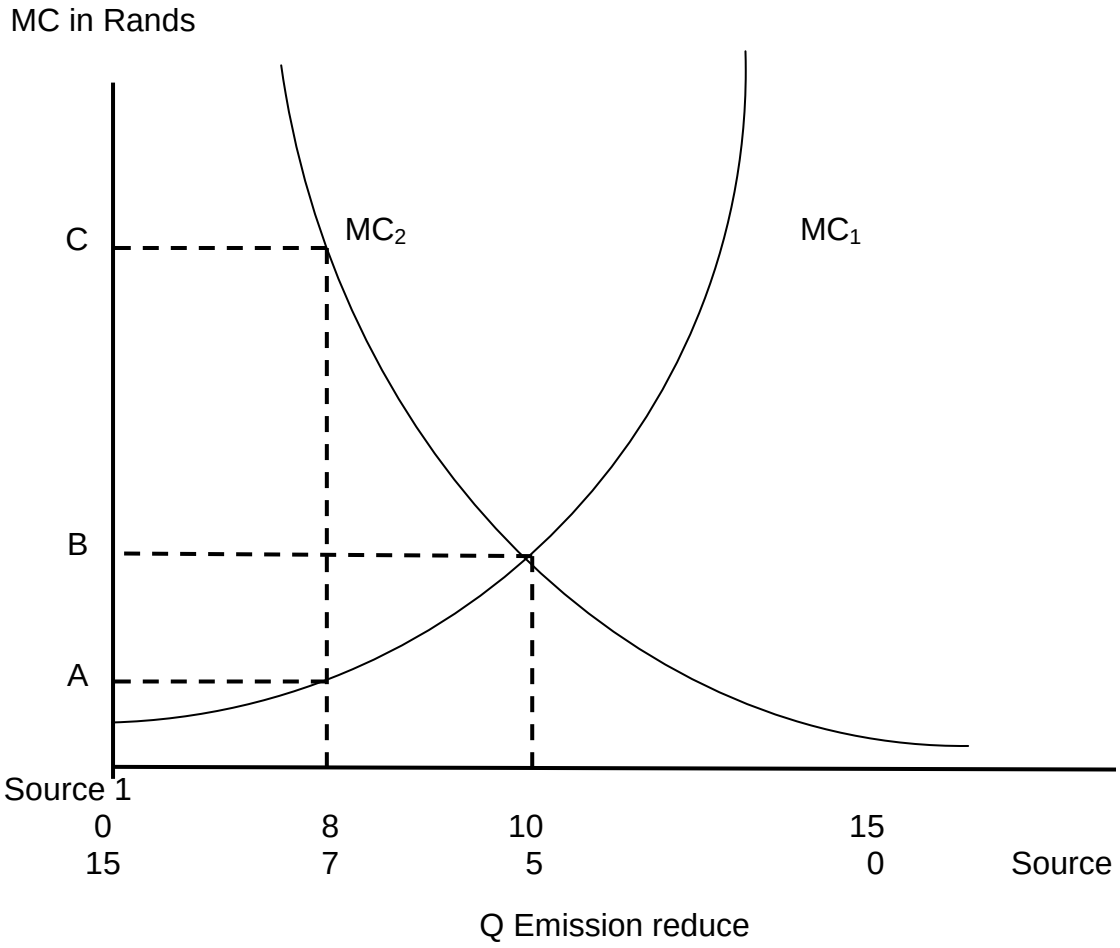
to economise (Black *et al.,* 2006:40-42). Government can also intervene through regulations such as setting emission standards and quotas to reduce the negative impact of production activities on the environment. Emission standards set the limit on how much emissions firms can generate. Any firm generating emissions in excess of the set standard can face financial or even criminal sanctions (Pindyck & Rubenfeld, 2009:653). Regulation however, has disadvantages in that it assumes that the government has sufficient information to enable it to determine the socially optimal level of production. In addition, regulation requires that each firm reduce its output by equal amounts or proportion. This requirement may violate the efficiency condition. This means that firms will not necessarily produce the level of output where marginal social cost equal the marginal social benefit. Costs and benefits vary within firms in the same industry and a blanket approach will therefore lead to inefficient utilisation of resources (Black *et al.,* 2006:40-42).

The government can also intervene through the issuing of tradable permits. Such permits can be auctioned in a market giving the highest bidders the right to pollute. Producers that cannot afford such permits may have to reduce their output or switch to cleaner technologies (Black *et al.,* 2006:40-42). Although this system is market-based, it can still be regarded as Pigouvian, as it is the government that issues the exact number of permits required to generate the desired level of emissions. **Figure 3.4** below illustrates how the tradeable permit system operates. Assume that pollution source 1 has 7 tradeable permits; this means that the source has to abate 8 units of emission since it has 15 units of emissions that it can generate if there is no control. This leaves pollution source 2 with 8 tradeable permits, meaning that it has to abate 7 units of emissions.

In **Figure 3.4** below, the marginal abatement cost for pollution source 2 (represented by letter C on the graph) is higher than that of pollution source 1 (represented by letter A). There is therefore an incentive to trade for both parties. Pollution source 2 can benefit from trade through the purchase of permits from pollution source 1 at a price lower than C. Whilst pollution source 1 can benefit from trade by selling permits at a price higher than A. The two

sources will continue to trade until the price is at B, which represent the marginal value of the traded permit for both parties (Storfner, 2004:9).

Figure 3.4: Tradeable permits

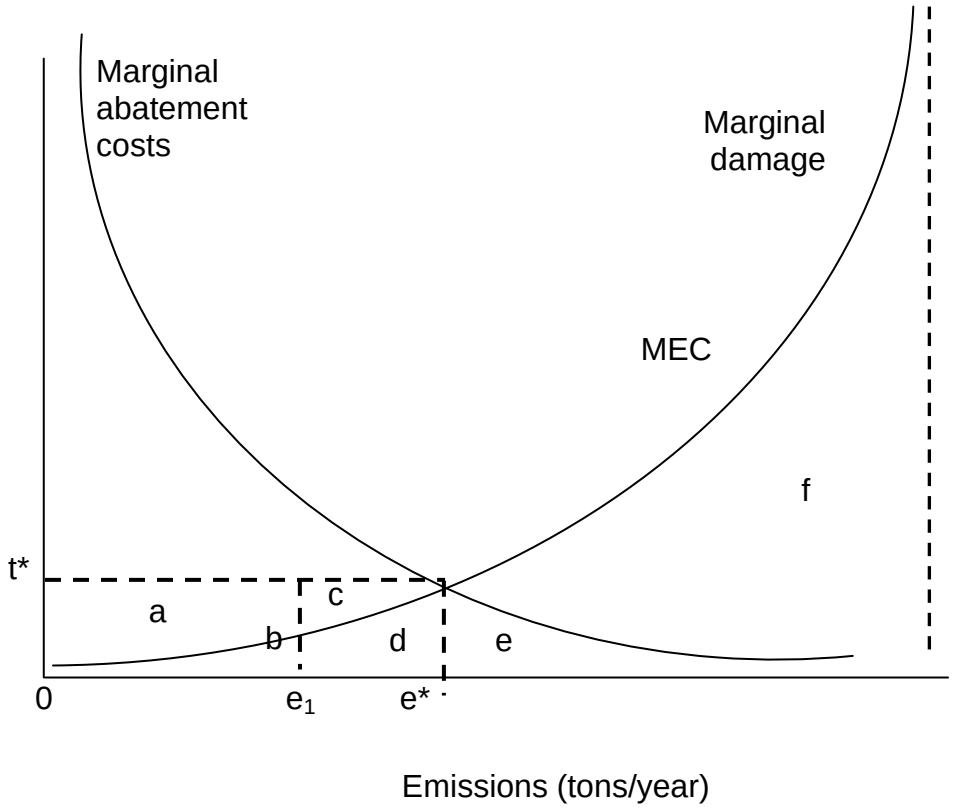


Source: Storfner, 2004:5

Emission fees are levied on each unit of a firm's emission. These fees encourage firms to produce in an efficient manner (Pindyck & Rubenfeld, 2009:653). **Figure 3.5** below, shows that a tax rate equal to t* is being levied. At this rate of taxation, emission are equal to e*, and the marginal damage equal the marginal abatement costs. Abatement costs and tax payments are represented by the rectangle abcd. Reducing emission from e0 to e* will reduce damages equal e + f. The remainder of the damages, that is, b + d are below what the firms pay in the form of taxes. Other than being a source of revenue for the government these taxes are also beneficial in that they help to

stimulate innovation on the part of producers and motivate them to move towards cleaner technologies (Storfner, 2004:9).

Figure 3.5: Emission taxes



Source: Storfner, 2004:9

3.15.1 Criticism of the Pigouvian approach

The Pigouvian approach has been criticised on various grounds. Firstly, the difficulty associated with the measurement of non-market goods make it difficult to precisely determine the optimal level of any corrective adjustment. There are a variety of direct and non-direct methods of valuing non-market goods. These methods were discussed in section 3.7 and 3.8 of this chapter. As was noted in the discussion on valuation techniques, it is often difficult to get honest valuations of non-market goods as respondents have an incentive more emphasis on the efficiency of outcomes at the expense of efficiency of processes. Process efficiencies however, are also important in determining socially efficient results, for instance, a policy aimed at reducing the levels of air-pollution, to a level that is considered optimal in terms of in terms of

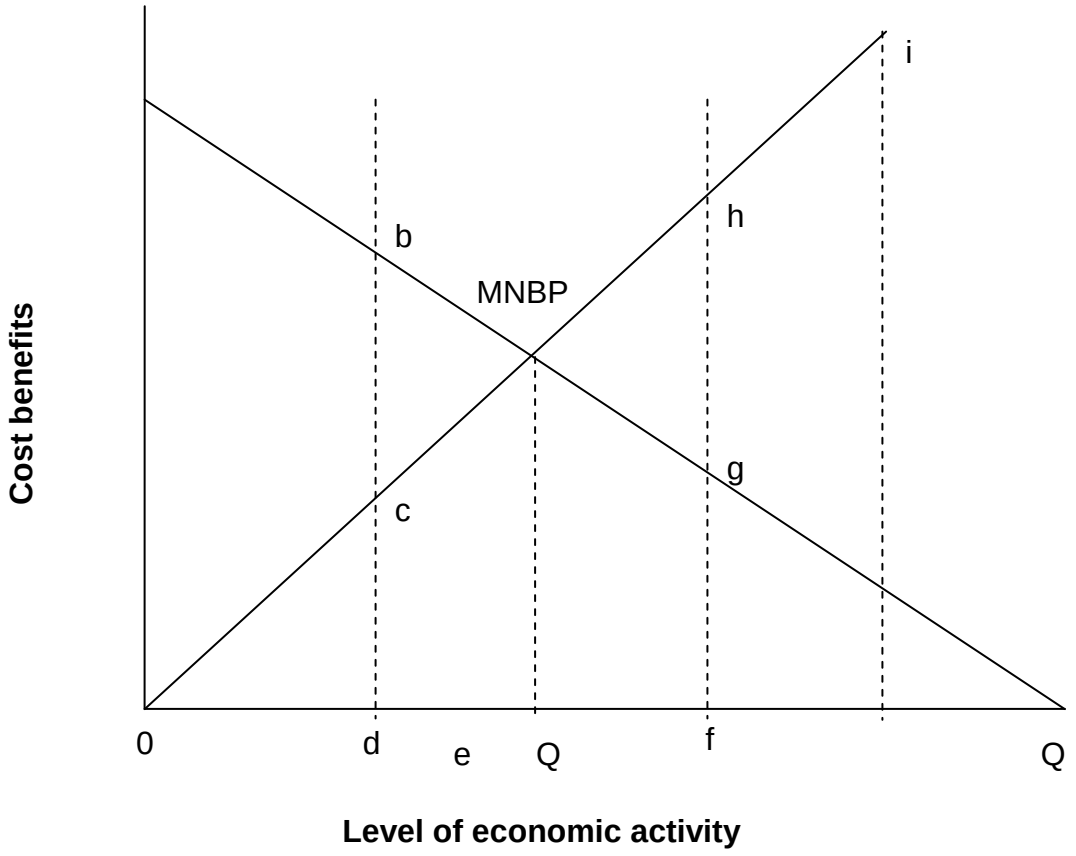
marginal cost and marginal benefit analysis might produce inefficient results due to costs inherent in the policy process. Such costs would include, among others, administrative costs, political costs especially in cases where the policy is unpopular, and compliance costs. The policy will be rendered inefficient if compliance costs exceed the cost of abatement. The Pigouvian approach is criticised for ignoring the type of costs described above. Thirdly, the Pigouvian approach assumes zero transaction costs. In the real-world transaction costs always exist and ignoring such cost will lead to inefficiencies. Fourthly, the Pigouvian approach assumes static property rights which are assumed to represent societal preferences. Different groups in society can have different preferences with regard to policies aimed at solving externality problems. Lastly, the Pigouvian approach tends to ignore the fact that government in addition to maximising efficiency also seek to maximise welfare (Webster, 1998:63-66).

3.16 THE COASIAN APPROACH TO THE EXTERNALITY PROBLEM

The Coasian approach favours the application of the market system to decide the efficient allocation of resources. According to this approach, government should only intervene where bargaining between two parties does not yield the desired outcome. In cases where the legal specifications pertaining to ownership are clearly defined, negotiations will yield the desired results. Efficient allocation can be achieved provided the following conditions are met; firstly, the affected party must be willing to pay more than the polluter's net gain from damaging the environment; secondly, the affected party will be willing to pay as long as the compensation is less than the cost incurred from pollution and lastly, the polluter will be more considerate as long as the compensation he/she receives is greater than the net loss from reducing production (Nas, 1996:40). According to the Coase theorem, well defined property rights will lead to an amicable resolution of disputes especially when transaction costs are negligible, as the presence of transaction costs tends to complicate the negotiations process. Another important aspect to be considered is preference revelation. Preference revelation may lead to the free-rider problem. Some people may be reluctant to partake in litigation

processes against polluters but will still benefit from the outcome if judgement is in their favour (Nas, 1996:40).

Figure 3.6: The Coase theorem



Source: Storfner, 2004:3

Figure 3.6 above; illustrate what has been described in the preceding paragraph (the Coase theorem). The optimum level of output is at Q*. If property rights are assigned to the victim, that is, the victim has the right not to be polluted; the polluter will have to negotiate with the victim for him to be able to generate some pollution. If the bargaining process results in a movement from a to d, the polluter will gain area 0abd, and the sufferer will gain area 0cd. As area 0abd is greater than area 0cd this constitutes an incentive for bargaining. According to the Coasian theorem there is therefore, no need for government intervention as the market system is inherently able to correct for externalities (Storfner, 2004:8).

3.16.1 Criticisms of the Coase theorem

The Coase theorem has over the years been subject to several criticisms. Firstly, the theorem is criticised on the grounds that it presupposes the existence of economic rents which in some instances may not exist. In the absence of rents Coase theorem will not hold under long-run perfectly competitive markets. If the polluter is not earning rents and the liability for pollution is assigned to him / her, the polluter will be forced to exit the market since he / she does not possess resources to compensate the victim. On the other hand, if liability is assigned to the victim, the victim will also be forced to exit the market as he / she also does not have resources to induce the polluter to cease operations.

The situation described above yields an efficient outcome even without bargaining as proposed by the Coase theorem. The polluter in this instance was able to continue operating inefficiently and inflicting damages on the victim because he / she did not have to incur the full social cost of his / her actions (Medema & Zerbe Jr., 1999:840-841). Secondly, due to long-run entry effects, if polluters are the ones deemed liable for damage, the flow of income to the victim will encourage entry in the victim market thus leading to a more than optimal output in the victim market. The opposite will hold in the case where liability is assigned to the victim. The payment flow from the victim market to the polluter market will lead to higher levels of output in the polluter market relative to what is considered optimal (Medema & Zerbe Jr., 1999:840-841). Lastly, income, tastes and preference effects need to be taken into account.

If one or both parties to the externality happen to be consumers then the Coase theorem will not hold. In this instance one will be obliged to consider effects on demands that accompany alternative allocation of rights. Consumer tastes and preferences differ; therefore a change in the income of consumers may lead to a change in the pattern of demand and in the manner in which resources are allocated. These changed patterns may not necessarily result in an efficient allocation of resources (Medema & Zerbe Jr., 1999:846-847). Almost all criticisms against the Coase theorem can be invalidated by simply

invoking the zero transaction cost assumption. The assumption is, however, unrealistic as in real life transaction costs are always positive (Medema & Zerbe Jr., 1999:855-856).

Hahnel and Sheeran (2009:219) present a not so conventional critique of the Coase theorem. Their criticism is more internal to the Coase theorem as it does not reject the premise of the theorem but instead reveals that even without rejecting the assumptions of the Coase theorem, the theorem still fails to achieve efficient outcomes. These criticisms are different from the traditional criticisms of the theorem described above. The starting point of the traditional criticisms is to reject the assumptions. Hahnel and Sheeran (2009:219) on the other hand, place more emphasis on perverse incentives that may arise even under Coase-friendly conditions.

According to Hahnel and Sheeran (2009:219) the Coasian bargaining process does not constitute a market process as claimed by proponents of the theorem but can be regarded as being merely a bilateral negotiation between two parties. Market conditions have particular characteristics which are not inherent in Coase's theorem. For instance in perfectly competitive settings there are many buyers and sellers and firms are price-takers. Coasian negotiations can essentially be considered as a non-cooperative game strategy. Under this strategy parties have complete information about each other and can bargain towards an efficient outcome. As soon as the complete information assumption is relaxed, negotiators cannot be expected to reach an efficient outcome even if both parties behaved rationally. Parties with private information, that is, parties with an information advantage are more likely to act deceitfully in order to maximise their benefits. The Coase theorem considers multiple victims as constituting transaction costs. According to Hahnel and Sheeran (2009:229), this is not the case as multiple victims are part of perverse incentives. Irrespective of whether parties negotiate severally or collectively the Coase theorem will not yield efficient outcomes. In the case of separate bargaining and where the property right is assigned to the polluter, the victim will have an incentive to opportunistically deny his damage with the hope of exploiting free-rider benefits. In cases where property rights are

assigned to the victim, each victim will have the incentive to deceitfully overstate their damage and hold out for as long as possible in order to receive the maximum benefit.

Collective bargaining is also not different as it also will not yield any efficient outcome. The main problem in collective bargaining is that the victim status of individuals cannot be objectively verified. If the polluter has the property right, some victims will not reveal their victim status with the hope that others will join the collective bargaining process and contribute towards abatement. On the contrary, it the property right is assigned to the victim, everyone will be tempted to claim the victim status in order to benefit from the compensation that the polluter will pay. Another related problem lies in objectively verifying the extent to which victims are affected. People who are more affected will tend to understate the damage if they are expected to pay for abatement. On the other hand, if compensation is flowing in the direction of victims, even those who are not so badly affected will have the incentive to overstate their damage (Hahnel & Sheeran, 2009:229-231).

3.17 SUMMARY AND CONCLUSION

The first part of this chapter discussed pollution. Pollution refers to the ambient quality of the environment (Stephen, Stephen & Stuart, 2002:131-136). The introduction of any substance into the environment that leads to the deterioration in the ambient quality of the environment is deemed as pollution. Although there are many forms of pollution, this chapter concentrated only on air pollution as it is the main focus of this study. The chapter discussed various aspects of air-pollution such as the types and sources of air-pollution and the effects of air pollution on the environment and human health. The effects of air pollution on human health are exacerbated when the victims happen to people of poor socio-economic standing. Air pollution was also discussed in a national and regional context. The region-specific context discussed the sources of air-pollution with specific reference to the Vaal Triangle area in which Bophelong is located. The chapter concluded by showing the relationship between poverty and energy choice. The poor are more likely to use dirty fuel as they usually cannot afford cleaner fuels such as

paraffin, gas and electricity. The main objective of this study is to measure the social cost of air-pollution in Bophelong. It is therefore important to look at the various theories of social cost. The second part of the chapter dealt with the issue of social cost in terms of explaining the concept of externalities that lead to the problem of social cost. A distinction was made between private and social costs as well as other costs related to environmental issues such as opportunity costs, environmental costs and enforcement costs. It was shown that due to market failure, there are instances where government will be justified to intervene in the economy to correct externalities.

The social cost problem was discussed on the background of the two schools of thought that dominate the literature in welfare economics, namely, the Pigouvian approach and the Coasian approach. The Pigouvian approach mainly favours direct government intervention such as the levying of taxes and issuing of tradeable permits whereas the Coasian approach advocates for more market-based interventions such as bargaining. The Pigouvian approach argues that it is only the government that can address market failure and the government should therefore be given the right to deal with externalities. The government is considered to be the only agent capable of producing efficient levels of output in so far as non-market goods are concerned.

The Coasian approach on the other hand, argues that, in the presence of well-defined property rights, bargaining would produce socially optimal outcomes. This means that the bargaining process serve to internalise the externalities into the price mechanism. Given the assumptions of the Coasin theorem, namely, perfect information, zero transaction costs and welfare maximising behaviour, bargaining will produce socially efficient levels of output. However, assumptions of the Coasian theorem do not seem to hold in practice and therefore necessitate the need for government intervention.

CHAPTER 4

AIR-POLLUTION ABATEMENT STRATEGIES, RENEWABLE ENERGY AND SUSTAINABLE DEVELOPMENT

4.1 INTRODUCTION

One of the major factors that contribute to pollution in Bophelong is the continued combustion of bio-fuels, particularly coal. Despite the fact that almost 100 percent of the households have electricity in their houses, many residents still continue to use coal due to its affordability and multiple uses. Electricity on the other hand is considered more expensive and the situation is likely to continue for a long time in the future. Approximately 3 percent of coal used in the country is consumed by households and this combustion is responsible for approximately 20 percent of national particulate emissions (Wagner *et al.,* 2005:2*).*

This chapter begins by providing a historical background of air-pollution abatement strategies that were tried in South African Townships since the 1960s but were largely unsuccessful. The chapter proceeds by discussing the more recent air-pollution abatement strategies that are currently being implemented in South African Townships. The more recent air-pollution control strategies are the top-down ignition method referred to as Basa-njengo-Magogo, electrification, and construction of thermally comfortable housing. The next part of the chapter deals with the positive and negative effects of intervention strategies.

Biomass fuels are finite by nature and if not upgraded many of them can be categorised as dirty fuels. There is therefore, a need to explore other sources of energy which are renewable in nature, more efficient and cleaner. Renewable energies are discussed in terms of sources of renewable energy, the importance of renewable energy sources and factors that can hinder renewable energy development. The concept of renewable energy is closely linked to the concept of sustainable development. It is on this basis that sustainable development forms an important component of the chapter.

Elements of sustainable development such as policies that developing countries can use to improve the living conditions of the poor as well as the various factors that may influence such are also discussed in this chapter.

4.2 HISTORICAL OVERVIEW OF AIR POLLUTION ABATEMENT STRATEGIES IN SOUTH AFRICAN TOWNSHIPS

Several attempts were made from as far back as the 1960s to combat air-pollution in South African Townships. The problem with the majority of these efforts is that they tended to follow a prescriptive top-down approach which did not allow end-users to participate in the design of the technology and therefore make the part or the problem-solving process (Van Niekerk, 2006:58). This section provides an overview of these technology transfer efforts which were on the whole unsuccessful:

- Devolatilised coal - This method was tried as far back as the 1960s. Not much is known about what eventually happened to this effort and it can therefore be concluded that it was unsuccessful source;

- Low-smoke fuel stoves - In the 1970s low-smoke fuel stoves were prescribed in terms of the Air Pollution Prevention Act of 1973. According to this Act new stoves had to meet certain requirements with regard to durability and performance. Although stove manufacturers produced stoves that complied with this legislation the initiative was to a large extent unsuccessful source;

- Electrification - South Africa's Electricity Utility Company, Eskom, announced the National Electrification Drive (NED) in 1991. The aim of this initiative was to electrify 3 million homes within a period of five years. Despite these electrification efforts, many households still continue to use coal due to its multiplicity of uses and affordability. Electricity does not seem to satisfy all the needs of households such as space-heating. Secondly, if not sufficiently subsidised, electricity can become unaffordable to low-income households, and

- Low-smoke fuels - In the 1990s, the government through the then Department of Energy and Mineral Affairs commissioned an investigation into the feasibility of low-smoke fuels. The investigation found that no single fuel type contained all the attributes to serve as a viable alternative to coal within South African Townships. These attributes would include factors such as low emissions, positive health impacts, technical efficiency, social acceptability and economic viability (Van Niekerk, 2006:58).

4.3 AIR POLLUTION CONTROL STRATEGIES

This section discusses pollution abatement strategies that have been adopted by the South African government since 1994. These intervention strategies are mainly intended for low income settlements in South Africa; these are areas that tend to be more vulnerable to air-pollution due to the high usage of biomass fuels. The strategies discussed are the top-down combustion method known as Basa-njengo-Magogo, electrification and, construction of energy efficient housing

4.3.1 Basa- njengo- Magogo (BnM)

Basa-njengo-Magogo is an adapted Scottish coal ignition method whereby coal is lit from top-down instead of the conventional bottom-up approach. This method generates fewer emissions as smoke rises through the hot area and is thus burnt. The Basa-njengo-Magogo method has been scientifically proven to reduce particulate emission by 80 percent (Bekker *et al*., 2008:3125). In June 2008 an outreach campaign referred to as the “clean fires campaign” was launched by the Department of Environmental Affairs in the Sedibeng District Municipality. The main aim of the campaign was to introduce the Basa-njengo-Magogo method to the residents of the Vaal Triangle’s low income settlements such as Bophelong where there is significant utilisation of coal for cooking and heating purposes, particularly during the winter months. During the launch hundreds of community members were trained with the intention of letting them go and further train other community members (DEAT, 2005). Reductions in PM concentration lead to benefits of reduced health costs for residents. Furthermore, this method saves coal as the fire

burns for up to two hours longer than when the conventional method is used. **Figure 4.1** below illustrates the two methods of igniting fire. The brazier on the left was ignited using the BnM method whilst the one on the right hand side made use of the conventional method (Wagner *et al*., 2005:13).

Figure 4.1: Basa-njengo-Magogo

Source: Wagner *et al*., 2005:13

4.3.2 Electrification

Free basic electricity is offered to residents of low-income settlements to encourage households to switch from biomass to electricity (Bekker *et al*., 2008:3126). The main advantage of electrification lies in its contribution towards the reduction of health impacts (Bond, 1999:51). Bond (1999:54) also notes that allowing perpetual inequalities in society in terms of infrastructure development between the rich and the poor will also impact negatively on the wealthier members of society as many of the health conditions associated with air pollution tend to be contagious in nature. There is therefore a need for an increase in the provision of subsidised electricity within budget limits for poor areas. Availability of electricity will not be beneficial to low income

consumers if the price is not low enough to constitute a substitution effect (Bond, 1999:51).

4.3.3 Energy-efficient houses

Although the current Reconstruction and Development Programme (RDP) housing units are energy inefficient, there is recognition by the government that all newly constructed houses should take thermal comfort into consideration (Friedl *et al*., (2008). Energy efficient houses would be built making use of building materials such as ceilings and ceiling insulators, in addition houses should also be properly oriented. If this is taken into account during the building stages, then the use of dirty fuels such as coal would be eliminated. This will also have health impact due to a reduction of indoor exposure and ambient pollution (Friedl *et al.,* 2008).

4.4 INTERVENTION STRATEGIES IMPACTS

The World Health Organisation (WHO) identifies several impacts associated with energy intervention strategies. These impacts can either be positive or negative. This section starts by discussing the positive impacts of switching to cleaner fuels and then continues to discuss the negative impacts of energy switching. Moving to cleaner fuels can have positive impacts for a household in the form of reduced exposure to indoor air-pollution, reduced number of accidents from open fires and also in the reduction of hazards associated with fuel collection. Health expenditure will also fall as households move up the energy ladder which will also lead to an improvement on productivity.

Utilisation of efficient fuels can also result in non-health related impacts such as savings on time spent to collect fuel and reduction in cooking time. It also improves productivity and potential to earn extra income as members of the household can do some work even in the evenings. Efficient fuel usage can also reduce overall expenditure on fuels. The environment can also benefit through reduction in damage such as deforestation and reductions in greenhouse gas emissions, however, cleaner energies can have negative impacts as well. Some cleaner fuels such as kerosene are associated with the risk of poisoning through ingestion, especially by children, burns as well as

explosions. The running and maintenance of equipment associated with cleaner fuels may lead to households experiencing recurrent costs which could end up increasing their fuel bill. In addition cleaner fuels may lead to changed patterns of land use such as the substitution of food crops by fuel crops which may lead to food shortages (WHO, 2006:37).

When implementing intervention strategies, it is also imperative that the various stakeholders reach consensus with regard to requirements that a product should adhere to. The requirements are described below (Van Niekerk, 2006:61):

- Functional - This refers to proper functioning and ease of use of the product i.e. the product must be user-friendly.

- Affordability - Users must be able and willing to pay for the product either by themselves or some agent such as government or business must be prepared to pay on their behalf.

- Beneficial - The product must provide net benefits to society and not merely divert the problem to other areas or communities.

- Cost-effective - This refers to the ability of a solution to achieve the goal of the project in this case reduction in air-pollution.

- Desirable - The product must be socially acceptable. End-users must be able to implement the solution without much coercion.

- Sustainable - The solution must be socially, financially and ecologically sustainable (Van Niekerk, 2006:61):

4.5 THE NEED FOR RENEWABLE ENERGY

South Africa is heavily reliant on coal-based energy. However, the burning of coal is related to carbon dioxide emissions which are considered responsible for climate change with accompanying problems such as extreme storms and drought conditions. Furthermore, non-renewable energy sources are finite in nature, and as they diminish they become more expensive to extract leading

to increased prices for both industry and households. High price may in turn lead to undesirable economic and social circumstances. Combustion of fossil fuels for domestic and industrial purposes also leads to pollution which has adverse impact on health and vegetation (Stutz & Warf, 2007:131).

4.6 SOURCES OF RENEWABLE ENERGY

Knowledge and utilisation of renewable sources of energy is imperative if successful pollution abatement and sustainable development are to be achieved. The paragraphs below discuss various sources of renewable energy that can be used to help in the reduction of pollution and attainment of sustainable development:

- Solar energy - Solar energy is inexhaustible and pollution free. This form of energy is produced by converting sunlight into energy through the use of photovoltaic equipment. This energy can then be used for a variety of tasks including water heating and solar cooking. Solar energy can therefore be used to assist in the reduction of fossil fuel combustion and thereby lead to reduced pollution. However, this type of energy is still expensive to produce (Banks & Schaffer, 2005:14).

- Wind energy - Wind energy is produced through turning the kinetic energy of wind into electricity. This electricity can then be used to supply power to electrical networks. This type of energy is presently still very expensive to produce and consequently struggles to compete with conventional forms of energy (Banks & Schaffer, 2005:21).

- Hydropower - Similar to other forms of renewable energy, hydropower is also inexhaustible. Hydropower is produced through transforming energy from rivers into electricity. Its disadvantage however is that it alters the natural landscape. In addition, the building of dams and reservoirs may lead to the occurrence of waterborne diseases, e.g. stationery water in dams may lead to the development of diseases such as schistosomiasis (Stutz & Warf, 2007:134).

- Nuclear energy - Another alternative energy source that can be considered is nuclear power. This form of energy is much cleaner than fossil fuels. Production of nuclear power, however, has disadvantages, such as radiation, radioactive waste disposal, and fear of terrorism. In addition it is also highly costly to install nuclear power stations (Stutz & Warf, 2007:131).

- Geothermal power - Geothermal power holds potential as a future source of renewable energy especially for those countries that are endowed with underground supplies of hot water that can be tapped (Stutz & Warf, 2007:135). This form of energy can be obtained from dry steam, hot water springs and ambient ground heat (Bull, 2001:1220). Too small to be a sub-section,

- Biomass - Biomass energy can be used directly (i.e. through combustion) for a variety of applications such as heating and cooking. It can also be converted in cleaner fuels such as ethanol and methanol. Methanol and ethanol can be used in other more unconventional activities such as transportation. In terms of emissions biomass energy is considered to be carbon dioxide neutral. Biomass energy does have its own limitations in the sense that, using vast tracts of land for energy crops may inevitably compete with land meant for food crops thereby leading to food shortages. Secondly, biomass can be depleted if consumed faster than is being replenished, however if properly managed biomass is renewable (Banks & Schaffer, 2005:27).

4.7 IMPORTANCE OF RENEWABLE ENERGY SOURCES

Dincer (1999:1167) describes renewable energy technologies as technologies that produce marketable energy by converting natural phenomenon into useful energy forms. Renewable energy sources contribute less to environmental degradation than other forms of energy to an extent that they are considered to be even better than having stricter legislation such as emission quotas on conventional sources of energy. Secondly, renewable resources are not exhaustible; therefore they are sustainable for an indefinite period of time

whereas fossil fuels are exhaustible over time (Dincer, 1999:172). Lastly, renewable resources are flexible and do not necessarily depend on the national grid and can thus also be used in remote settlements (Dincer, 1999:172). For society to realise the full benefits offered by renewable energy, action needs to be taken with regard to the following (Dincer, 1999:169):

- Research and Development – all participants in the energy sector such as private sector firms, energy utilities as well as national, provincial and local governments must be included in Research and Development initiatives;

- Technology assessment – Data collection should take place through laboratory trials, field surveys in order to establish factors such as costs and benefits, reliability, environmental impacts and safety;

- Standards development – technical and safety standards development is very crucial in motivating the acceptance of proven technologies in the market. The development of technical and safety standards must be undertaken in conjunction with national and international standards writing bodies as well as with other national regulatory bodies, and

- Technology transfer – technical workshops, seminars and conferences can be used to transfer results of Research and Development. Results can also be transferred through the compilation of training manuals and the publication of technical reports (Dincer, 1999:169).

4.8 BARRIERS TO RENEWABLE ENERGY DEVELOPMENT

Use of renewable energy can contribute greatly to the reduction of South Africa's carbon foot print; however, there are some barriers that can impede efforts aimed at development of renewable resources. Firstly, South Africa's heavy reliance on cheap coal for electricity and fuel production constitutes an obstacle towards the development of more sustainable energy forms. Secondly, technological risk makes it difficult for companies to access lending to invest in renewable energy projects. Failed projects can lead to reputational risk for companies making financial institution more reluctant to extend loans. When considering loan applications, financial institutions will factor all these

risks into their lending models and may end up granting such loans at high interest rates. Lastly, renewable energy resources in South Africa are not cost competitive due to high initial investment relative to the low cost of coal, therefore they tend not to be commercially viable (Pegels, 2010:4945-4954).

4.9 SUSTAINABLE DEVELOPMENT

Sustainable development is a pattern of development that permits future generations to live at least as well as the current generation generally requiring at least a minimum environmental protection (Todaro & Smith, 2011:784).Environmental degradation, including air pollution is a direct result of absolute poverty. The United Nations (2008:21-22) has a two-dimensional view of sustainable development, namely, the integrated view and the future-oriented view.

The integrated view considers sustainable development as a way of ensuring the welfare of the present generation whilst not compromising the welfare of future generations. The future-oriented view on the other hand, regards sustainable development as being only concerned with the welfare of future generations. The integrated view attempts to reconcile the needs of the present generation with those of future generations. The integrated approach therefore includes both the inter-generational and the intra-generational approach. According to this approach a balanced redistributional justice must exist between the present generation and future generations. This means that the present generation needs to secure their right to existence while ensuring that there is development for future generations (i.e. inter-generational justice). The integrated approach requires that resources be utilised in a manner that sustains current generations, whilst not being detrimental to the needs of the future.

The future-oriented approach distinguishes between development and sustainable development. This view regards sustainable development as being purely an inter-generational matter whilst development is considered as being concerned only with short-term well-being. This implies that, all developmental issues relating to the present generation must not be taken

into account when dealing with sustainable development, thereby enabling policies to specifically target the well-being of future generations. The future-oriented approach is favoured by those who are of the opinion that governments prioritise current issues of development over future concerns of sustainability. However, most governments would argue that their approach to sustainable development does take into account both short and long term needs as captured in the conventional definition of sustainable development. The future-oriented approach is often criticised for ignoring short-term equity. Many people, especially the poor, require that equity be addressed in the short-term and they would not wish to sustain disparities into the future (United Nations, 2008:21-22).

Sustainable development can also be viewed in terms of weak sustainability and strong sustainability. Weak sustainability implies that the current generation can compensate future generations for their loss of environmental amenities through providing them with alternative sources of wealth creation. This approach implies that environmental degradation can be compensated. Strong sustainability on the hand, holds that environmental amenities cannot be substituted with man-made capital, and argue that future generations should not be beset with a degraded environment irrespective of the amount of alternative sources of wealth bequeathed to them. Depletable natural resources cannot be replaced by human capital; therefore the conservation of alternatives is a more desirable option if sustainability is to be achieved. Advocates of strong sustainability further argue that the substitution of environmental assets with man-made assets mean that common environmental assets which are currently accessible to all will be replaced with private capital, which must be bought and as a result, in the future, people who cannot afford the purchase price will be excluded (Beder, 2000:2-3).

Successful environmental policies should be aimed at reducing inequities in society. Inequities may lead to environmental degradation. Poor people in particular – in their quest for survival - are more likely to degrade the environment in which they live through actions such as the cut-down of forests

and the overgrazing of grasslands. (Todaro & Smith, 2011:496-498). Todaro and Smith (2011:496-498) identify several policy option which developing countries can apply to improve the living conditions of the poor. These policies are described below:

4.9.1 Proper resource pricing

Governments need to seriously consider their own pricing policies. Some subsidies offered by governments can have the undesirable effect of aggravating the shortage of resources and can even stimulate unsustainable production methods. In some cases programmes aimed at poverty alleviation often end up benefitting the rich thereby worsening the existing inequalities. For instance, in many developing countries high income earners are the main beneficiaries of environmentally damaging water, energy and agricultural subsidies. Corrective measures aimed at the elimination of misdirected subsidies is a relative cheap exercise to implement, but may be resisted by powerful elites leading to dire political consequences for those in power (Todaro & Smith, 2011:496).

4.9.2 Community Involvement

Community participation is important for the success of any programme aimed at improving environmental conditions. Programmes embraced by the community have a higher chance of success in poverty alleviation. Communities are often prepared to contribute to programme costs if they can derive benefits from such programmes. Programmes undertaken by various development agencies have shown that community involvement is essential and can be cost-effective because in addition to providing jobs to the local communities they also result in the use of low-cost alternatives (Todaro & Smith, 2011:496).

4.9.3 Property rights and resource ownership

Guaranteeing land tenure to the poor is one of the steps that can be undertaken to encourage investment in the environment. If the poor have tenure, they will be able to invest in their land thereby leading to an

improvement in their living conditions. In addition land reform may be necessary especially where vast tracts of fertile uncultivated land exist side by side with over exploited marginal lands cultivated by large numbers of landless people (Todaro & Smith, 2011:497)

4.9.4 Raising the economic status of women

There is a negative relationship between high levels of education attainment and child-bearing. Education offers women an opportunity to be involved in the economy thereby raising the opportunity cost of their time leading to a decrease in the desired family size. In developing countries women are largely responsible for meeting the day-to-day needs of their families, and their ability to meet these needs is dependent on their sustainable management of water and fuel supplies (Todaro & Smith, 2011:497).

4.9.5 Industrial emission abatement policies

Market oriented instruments of pollution abatement such as carbon trading and taxation are much more effective as they reward efficient producers, are more flexible to firms, and easier to enforce. Non-market oriented instruments on the other hand such as quotas and standards are less flexible and harder to enforce (Todaro & Smith, 2011:497).

4.9.6 Improve economic alternatives for the poor

Agricultural investments such as investments in irrigation schemes, sustainable farming technologies and use of cleaner fuels may contribute immensely towards the improvement of living conditions of the poor. These investments are, however, unaffordable to most of the poor. Governments should therefore facilitate access to credit, to enable the poor to undertake such investments. Infrastructure development in rural areas can also help to create jobs thereby reducing urban migration. The improvement of economic alternatives for poor people can be attained through using the strategies described below (Todaro & Smith, 2011:496):

- Taxes- taxes such as fuel levies can be used to discourage extensive use of motor vehicles and as a result minimise emissions emanating from the operation of motor vehicles, which will prevent further damage to the environment;

- Tax concessions – granting tax concessions to individuals and companies that act in an environmentally sustainable manner, such as granting tax cuts to people or companies who install solar panels can motivate more people to act in an environmentally sustainable manner;

- Subsidies – the government can induce environmentally sustainable conduct by providing start-up capital for individuals and companies that want to start environmentally sustainable projects;

- Regulation – the government can enact laws and regulations that control environmental pollution. This could be laws that regulate ambient air-quality, laws aimed at ensuring water quality etc;

- Provision of environmental services – good environmental services such as provision of clean drinking water, sanitation, waste removal and disposal can make a huge contribution towards improving environmental quality, and

- Environmental education and awareness - provision of environmental education and awareness programmes can go a long way in ensuring that people are aware of environmental issues both at national and international level (Todaro & Smith, 2011:496):

4.10 FACTORS THAT INFLUENCE SUCCESSFUL SUSTAINABLE DEVELOPMENT

Sustainable development is dependent on what is accessible. A variety of constraints can impede successful sustainable development. These constraints can be divided into three broad categories namely, (i) constraints of physical condition and laws of nature, (ii) constraints of human nature and human goods and (iii) constraints of time. Each of these constraints can be

further subdivided into different elements as discussed below (Bossel, 1999:1).

4.10.1 Constraints of physical condition and laws of nature

Firstly, the laws of physics and rules of nature cannot be defied. For instance each plant has to meet certain minimum nutrient requirements for it to grow. Secondly, the development of human society is dependent on conditions that prevail in their environment. The development of human society can therefore be constrained by factors such as the presence of renewable and non-renewable resources, climatic factors, and atmospheric conditions. Thirdly, solar energy flows and the stock of material resources available can also have an impact on sustainability. Solar energy is the only source of energy that is permanently available. All other sources of energy such as fossil fuels are finite. These finite forms of energy constitute a constraint on sustainability. Lastly, the carrying capacity of a region, that is, the number of organisms of a particular species that can successfully thrive in a region, is dependent on the productivity of the region and the demands of the specific species (Bossel, 1999:4-5).

4.10.2 Constraints of human nature and human goods

Firstly, human beings are imaginative and creative in nature, they can invent solutions to problems facing them, and on the other hand they may not even recognise the most obvious ones, which may lead to a restraint on sustainability. Secondly, the existence of human organisations, cultural, political systems and technology can constitute a constraint on sustainability due to their influence on human behaviour and adaptability to change. Lastly, ethics and values can also constitute a constraint to sustainability because not everything that is accessible will be acceptable by ethical or cultural standards of a particular society (Bossel, 1999:5-6).

4.10.3 Constraints of time

Sustainability is a dynamic process and all dynamic processes take time. Sustainability related activities such as the introduction of a new technology

and introducing new measures to control population growth require some time and can pose challenges on what can be achieved and the pace with which such achievements can be accomplished. Furthermore, sustainable development is an evolutionary process, which means that it is subject to constant change. Processes and functions need to be diverse if successful sustainability is to be achieved. Diversity facilitates quick adaptation to change through offering a variety of alternatives. Some of the alternatives offered may happen to be more suitable to dealing with present situations than others (Bossel, 1999:6). In addition, Dincer (1999:172) has noted several parameters which can assist in achieving successful sustainable development. The parameters are discussed below as follows (Dincer, 1999:172):

- Public awareness: the public should be made aware of renewable energy projects through non-governmental organisatons (NGOs), the media etc.

- Information: the public should be provided with information on the use of energy, its impact on the environment and the availability of renewable energy resources;

- Environmental education and training: the cornerstone of successful sustainable energy programmes is environmental education and training. Any programme which does not incorporate these as its integral part is more like to fail;

- Promoting renewable energy resources: continuous promotion of renewable energy resources is needed if renewable energy programmes are to succeed;

- Innovative energy strategies: innovation is the key for an effective sustainable energy programme;

- Finance: finance is a tool that can be used to support and achieve the main objective of achieving widespread implementation of renewable energy programmes;

- Monitoring and evaluation: it is imperative that proper monitoring and evaluation is undertaken at each step of the process to ensure successful implementation (Dincer, 1999:172).

4.11 SUMMARY AND CONCLUSION

This chapter discussed air pollution abatement strategies, renewable energy and sustainable development. The chapter began by providing a historical overview of different air pollution abatement strategies that were implemented in South African townships since the 1960s. Other than electrification these strategies were mostly unsuccessful. The chapter proceeded by discussing the more recent air pollution abatement strategies in South African townships. The abatement strategies discussed includes the top-down ignition method referred to as Basa-njengo-Magogo, wherein coal is lit from top-down instead of the conventional bottom-up approach. This method generates fewer emissions as smoke rises through the hot area and is thus burnt. Other abatement strategies such as energy efficient housing which requires that all newly constructed houses should take thermal comfort into account.

The positive and negative impact of switching to cleaner fuels was also discussed. One positive advantage of switching to cleaner fuels is the reduction in indoor air pollution. On the other hand, costs associated with the operation and maintenance of cleaner fuels equipment can result in consumers incurring additional cost which can result in an increased fuel bill. The next section of the chapter discussed twin concepts of renewable energy and sustainability. The burning of coal, especially in low-income settlements is responsible for air pollution. It is on this basis that there is a need to explore the use of other forms of energy such as solar, wind, hydropower, nuclear and geothermal power as these sources of energy do not generate any emission and therefore contribute to a cleaner environment.

Closely linked to the concept of renewable energy is the concept of Environmental Sustainability. Sustainable development is a concept that advocates for the responsible use of resources by current generations in order not to compromise the ability of future generations to derive benefit from

environmental resources. The success of successful sustainable development can be influenced by a variety of factors such as constraints of the physical condition and the laws of nature, constraints of human nature and human goods as well as constraints of time.

CHAPTER 5

ECONOMIC VALUATION TECHNIQUES

5.1 INTRODUCTION

An increase in human production and consumption does lead to unintended negative consequences such as increased health risk and damage to the environment (Nas, 1993:172). There is therefore, a need for an adequate policy response to combat the health damage resulting from air pollution caused by human activities. Environmental economics provide economists with a variety of tools that can be used to value the environment. Before the introduction of the economic valuation tools environmental decisions were taken without quantifying the costs and benefits of the decisions (Rabi *et al.,* 2007:316). All the economic valuation techniques discussed in this chapter have strengths and weaknesses and each of them should therefore be used for a purpose for which it is most appropriate. One major criticism against environmental valuation is that some people find it wrong to attach a monetary value to environmental goods such as good air quality. Some kind of evaluation of the environment is, however, necessary because there is a need to timorously and systematically assess the consequences of an environmental decision. Several stakeholders may be interested in the results of economic valuation. The various stakeholders who may show interest in the results of economic valuation are described below (WHO, 2006:56-57):

- Governments: since governments are responsible for allocating national budgets, it is imperative that they be adequately informed so that they can take well informed decisions about which interventions to promote.

- Private Companies: economic valuation results can be used by companies to assist them in identifying potential profit-making markets in which they can invest.

- Non-Governmental Organisations (NGOs): NGOs which operate in the energy sector may also be interested in comparing the benefits of one environmental intervention over another.

- Private Households: private households may be interested in knowing the benefits that may accrue to them compared to the cost of the environmental intervention.

- Research Funding Agencies: funding agencies may be interested in funding projects that will result in energy improvement options which are of lower cost and effective.

- Donors: Donors need to be well informed about environmental decisions so that they can know exactly which interventions to target and subsidise.

- Development Banks: Development banks would like to finance projects that have high social and economic returns and also contribute to local economic development (WHO, 2006:56-57).

This chapter begins by providing a background of environmental legislation in South Africa; it further introduces and provides a review of the different valuation instruments that can be used. The oldest and most firmly established impact assessment procedure is Environmental Impact Assessment. Environmental Impact Assessment is generally used to aid and improve the decision-making process by assessing the possible impact of a proposed project on the environment. The chapter further discusses cost–benefit analysis (CBA) which is a valuation instrument used to evaluate the merits of public projects. CBA is broader than simple financial analysis in that it also takes into account total social costs and total social benefits (Nas, 1993:1). Amongst various other measures of CBA the most commonly used is the benefit cost ratio which is used to determine the feasibility of a project during any given year or time span (Nas, 1993:122).

Another valuation technique which is discussed in the chapter is Scenario analysis. Jager *et al.*, (2005:20) define a scenario as a plausible and often simplified description of how the future may develop, based on a coherent and

internally consistent set of assumptions about driving forces and key relationships. The chapter proceeds by differentiating between indirect and direct valuation techniques. Indirect techniques are those that make use of surrogate markets to estimate the price of an environmental good (Birol *et al.,* 2006:109) whilst direct techniques are commonly used to measure goods with no market value (Brookshire & Crocker, 1981:237).Whilst not undermining the role and importance of other valuation techniques the chapter advocates for the usage of contingent valuation as an appropriate instrument for quantifying the monetary costs of air pollution to the residents of Bophelong.

The second part of the chapter deals with the theory of social cost. Field and Field (2004:54) describe social costs as all costs that result from an action irrespective of who experience such costs. These costs are different from private costs in that private costs are only borne by parties responsible for the decision leading to a cost-bearing action. The section also discusses externalities concentrating mainly on negative externalities. External costs are costs that result from production processes but are not considered as part of production costs by the producers. These costs are considered external because in spite of the fact that they represent a cost to society they are not taken into account when decisions are made about levels of output (Field & Field, 2004:71). The social cost theory is an outgrowth of welfare economics which is dominated mainly by two schools of thought namely the Pigouvian approach and the Coasian approach. The Pigouvian approach advocates for government intervention as a way of correcting for externalities whereas the Coasian approach advocates for a market-oriented approach to deal with externalities.

5.2 BACKGROUND TO ENVIRONMENTAL LEGISLATION IN SOUTH AFRICA

The USA was the first country in the world to introduce environmental legislation through the passing of the National Environmental Policy Act (NEPA) of 1969 (Mokhehle & Diab, 2001:10). Many developed countries followed immediately afterwards with their own versions of environmental legislation. Developing countries also followed with their own attempts at

regulating environmental protection, but on the main they tended to lack far behind the developed world. Although many developing countries made attempts to regulate environmental protection their efforts at enforcing such legislation were hampered by factors such as lack of well trained personnel, lack of financial resources, poor administration and organisational structures, institutional conflicts, lack of monitoring equipment and lack of public awareness programmes (Mokhehle & Diab, 2001:10).Many developing countries, however, continue to deal with these challenges. Today, environmental protection is enshrined in the constitution of many developing countries such as South Africa, Lesotho and Ghana (Mokhehle & Diab, 2001:10).

Section 24 of the Constitution of the Republic of South Africa states that:

Everyone has the right:

- to an environment that is not harmful to their health or well-being; and
- to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that:
- prevent pollution and environmental degradation;
- promote conservation; and
- Secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

As with many developing countries South Africa lacked behind in formulating and implementing environmental legislation. In addition to the challenges mentioned earlier with regard to the implementation and enforcement of environmental legislation, implementation in South Africa was also hampered by the technocratic nature of the environmental processes that took place before the advent of the democratic dispensation in 1994. As a result, the first environmental impact assessment legislation only came into effect in 1997 under the Environmental Conservation Act of 1989.

The first post-apartheid environmental legislation, the National Environmental Management Act (NEMA) of 1998 which deals with management of environmental pollution including waste came into force on 01st April 2010. This act introduces an air quality management framework of international standards focusing on issues such as stipulating air quality standards across the country and issuing atmospheric emission licences targeted specifically on air polluting industries. The National Environmental Management Act (NEMA) of 1998 was preceded by the National Consultative Environment Policy (CONNEP) process. Although CONNEP was a widely accepted and a participative process it also had several short-comings, among them are the following: (i) lack of consultation with local government; (ii) lack of recognition of the role played by local government in environmental management; (iii) lack of continuous consultation with civil society in the implementation and monitoring of policy; and (iv) the failure to follow up key commitments in the policy. In an attempt to correct these short-comings, a policy review was undertaken which took into recognition the fact that resources can only be sustainably managed if people using these resources and those benefiting from use of the resource are involved in the decision-making process (Rossouw, 2004:134). The Air Quality Act was passed in 2004, and dealt specifically with issues relating to air pollution. It is in terms of this Act that the Vaal Triangle was declared an Airshed Priority Area. In 2008 the Waste Management Act was passed with specific focus on waste management.

5.3 CRITERIA FOR EVALUATING ENVIRONMENTAL POLICIES

Field and Field (2009:182-192) discuss several criteria that can be used to evaluate the success or failure of environmental policies. The criteria discussed in this section are, efficiency, cost-effectiveness, equity, environmental justice, incentives for technological development, enforceability, moral considerations and human and environmental well-being.

5.3.1 Efficiency

Efficiency is described as a state of economic affairs where no one can be made better-off without simultaneously making someone else worse-off (Nas,

1996:11). In pollution abatement an efficient level will be attained where marginal abatement costs equal marginal damages (Field & Field, 2009:182). Dietz (2003:36) advises that the concept of efficiency can be useful in making environmental decisions for as long as the shortcomings of markets and prices in guiding analysis are taken into account. Dietz (2003:36) further notes that the fact that efficiency can be quantified through methods such as cost-benefit analysis and cost-effectiveness analysis should not let the efficiency criterion dominate over other non-quantitative criteria.

5.3.2 Cost-effectiveness

A policy is cost-effective if it produces the maximum amount of environmental improvement at a given cost. The main concern of cost-effectiveness is technological efficiency where unlike in other forms of valuations which concentrate mainly on economic efficiency, costs and benefits are not assigned a monetary value (Field & Field, 2009:183).

5.3.3 Moral considerations and equity

Environmental policies should strive towards the attainment of socially equitable distribution of costs and benefits. The equitable distribution is, however, influenced by moral issues. Moral considerations stretch beyond the distributional issues of equity as society holds different views regarding how the pollution issue needs to be addressed. For instance, some people within society might prefer that polluters be taxed, whilst other might prefer that polluters be subsidised to stop their polluting activities (Field & Field, 2009:184).

5.3.4 Environmental justice

Marginalised members of society such as the poor are more likely to be exposed to environmental hazards than the more affluent members. Authorities are therefore called upon to consider issues of environmental justice by ensuring that the poor are not disproportionately exposed to such hazards (Field & Field, 2009:186). In relation to environmental justice Dietz (2003:35) states that procedural fairness must prevail. Procedural fairness

implies that all people who have an interest and are affected by a decision should have a say in decision – making. This means people should be afforded an opportunity to voice their concerns about a particular environmental matter before a decision is taken.

5.3.5 Incentives for technological improvement

Environmental policies must contain incentives for individuals or groups to find better methods of reducing environmental damages. These incentives can be achieved through research and development programmes as well as education and training which could help to achieve a downward shift of the marginal abatement costs function. Environmental policies have historically lacked such incentives (Field & Field, 2009:186).

5.3.6 Enforceability

Environmental policies do not enforce themselves, so there is a need for monitoring and enforcement to ensure compliance. Those not complying with the regulations will have to be sanctioned. Voluntary compliance is encouraged as the sanctioning process involves large transaction costs such as prolonged and costly court battles (Field & Field, 2009:188).

5.3.7 Human and environmental well-being

Decisions about the environment can be approached from an anthropocentric viewpoint, ecocentric viewpoint and from a view point which combines the two approaches. According to anthropocentrists the environment is important only in so far as it influences human welfare. Ecocentrists on the other hand, believe that environmental assets should be valued regardless of whether they contribute to human welfare or not. And then there are people who hold the view that these two approaches are not necessarily exclusive. A person can care about the well-being of the environment without disregarding human well-being (Dietz, 2003:34).

5.4 DIFFERENCES BETWEEN ECONOMIC ANALYSIS AND FINANCIAL ANALYSIS

Economic analysis differs from pure financial analysis in that it takes into account the overall impact of an intervention on the country's economy; these impacts would include overall resource uses, and consequences based on the premise of scarcity of resources. Financial analysis on the other hand, only estimates the financial impact of the interventions. These impacts would include the assessment of income, expenditure, cash flows and profit. **Table 5.1** provides a summary of the differences between financial analysis and economic analysis.

Table 5.1: Differences between financial and economic analysis

Variable	Financial analysis	Economic analysis
Outputs of interest	Income, expenditure, cash flow, profit, end of period balance, internal financial rate of return, net present financial value	Benefit-cost ratio, internal economic rate of return, net present value.
Costs	All financial outlays, present or future, which have a monetary cost.	All uses of resources, present or future, which have an economic cost.
	Examples include actual monetary payments for human resources, materials or infrastructure.	Examples include the use of scares human resources, infrastructure that have alternative uses, and donated goods.
	Valuation of future expenditures is at present value using market interest rates.	Valuation of future expenditure is at present value using a discount rate that reflects social time preference.

Variable	Financial analysis	Economic analysis
Consequences or outcomes	All financial consequences of a given intervention, including further associated expenditures, cost savings or revenues.	All resource consequences associated with a given intervention, including the freeing up of spare capacity for alternative uses, improvements in qualititative indicators, and economic value of resource savings.

Source: WHO, 2006:6

5.5 ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

The USA's National Environmental Policy Act (NEPA) which became effective on the 01st January 1970 was the first law which required Environmental Impact Statements (EIS) for publicly funded projects which are likely to have impacts on the environment (Thomas & Elliot, 2005:80).Since then many countries around the world have followed with their own EIA laws and procedures. Each country has its own regulations and procedures that need to be followed when EIA is implemented. There are, however, many common aspects of the EIA process. **Table 5.2** below illustrates a framework for a typical EIA procedure.

Thomas and Elliot (2005:16) summarise the framework illustrated in **Table 5.2** into two broad categories, namely; preparation of the document i.e. the Environmental Impact Statement (EIS) which provides information upon which the assessment is based and; review of the document (i.e. review of the EIS) by the public and government officials.

The EIA framework can thus be summarised as EIA = EIS + assessment report. Environmental impact assessment is an important tool used by policy makers to assist in decision-making and it has several advantages. Firstly, it ensures appropriate protection levels for natural resources, environmental quality and public health. Secondly, it ensures that all the relevant information

about a proposed project and its alternatives are presented in a single document. Lastly it enables the identification of potential impacts during the early stages of project planning (Gonzalez, 1995:124).

There are problems which present themselves when EIA is practically applied. The first problem is scaling; problems associated with scaling may lead to the cumulative impacts of several small projects not to be taken into account. The second problem is time constraint, due to its short-term nature EIA may not provide solutions to environmental challenges across the globe. The third problem is scope, due to the fact that most EIA are compiled for particular projects its usage may cover only a limited set of alternatives. Lastly, the methodology used can present problems as there is no single method for conducting EIA (North *et al.,* 1993:160). Notwithstanding the limitations mentioned above, EIA can still play an important role in protecting the environment against the negative impacts of human activities.

Table 5.2: A typical EIA framework

Procedure	Description
1. Screening	Deciding whether EIA is required for a particular project.
2. Scoping	Identifying the key issues of concern that should be included in the environmental assessment. Scoping should involve all stakeholders such as environmental agencies and the general public.
3. Preparation of EIS	Preparation of the draft environmental impact statement that reports the findings of EIA. It Involves scientific and objective analysis of the scale, significance and importance of the impacts identified.
4. Review	Aims to identify risks and benefits of the project and is usually carried out by government or an independent review panel.
5. Monitoring	Ensuring that implantation is carried out in accordance with prescribed procedures or rules.
6. Evaluation	Conducting an audit of the project and determining whether the procedures have achieved the set objectives.

Source: IIED, 1999:16 (Adapted)

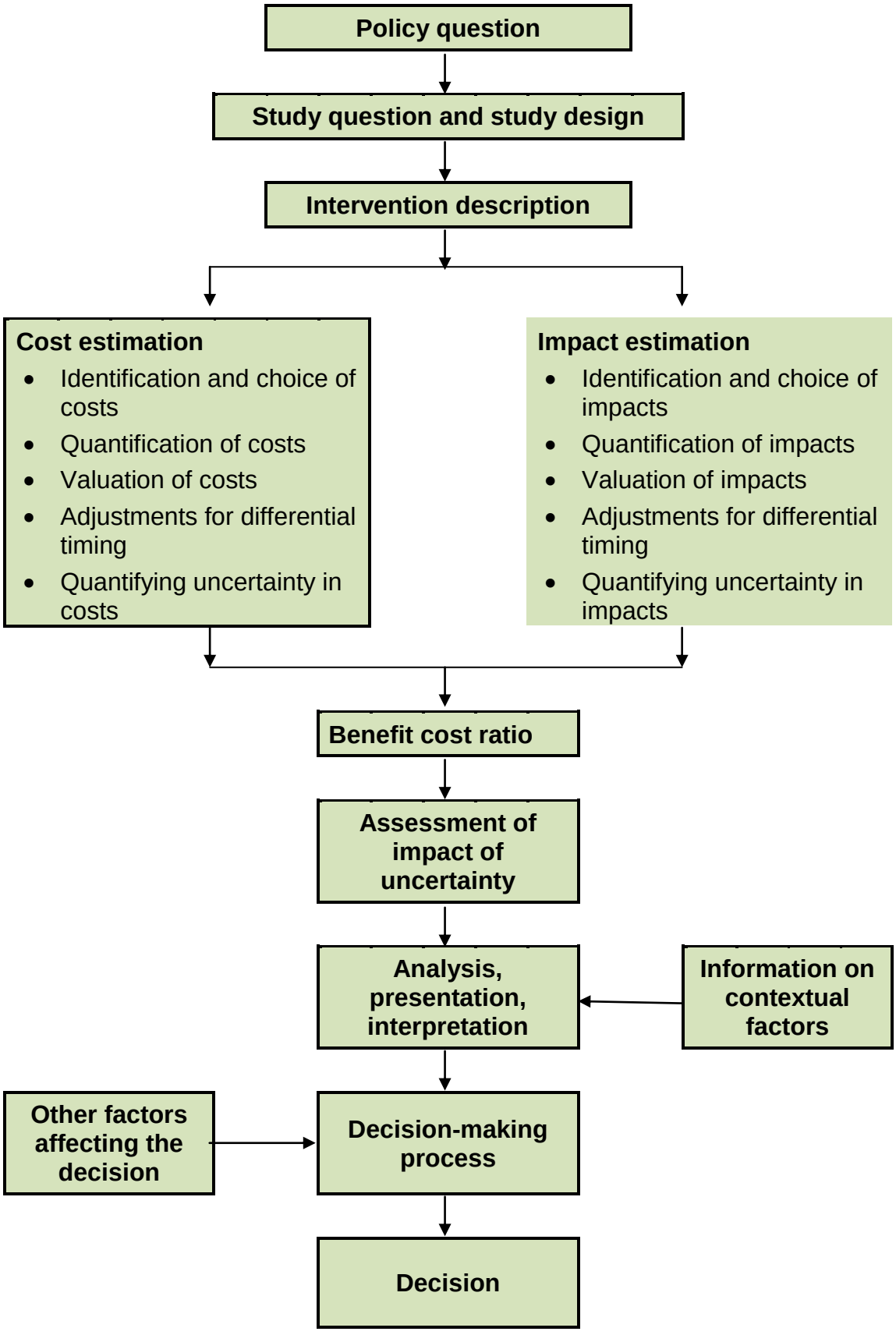
5.6 COST-BENEFIT ANALYSIS

Cost-benefit analysis is a valuation method that has been developed to facilitate efficient allocation of public resources. CBA can be used both in the private sector and in the public sector. In the private sector financial CBA is used to justify the acquisition of equipment and technology, measure life-cycle costs, adhering to regulations cost-effectively and quantify hidden costs and intangible benefits. Social CBA on the other hand, is used to appraise the social merit of projects or policies (DEAT, 2004:4). Several steps are involved

in the process of conducting a proper CBA study. **Figure 5.1** illustrates a step by step approach to a CBA study (DEAT, 2004:4).

Cost-benefit analysis is a valuation method that has been developed to facilitate efficient allocation of public resources. This method makes use of several decision rules to determine if a project is desirable from society's point of view (Black *et al.,* 2007:104). The next sub-section summarises some of the decision rules that are used in Cost-benefit analysis.

Figure 5.1 Step-by-step approach to cost-benefit analysis



Source: DEAT, 2004:4

5.6.1 Net Present Value

The net present value determines whether the return on investment is greater or equal to the interest that can be earned had the money been invested elsewhere. This method reduces future benefits and costs to a single present rand value (Black *et al.,* 2007:105-106). The difference between the discounted benefits and costs represent the net present value.

A study conducted by the South African Clean Air Initiative (Leiman *et al.*, 2007) found that most of the air pollution abatement strategies which yielded positive net present values were those applicable to households whilst the majority of the air pollution abatement strategies applicable to industries yielded negative net present values. This suggests therefore that policy interventions in South Africa (particularly in densely populated areas) must be directed more towards households as opposed to industrial emissions. When comparing two or more projects, the project yielding the highest net present value will be chosen over the one that yields a lower net present value.

5.6.2 The Benefit-Cost Ratio

The benefit-cost ratio is used to determine the feasibility of a project during any given year or over a time span. It involves discounting the future streams of expected benefits and costs for a given project. This is done through providing the present value of benefits divided by corresponding costs. The benefit-cost ratio is calculated by taking the present value of future benefits over the present value of costs. (Black *et al.,* 2007:107).

5.6.3 Internal rate of return

The internal rate of return determines the actual rate of return earned by an organisation when undertaking a particular project. The internal rate of return represents the discount rate that yields a zero net present value. The formula for calculating the internal rate of return is represented as follows (Nas, 1996:123).

$$0 = -I_0 + \sum_{n=1}^{N} \frac{NB_n}{(1+\pi)^n}$$

Where:

I_0 = Initial Investment cost

NB_n= the benefit stream that occurs in yea 1 (n = 1)

N = the project's lifetime

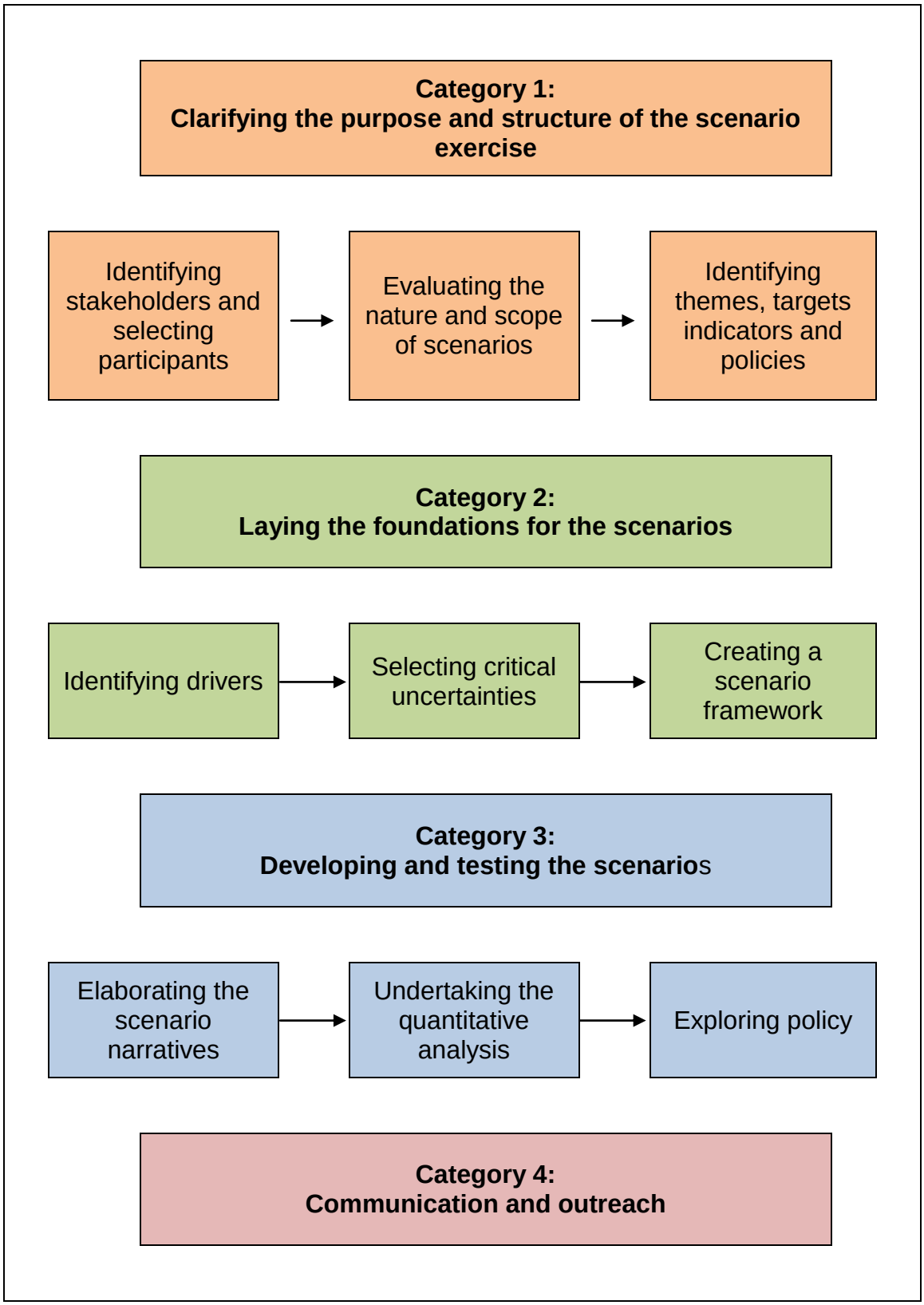
π = Internal rate of return

A project becomes acceptable if the internal rate of return exceeds the market rate of return. The internal rate of return method however has flaws in that, firstly, it can produce more than one internal rate of return and thereby lead to ambiguous or incorrect conclusions and secondly, it is inconsistent with the net present values' accept or reject decisions.

5.7 SCENARIO ANALYSIS

Scenario analysis is not a forecasting tool but only provides a plausible description of how the future may develop. It functions as a support tool to assist decision makers in choosing between different alternatives (Postma & Liebl, 2005:162). Scenarios can be used on a micro level (e.g. individual decision making), but they tend to be more useful when applied on a macro level (e.g. when used by government and the corporate sector). Several steps are involved in the process of formulating a scenario. These steps can be divided into four broad categories as illustrated in **Figure 3.2** below (Jager *et al.,* 2005:20).

Figure 5.2: Scenario formulating process



Source: Adapted from Jager *et al*. (2005:21)

A good scenario must meet several criteria. Firstly; it must be relevant and as such satisfy the needs of users. Secondly, it must be internally consistent i.e.it must be consistent with theory, for example, it should be able to reflect the theoretical relationship between unemployment and inflation. Thirdly, it must be able to generally describe different future scenarios rather than variations of just one theme. Lastly, it must have an element of equilibrium i.e. it should be able to describe a situation that will prevail for a long time in the future. While scenarios are a good support tool for decision makers, they also have limitations in that they are vulnerable to bias and are also subject to internal inconsistencies (Schoemaker, 1995:30).

5.8 INDIRECT VALUATION TECHNIQUES

Indirect valuation methods also referred to as revealed preferences methods make use of surrogate markets to estimate the price of an environmental good (Birol *et al*., 2006:109).Several of these methods are discussed in this chapter, namely: Hedonic pricing, Travel cost, Replacement cost, averting expenditure, production function approach, net factor income and cost of illness.

5.8.1 Hedonic Pricing Method

According to the hedonic pricing method, differences in property prices are a reflection of the environmental benefits associated with a particular market transaction (Brookshire *et al*., 1982:165). For instance, the price of a house is made up of its different characteristics such as proximity to community amenities like sports fields, clinics, schools, etc. This implies that these benefits are implicitly reflected in the price of the house. The Hedonic pricing method can be used to estimate economic benefits or costs associated with environmental quality, including air pollution, water pollution or noise, as well as environmental amenities such as aesthetic values or proximity to recreational sites. There are several limitations that can be noted from the use of the Hedonic pricing method. Firstly, the individual items being valued such as air quality, are not marketed explicitly as separate items, but are marketed implicitly as part of a bundle of many attributes. Secondly, an implicit

relationship is assumed between for instance, housing prices and air-quality, but since air quality is not a tradable good, it cannot be ascertained that the measure of air quality is the one that people actually use. Lastly, it may not be clear the extent to which individuals are fully and correctly informed about the impacts of air pollution. When individuals are less informed about the health effects of air pollution, the more likely they are to express a low willingness to pay for cleaner air, than they would if they were fully informed (Delucchi *et al.,* 2002:140-141). This method was not chosen for this study because it cannot be used to measure the benefits of air pollution abatement in Black townships as it depends heavily on highly developed property markets. The method can therefore, be most useful in high income areas. Under Apartheid legislation Black people were not allowed to own property in urban areas, as a result no real estate market developed in Black areas. Large sections of housing development in Black areas comprise of government-built housing units. The benefits of clean air will therefore not be reflected in property prices (Simon *et al.,* 2008:76).

5.8.2 Travel Cost Method

This method takes into account the time and travel expenses incurred to visit a site. The incurred travel expense can thus be regarded as an estimate of the consumer's marginal willingness to pay. Problems associated with this method involves amongst others the difficulty associated with measuring the opportunity cost of time. In addition, except for the random utility approach to the Travel cost method, the Travel cost method does not take substitute sites into account (Birol *et al.,* 2006:110).

5.8.3 Replacement Cost Method

This method is based on the replacement cost of damaged assets. The basic premise of this method is that the value of the asset should not exceed its replacement cost. Its main advantage is that it is easy to compute as it tends to rely on observed behaviour (Abaza & Rietbergen-McCracken, 1998:5).

5.8.4 Averting Expenditure Method

In this method consumers may respond to environmental degradation by embarking on an averting behaviour e.g. buying bottled water and water filters to avoid drinking contaminated water (Birol *et al.,* 2006:111). The disadvantage of using this method; however is that consumers may engage in more than one averting behaviours, thus making averting behaviour a discrete variable. Some of the averting behaviour may have benefits which are not necessarily explicit (Birol *et al.,* 2006:111).

5.8.5 The Production Function Approach

Mohr and Fourie (2004:203) define production as the physical transformation of inputs into outputs. The production function thus refers to the relationship between the quantity of inputs used to produce a good and the quantity of output of that good. The inputs involved in production of outputs includes factors of production which have a market price and intermediate goods which may or may not have a market price e.g. air quality. For those goods that do not have a market price, their implicit value can be estimated by calculating the contribution to the profit.

5.8.6 Net Factor Income Method

According to the Net Factor Income Method the costs of other inputs in production (other than the environmental input) is subtracted from total revenue. This implies that the remaining surplus represents the value of the environmental input (Birol *et al.,* 2006:111).

5.8.7 Cost of Illness Method

The cost of illness method considers expenses related to medical care such as medical tests, hospitalisation and opportunity cost such as loss of earnings due to illness. The costs can be measured directly or indirectly. The direct costs would include costs for prevention, detection and treatment of ailments whilst the indirect cost would entail loss of production due to morbidity and mortality (Cooper & Rice, 1976:4).The main disadvantage of this method,

however, is that it does not take into account any averting expenditure that individuals might have taken to prevent illnesses (Birol *et al.,* 2006:111).

5.9 DIRECT VALUATION TECHNIQUES

Direct valuation methods or stated preferences methods are used to value goods that do not have a market value i.e. price-quantity data does not exist for such goods (Brookshire & Crocker, 1981:237). Two of such methods are discussed in this chapter, namely, the contingent valuation method and the choice experiment method.

5.9.1 The Choice Experiment Method

The choice experiment method (also referred to as the Contingent choice method) is the latest of the direct evaluation techniques. It is used to reveal respondents' preferences for different hypothetical scenarios e.g. describing the quality of coastal water in terms of bathing water quality. The quality of the water can be ranked into high medium or low. The benefits of using the Contingent choice method are that it makes it possible to measure the implicit value of the attributes of a resource and in addition the respondents tend to be more familiar with the choice and lastly, it helps to address some of the biases found in the Contingent valuation method, namely, strategic bias which is reduced because prices of the resource are included in the choice sets and, the embedding effect which is also reduced because the choice sets offered to respondents are complete. Individual respondents will therefore, not be able to misinterpret the hypothetical offer of a good or service (Birol *et al.,* 2006:113).

However, there are some similarities between the Choice experiment method and the Contingent valuation method. The Choice experiment method is similar to the Contingent valuation method in that it (Choice experiment method) can also be used to estimate values for any environmental service and can also be used to estimate use and non-use values. The Contingent choice method differs from the Contingent valuation method in that the estimated values for this method (Contingent choice method) are not

expressed in terms of rands, instead values are inferred from the hypothetical choices or trade-offs that people make (King & Mazzotta, 2000).

5.9.2 Contingent Valuation

Contingent valuation is a stated preference approach to valuation, it enquires about future behaviour by asking willingness to pay (WTP) and willingness to accept (WTA) type of questions (Smith, 2006:7). Smith (2006:7) describes contingent valuation as an evaluation approach that makes use of survey questions to elicit information that allows economic value for non-market resources to be estimated. The survey information would then be used to estimate a bid function which is used in the prediction of sample mean or median values. The predicted mean or median values would then be converted into total willingness to pay by multiplying the sample mean or median with the total estimated household population.

Several steps are involved in the formulation of a Contingent valuation study. The discussion that follows provides a brief description of these steps. Firstly, the valuation problem needs to be defined, and then the method through which the survey will be conducted must be established. Thereafter, the researcher needs to construct the actual survey design which can be initiated through conducting interviews with specific focus groups, subsequently; the survey must be implemented by making use of statistical sampling methods. Lastly, the researcher must compile, analyse and report the results by making use of appropriate statistical techniques. Due to its flexible nature Contingent valuation is widely used by economists to estimate total economic value. Contingent valuation can be used to measure the economic value of most commodities and, its results are relatively simple to analyse and report (Ninan, undated).

In addition, Pope III and Miner (1988:382) suggest certain guidelines that need to be followed when designing a Contingent valuation survey. Firstly, the concept of air-quality must be established as a good and then, a hypothetical air quality market in which air quality can be traded as a good must be established, thereafter the information must be presented in a manner that

would facilitate the detection and examination of information bias subsequently, the influence of benchmark values on bids must be evaluated and lastly, the socio-economic factors that would affect bids for improved air quality must be taken into account (Pope III & Miner, 1988:382). Since this study makes use of Contingent valuation survey, every possible attempt has been made to adhere to these guidelines.

Table 5.3: Contingent Valuation Method Biases

Type of bias	Description
Strategic bias	The respondents understate/overstate the value in order to influence a particular outcome.
Hypothetical bias	Arises as a result of the hypothetical nature of the market in contingent valuation surveys. There is a difference in the way that people make hypothetical decisions to the way they make actual decisions.
Information bias	Provision of insufficient or misleading presentation of information can lead to an information bias.
Starting point bias	An initial valuation figure can significantly influence the final value e.g. choosing a low initial figure leads to a low mean willingness to pay.
Payment Vehicle bias	Respondents give different willingness to pay values depending on the specific payment vehicle chosen. Generally respondents are averse to taxes; and tend to have a favourable disposition toward donations etc.
Aggregation bias	Problems such as sampling errors and insufficient sample size may lead to the sample not being representative of the population which can lead to an aggregation bias.

Type of bias	Description
Embedding problem (scope effect)	The hypothetical offers for a specific item may be misconstrued as being indicative of an offer for a wider range of goods or services with similar characteristics.
Credibility	Low income can act as a constraint on willingness to pay. Furthermore, the contingent valuation method may also encounter ethical issues especially in developing countries.

Source: Ninan, Undated (Adapted)

Although the use of the Contingent valuation method has its advantages as described above it also suffers from several limitations, most notably measurement errors which may manifest themselves in the form of different types of biases which are described in **Table 5.3** above (Ninan, undated).

In addition to the problems of a variety of biases discussed in **Table 5.3**, King and Mazzota (2000:9-11) discuss some advantages and disadvantages of using the Contingent valuation method. Firstly, the Contingent valuation method is flexible and can be used to estimate use and non-use values as well as well as existence values, option values and bequest values. Secondly, the results of Contingent valuation are easy to analyse and interpret.

The use of the Contingent valuation method does however, have several shortcomings. The first shortcoming of this method is its inability to adequately capture and determine respondents' willingness to pay for the improvement of their environment. The second shortcoming has to do with the fact that people may not necessarily understand the hypothetical question being posed to them and as a result may not have a strong ground on which to reveal their true value. The third disadvantage of using the Contingent valuation method is linked to the second one. That is, other than simply not understating the hypothetical question, the manner in which people make hypothetical decisions is fundamentally different to the manner in which they make real decisions.

There are two types of questions that can be asked to elicit respondents' willingness to pay for an environmental good, namely, willingness to pay and willingness to accept. In theory the two questions should yield valuations that are similar. Empirical evidence, however, has shown a huge divergence between willingness to pay and willingness to accept responses, this then represents the fourth shortcoming, that is, some economists are sceptical about the results of Contingent valuation studies claiming that the results do not represent true valuations but simply represent respondents' opinion about the situation. The fifth shortcoming is that Contingent valuation surveys are very vulnerable to protest bids and may, as a result, produce a very high number of zero bids. Lastly, Contingent valuation surveys can be very costly and time consuming due to the extensive survey work involved (King & Mazzota, 2000:9-11). The pros and cons of Contingent valuation can also be assessed by determining its validity and reliability. The section that follows discusses issues pertaining to the validity and reliability of Contingent valuation.

5.9.2.1 Contingent valuation method: elicitation formats

There are different types of elicitation formats that can be used to carry out a Contingent valuation survey. The elicitation formats and problems associated with the use of each of these formats are described below.

5.9.2.1.1 Open-ended format

The open-ended elicitation format involves asking respondents the maximum amount that they are willing to pay for an environmental good or policy. This elicitation format has several advantages in that it is convenient for respondents to answer and does not necessarily require the presence of the interviewer and is not vulnerable to starting-point bias. The shortcomings related to this format relates to the fact that it often results in very conservative estimates with very high numbers of zero responses or protest bids. Furthermore, the technique is also vulnerable to strategic bias as respondents are less likely to provide a true answer on how they value the resource in question (Venkatachalam, 2004:106). Arrow *et al*., (1993:20) also note that

the open-ended format is less likely to provide reliable valuations because respondents are in general not accustomed to valuing environmental goods.

5.9.2.1.2 Bidding game format

In the bidding game format respondents are assigned a particular predetermined bid on a random basis. The respondents are then asked to respond with a yes or no answer to a particular bid. If the respondent answers in the affirmative to the question being posed, that is, the respondent say “yes” to the question being asked, then the interviewer keeps on increasing the bid until the respondent provides a negative answer, that is, the respondent answers “no” to the question. In the case where the respondent answer “no” to the question being asked the interviewer will keep on decreasing the bid until a “yes” is given. An advantage of the bidding game format is that it fairly resembles true market situations and is therefore likely to result in relatively better results than the open-ended format. Another advantage of this format is that it makes it easier for the interviewer to elicit the maximum willingness to pay from the respondent. However, this method is vulnerable to starting-point bias as the bid starting points will inevitable influence the final estimated value of the stated willingness to pay (Venkatachalam, 2004:106).

5.9.2.1.3 Payment card format

The payment card method makes use of a range of willingness to pay values from which a respondent will be asked to select their maximum willingness to pay value. The main advantage of this format is that it makes it relatively easier for the interviewer to obtain the maximum willingness-to-pay value. However, this method also has problems in that it is vulnerable to range and centering biases (Venkatachalam, 2004:106).

5.9.2.1.4 Single- bounded dichotomous choice format

In the single-bounded dichotomous choice format, respondents are assigned a single bid from a range of pre-selected bids which portrays the potential maximum willingness to pay of the respondent for a particular environmental

good. This method is also referred to as the take- it- or- leave- it format as respondents are expected to respond to the bid assigned to them with a “yes” or “no” answer on an all-or-nothing basis. The main advantage of this format is that it makes it easier for the respondent to complete the survey; in addition, it also eliminates the problem of strategic bias. Furthermore, Arrow *et al.,* (1993:21) notes that question asked in this format are realistic as they reflect real a real life situation where respondents are often surveyed about the provision of public goods and the respondent also has no real reason not give a true answer. On the other hand, respondents who are actually willing to pay may prefer to offer negative answer for several reasons as indicated by Arrow *et al*., (1993:22), firstly, the respondent might be of the opinion that the proposed scenario distributes the burden in an unfair manner, secondly, the respondent might doubt the feasibility of the proposed action and feel that making a contribution towards such an action would be a waste of money, thirdly, the respondent may simply just be averse to paying taxes or hold the view that someone must pay for the action, fourthly the respondent may be of the opinion that his / her contribution will not influence the outcome and lastly, the respondent might not have sufficient information about the item being valued. One of the disadvantages of this format is that it does not allow for variation in stated willingness to pay. The interviewer can only derive the maximum willingness to pay and not any other value in between. The format is also vulnerable to starting point bias as the pre-selected bids can have an influence on the final estimated willingness to pay value. In addition, the format is difficult to apply in situations where individuals may have already made a decision on their willingness to pay value (Venkatachalam, 2004:107).

5.9.2.1.5 Double-bounded dichotomous choice format

The double-bounded dichotomous choice format assigns an additional bid to the original bid. The additional bid is dependent on the answer obtained in the original bid. The format is also known as the take-it-or-leave-it with follow up because of the additional bid. The format is considered to be statistically more efficient and makes it easier to locate the maximum willingness to pay from the survey data. The main disadvantage of the using this format is that it can

be relatively more expensive to apply as it requires a bigger sample size and its analysis involves the use of sophisticated econometric techniques (Venkatachalam, 2004:107-108).

5.10 VALIDITY AND RELIABILITY OF CONTINGENT VALUATION

Further criticisms levelled against Contingent valuation are based on the concepts of validity and reliability. In the context of Contingent valuation, validity refers to the extent to which the Contingent valuation method measures the true economic value of society. Reliability refers to the degree to which the results can be reproduced using the same instrument. There are three types of validity that can be measured, namely, content validity, criterion validity and construct validity. Content validity refers to the ability of the instrument to adequately measure - in the case of Contingent valuation studies – economic value. Criterion validity refers to the effectiveness of the measuring instrument in predicting outcomes. Construct validity refers to the extent to which the instrument measures what it is supposed to measure. Construct validity can be divided into two categories namely, convergent validity and theoretical validity. Convergent validity measures the correlation between two measures of the same theoretical construct. With regards to theoretical validity, a Contingent valuation study will be considered to be theoretically valid if the results of the survey conform to the underlying principle of economic theory. The section that follows discusses the factors that may affect the validity and reliability of Contingent valuation studies (Venkatachalam, 2004:107-108).

5.10.1 Factors affecting the validity of Contingent valuation studies

The validity of Contingent valuation studies can be affected by a variety of factors. Several of these factors are described in the sub-sections below.

5.10.1.1 Differences between willingness to pay (WTP) and willingness to accept (WTA)

The divergence between WTP and WTA can be described in terms of the compensating variation and the equivalent variation concepts. For a welfare

gain the compensating variation is the amount that an individual is willing to pay to experience the welfare gain, whilst the equivalent variation refers to the amount of monetary income an individual is willing to accept in lieu of the improvement in welfare (Nas, 1996:71). For a welfare loss, the compensating variation refers to the amount of monetary income that an individual is willing to accept as compensation for the loss of welfare, whilst equivalent variation refers to the amount of monetary income that an individual is prepared to sacrifice to be exempted from the welfare loss or to prevent the welfare loss from occurring in the future (Nas, 1996:71). Thus in theory, there is not supposed to be any divergence between results measured using either WTP or WTA. Both methods are used to measure individuals' willingness to pay and willingness to accept for a welfare change. Empirical studies have, however, shown that in most cases there is no convergence between WTP and WTA results (Vankatachalam, 2004:92). The divergence between WTP and WTA can be attributed to factors such as the existence of income and substitution effects, transaction costs and property rights. In empirical studies WTA values in most cases were found to be larger than WTP. Economists in general prefer the use of WTP over WTA, because WTA is considered not to be consistent with convergent validity as it does not adequately measure economic surplus (Vankatachalam, 2004:95).

5.10.1.2 Embedding effect

The embedding effect refers to a situation where the WTP value shows a large degree of variation for the same good. The variation is dependent on whether the good is separately valued or is valued as part of a more inclusive package. A good may attract a low WTP value when measured as part of more inclusive package rather than when separately measured, this can therefore; result in different surveys yielding different results for exactly the same good. Contingent valuation studies that contain embedding effects will not meet the theoretical validity criterion.

The embedding effect violates the rationality principle, namely, that more is preferred to less and that consumers are prepared to pay more for a larger quantity than for a smaller quantity, therefore studies that contain the

embedding effect will tend to be theoretically inconsistent. Proponents of Contingent valuation surveys however, argue that the marginal utility theory offers an answer to concerns regarding theoretical validity emanating from the embedding effect namely, that the marginal utility of an individual diminishes as more of the good is consumed. Advocates of Contingent valuation surveys also argue that the embedding effect may be a result of a poor study design such as poorly designed questionnaires, use of convenience sampling instead of probability sampling and self-administered questionnaires that generally tend to provide unreliable results (Arrow *et al*., 1993:9-11).

5.10.1.3 Sequencing effect

Different WTP values can be obtained based on the order of the good in a sequence (Vankatachalam, 2004:102). The sequencing effect can also render a study to be theoretically inconsistent. The sequencing effect can be eliminated through proper administration of the survey and also through allowing respondents to revise their bids at the end of the survey (Vankatachalam, 2004:102).

5.10.1.4 Elicitation effect

There are several elicitation formats that can be used to obtain respondents WTP values, the elicitation formats which include the following: open-ended question, payment card, bidding game, single-bounded dichotomous choice and the double-bounded dichotomous choice. Different elicitation formats can yield different WTP values. Empirical evidence reveals that in general the WTP value derived from dichotomous choice is larger than that of open-ended formats. In general, open-ended question formats tend to provide more conservative estimates. The conservative estimates produced by open-ended format questions can be a result of factors such as strategic bias, that is, respondents' tendency to understate their true preferences. In defence of this argument, Contingent valuation practitioners argue that the cognitive demands of the different elicitation formats differ and convergences of values when using different formats cannot therefore be expected. Factors such as

the type of good being valued, the cost of the survey and statistical techniques used will determine the elicitation format chosen (Vankatachalam, 2004:110).

5.10.1.5 Hypothetical bias

The hypothetical bias arises as a result of the hypothetical nature of the market in Contingent valuation. Divergence in values is often encountered when valuing hypothetical scenarios and real scenarios, with the valuations for hypothetical scenarios often being higher that of real scenarios. The hypothetical bias can be eliminated through ensuring that the respondents are familiar with the good being valued (Vankatachalam, 2004:112).

5.10.1.6 Strategic bias

Respondents can behave strategically in two ways, namely, free-riding and overpledging. Free-riding occurs when a respondent understates the value in order to influence a particular outcome, for instance, a respondent may underestimate the value on the expectation that others will pay enough for the good. On the other hand, overpledging occurs when a respondent acts on the expectation that his/her WTP value would influence the provision of the good in question. Many Contingent valuation practitioners do not consider strategic bias as a problem in Contingent valuation studies (Vankatachalam, 2004:112).

Proponents of Contingent valuation state the following in defence of the existence of strategic bias in Contingent valuation studies: Firstly, Contingent valuation survey does not provide sufficient data to enable strategic behaviour, secondly, respondents are made aware that a large number of them is being interviewed and therefore their stated WTP value, will not influence the overall outcome, thirdly, respondents are always reminded about their budget constraint and are therefore less likely to overstate their bids, lastly, respondents are less likely to understate their bids, especially when considering the fact that understating their bids may result in the good not being provided (Vankatachalam, 2004:113).

5.10.2 Reliability of Contingent valuation surveys

The reliability of Contingent valuation surveys can be achieved in two ways namely, testing for convergent validity and using the test-retest method. Convergent validity can be tested through comparing the results of Contingent valuation studies with the results of other revealed preferences methods such as hedonic-pricing. A prior expectation is that WTP values obtained through other revealed preferences techniques should be more than those obtained through Contingent valuation. The conclusion drawn from various empirical studies testing for convergent validity have confirmed that Contingent valuation studies are convergent. The second type of reliability testing, namely, test-retest method can be carried out through repeating a Contingent valuation survey that was conducted earlier in a community by using the same sample of households or a different sample within the same community. When using the test-retest method the time differential between the two surveys becomes very important that is, the two surveys must be conducted within a reasonable time of each other in order to eliminate the recall effect. The recall effect refers to a situation where respondents simply recall their answers for the previous survey and presenting them in the current survey (Vankatachalam, 2004:91).

5.11 FACTORS INFLUENCING WILLINGNESS TO PAY BIDS

The respondents' willingness to pay bids are influenced by a variety of factors. The factors discussed in this section are information and question type, opinion, per capita income, health and education (Pope & Miner Jr., 1988:384-386). These are discussed below:

- Information and question type - Benchmark bids tend to have an influence on bids. In a study conducted by Pope III and Miner Jr. (1988), respondents who were provided with a benchmark minimum bid tended to report a higher mean bid than those provided with an open-ended bid.

- Opinion of the respondent - Respondents who perceive the given pollution levels to be serious will tend to have a higher willingness to pay than those that consider the problem to be less serious. The respondents' opinion of

the seriousness of air-pollution is therefore positively correlated with their willingness to pay.

- Per- Capita Income - It would be expected that individuals with higher per capita incomes will reflect a higher willingness to pay than those with lower per capita incomes. On the contrary the study by Pope III and Miner Jr. (1988), showed that on average individuals in different income brackets were willing to pay roughly the same amounts for improvement of air-quality, thereby suggesting that air-quality is considered a necessity.

- Health - The mean bid for those with air-pollution related problems tends to be higher than for those without health problems.

- Education - Studies conducted by Lin and Van der Westhuizen (2006) found that strong correlation exists between levels of education and willingness to pay. On average individuals with higher levels of education tend to have higher willingness to pay bids than those with lower levels of education. On the other hand, it can be argued that highly educated individuals have higher per capita incomes and are therefore willing to pay more.

Hanemann (1994:32-38) argues that in spite of the measurement biases described in **Table 5.3**, Contingent valuation is still consistent with economic theory. Critics of Contingent valuation assert that people's valuations of their own personal circumstances should not be influenced by factors such as altruism, sense of loyalty and moral duty because these reflect the warm glow effect and tend to distort their true economic preferences. This criticism is however not valid as people maximise their own welfare as they deem it fit irrespective of their altruistic or selfish interests. Since Contingent valuation is hypothetical in nature, its critics doubt the validity of this method on the grounds that the income effects stated in Contingent valuation are generally lower than would be expected if revealed preferences were measured. It is further argued that an income elasticity of demand of less than one is reason enough to reject willingness to pay results.

Regarding the first criticism, when a range of public goods are measured the willingness to pay for a whole change in a group of public goods may be lower than the sum of the willingness to pay for changes in the individual items. With respect to the second criticism it should be noted that the income elasticity of demand for willingness to pay depends on the commodity being valued. One other major criticism of contingent valuation is that it contradicts the revealed preferences method which many economists tend to prefer. It should be noted however, that this method is very useful in measuring the value of public goods. Under market conditions people are well informed and rational; the same behaviour is however not displayed when it comes to public goods (Hanemann, 1994:32-38). This study made use of the Contingent valuation method as it is deemed suitable for this kind of study due to its ability to capture use and non-use values.

5.12 OBJECTIONSTO SURVEYS

Although survey-based methods are considered suitable for valuing non-market goods, surveys do have their own limitations and as such are subject to several objections, four of which are described below (Hanneman, 1994:26-29).

5.12.1 Vulnerability to response effects

The order of questions and the manner in which questions are phrased can have a significant influence on responses, for instance, the manner in which questions are asked can lead to respondents to provide satisficing answers; these are answers that the respondent thinks the interviewer will accept. However, this problem can be controlled through altering the order of items in the questionnaire (Hanemann, 1994:26-29). A second type of a response effect is change in meaning similar words can turn out to mean different things to different people. This problem can be addressed through the application of cognitive techniques. Cognitive techniques will enable the interviewer to understand what his questions mean to people and what they mean in their responses (Hanemann, 1994:26-29).

5.12.2 Creation of values

Critics of the contingent valuation method argue that respondents do not have real value for the environmental commodity, but spontaneously make up an answer during the interview process. According to the critics, contingent valuation responses do not reflect true economic value. This implies that the interview process create the values. Advocates of Contingent valuation however argue that this problem can be sorted through conducting a debriefing session which will reveal if respondents were not focussed and simply provided spontaneous responses (Hanemann, 1994:27-28).

5.12.3 Lack of training

According to the critics of the Contingent valuation method, ordinary people are not sufficiently trained and informed to value environmental goods. Contingent valuation is modelled along a referendum-style voting process which renders the issue of competency in valuing the environment irrelevant. In a contingent valuation survey people are asked to assign a value to a non-market environmental good. In a market situation people are well-informed and act rationally, the same cannot be said about people's conduct outside the market situation (Hanemann, 1994:29).

5.12.4 Lack of validity

People opposed to Contingent valuation maintain that the results of its surveys cannot be validated. There are three ways in which result of contingent valuation can be validated. Firstly, contingent valuation can be validated through replication, secondly, through comparison with estimates from other sources and lastly, through comparison with actual behaviour. A review of literature in the contingent valuation field reveals that there is significant evidence to support the view that results of contingent valuation can actually be validated (Hanemann, 1994:29-31).

5.12.5 Willingness to Pay (WTP) versus Willingness to Accept (WTA)

Two types of questions can be asked to elicit respondents' valuation of a non-market good. A question can be asked either in the form of willingness to pay or willingness to accept. Willingness to accept questionnaires tend to elicit valuation responses that are much higher than willingness to pay questionnaires. Several reasons lead to the divergence between willingness to pay and willingness to accept values. Firstly, in cases where the majority of the people experience diminishing marginal utility of income, losses of utility as a result of a decrease in income of a specific amount will be greater than the utility obtained from an increase in income of the same amount. Willingness to pay for a normal non-market good such as reduction in air-pollution is subject to an individual's budget constraint. Willingness to accept decisions on the other hand are not subject to such budgetary constraints. It will therefore, be expected that stated willingness to accept values will tend to be higher than the stated willingness to pay values. Secondly, goods with no close substitutes tend to reflect a higher degree of divergence between willingness to accept and willingness to pay values. Willingness to accept to allow environmental degradation will be much higher that the willingness to pay to prevent environmental degradation. The choice of willingness to accept to elicit values for environmental goods can lead to an overvaluation of the good. Lastly, the loss averting behaviour of individuals can also lead to the divergence between willingness to accept and willingness to pay values. Individuals face a convex value function for gains and a concave value function for losses.

The degree of concavity is much higher than the degree of convexity with the result that losses of a particular size have a greater impact than gains of a similar size. Therefore, an individual who is offered money to give away a right will consider such an offer as a loss. On the other hand paying money to acquire a right will be considered as a gain. Since individuals exhibit a behaviour the amount that individuals will be prepared to accept to give away a right will be higher than the amount the person is prepared to pay to acquire the right, that is, people will require more compensation for the loss of a right

than they will be willing to pay to acquire such a right (Medeme & Zerbe Jr, 1999:847-849). On the background of what has been discussed above, the study make use of a Willingness to Pay questionnaire to elicit information about the value that respondents attach to the reduction of air pollution in their area. As discussed earlier, this approach is more conservative and is less likely to lead to overvaluation.

5.13 STRENGTHS AND WEAKNESSES OF VALUATION TECHNIQUES

Economic valuation techniques have advantages and disadvantages as discussed in the preceding section. **Table 5.4** below provides a concise summary of the strengths and weaknesses of economic valuation studies.

Table 5.4: Summary of the strengths and weakness of valuation techniques

Valuation technique	Strength	Weakness
Hedonic Pricing	Very useful in high income areas, and relies on data that is easily accessible	Too reliant on well-developed property markets, and cannot be used to measure non-use values.
Travel Cost	Relatively cheap and relies on observable behaviour and very useful in valuing recreational facilities.	Highly sensitive to opportunity cost of time. Difficult to establish if travel is single or multi-purpose.

Valuation technique	Strength	Weakness
Replacement Cost and averting expenditure	Relatively cheap and relies on observable data and behaviour.	Losses from environmental degradation cannot be fully captured. Can only be used to assess current situations. Cannot be used to measure non use values.
The Production Function	Relatively cheap and easy to understand	May underestimate willingness to pay because it disregards averting behaviour.
Net Factor Income	Based on easily observable data	Can only be used to value current situations.
Cost of Illness	Relatively cheap	May underestimate willingness to pay because of its disregard for averting behaviour. Can only be used to assess current situations.
The Choice Experiment	Makes it possible to measure the implicit value of the attributes of a resource and eliminates some of the biases associated with Contingent valuation	Can be difficult to understand and expensive to implement due to high costs associated with surveys.

Valuation technique	Strength	Weakness
Contingent Valuation	Can be used to measure the value of any environmental good and does not rely on observable data or behaviour. It is the only method that can be used to measure non-use values. Results are very easy to analyse and interprete.	Vulnerable to a variety of biases. Low incomes may influence willingness to pay bids. Vulnerable to credibility problems.

Source: Abaza and Rietbergen-McCracken, 1998:5 (adapted).

Crookes and de Wit (2002:128-129) discuss the criticisms of economic valuation techniques in a more generalized manner without specific focus on any of these techniques. Crookes and de Wit (2002:128-129) also continue to present arguments in favour of economic valuation techniques. Some of the criticisms levelled against economic valuation techniques in general are discussed in the paragraphs that follow.

Firstly, monetary valuation techniques are very burdensome to implement, as they generally tend to encounter data and methodological problems. Data and methodological problems may arise as a result of aspects such as poorly designed valuation instrument which can lead to incorrect application of the technique thereby leading to incorrect results. The Contingent valuation method, for instance, is subject to several types of biases which negatively affect the validity and reliability of the results. Furthermore, some of the economic valuation techniques may be controversial in nature they may be ethically unacceptable, for example, adapting the findings of other studies – as is done with the benefit transfer principle – to local conditions can be viewed as being unethical. Secondly, the data collection process can be lengthy and costly; in addition data in developing countries may be unavailable or limited. Thirdly, time impacts may not be dealt with in a consistent manner by the different forms of assessment. Some impacts can

happen within a shorter time period, for example, within the lifetime of the project, whilst other impacts such as environmental impacts can extend even beyond a lifetime. Economic valuation techniques differ in the manner in which they deal with time. Cost-benefit analysis makes use of discounting to deal with the issue of time whist in other forms of assessment time may be disregarded. Lastly, economic valuation techniques have problems dealing with risk and uncertainty and in addition they treat distributional issues differently and in most cases inadequately (Crookes & de Wit, 2002:128-129).

Crookes and de Wit (2002:128-129) provide some mitigating factors against the criticisms discussed above. Firstly, economic valuation techniques are not the same, whilst others may be subject to problems related to methodology and data collection, economic valuation theory does offer a wide variety of valuation techniques, which leaves it to the practitioner to choose the more robust technique suitable to his/her study and which may not be subject to such shortcomings. Secondly, evaluation techniques can be improved through the design – in the case of Contingent valuation – of more realistic scenarios, and improving aspects of the study design such as questionnaire design. Thirdly, proponents of economic valuation advise that efficient communication of the findings and a clear exposition of the findings on which the study is based must form an integral part of the process. Fourthly, data availability problems can be addressed through improved data collection techniques. Lastly, issues related to time and scope can be addressed by adjusting the time horizon of the analysis to include an extended time frame suitable for environmental projects (Crookes & de Wit, 2002:128-129).

5.14 UTILITY MAXIMISATION AND WILLINGNESS TO PAY

This study adopts the stated preferences approach to the analysis of willingness to pay. This section begins by discussing the consumer utility maximisation framework which forms the theoretical basis for measuring willingness to pay, the section then proceeds by describing the Contingent valuation method employed in the study and concludes by specifying the empirical model for estimating willingness to pay The microeconomic basis for

a consumer decision process is based on consumer utility maximisation. Utility maximisation assumes that:

- The consumer has full knowledge of all the information relevant to his decision;
- The consumer is rational in that they will always choose a most preferred bundle from the set of feasible alternatives;
- The consumer can rank his preferences according to the satisfaction of each basket; and
- The marginal utility of a commodity diminishes as the consumer acquires larger quantities of it.

The preference function for an individual can be expressed as $u(x,q)$ where $x = x_1,\ldots.x_m$ is the vector of private goods and $q = q_1 = q_m$the vector of public goods. Individuals can choose private goods (x) whilst public goods (q) are exogenously determined.

An individual has a given income (y) which sets limits to his/her maximising behaviour, that is, income acts as a constraint in the attempt to maximise utility. The indirect utility function $v(p,q,y)$ is given by:

$$V(p,q,y) = \max_x\{u(x,p)|p * x \leq y)\} \quad 5.1$$

The minimum expenditure function $m(p,q,u)$ is the dual to the indirect expenditure function given by

$$M(p,q,u) = \min_x\{p * x|u(x,q) \geq u\} \quad 5.2$$

The derivative of the expenditure function yields the utility-constant demand function with the subscript indicating the partial derivative

$$x_i^u(p,q,u) = m_{pi}(p,q,u) \qquad 5.3$$

The negative of the ratio of derivatives of the indirect utility function yields the Marshallian or ordinary demand curve:

$$x_i(p,q,y) = \frac{-Vp(p,q,y)}{Vy(p,q,y)} \qquad 5.4$$

When $u(x,q)$ is increasing and quasi-concave in $q, m(p,q,u)$ is decreasing and convex in q and $V(p,q,y)$ is increasing and quasi-concave in q (Haab & McConnell, 2003:6).

Willingness to pay measures the maximum amount of income the individual will be willing pay for an improvement in their circumstances or a maximum amount an individual is willing to pay to avoid deterioration in circumstances (Haab & McConnell, 2003:6). For an individual willingness to pay is the amount of income that compensates for (or is equivalent to) an increase in the public good. This can be expressed as:

$$V = (p,q,y - WTP) = V(p,q,y) \qquad 5.5$$

Where q* ≥ q and increase in q are advantageous ($\frac{\delta V}{\delta qi} > 0$, implying that higher consumption levels of q lead to higher utility).

In this study the binary choice model is used to analyse the decision of paying for improved air-quality as this model is one of CVM's most commonly used instrument. A random utility framework is used to analyse binary Contingent valuation responses. The indirect utility for the jth respondent may be expressed as follows:

$$vy = vj(yj,zj,\varepsilon_y) \qquad 5.6$$

Where i = 1 is the situation when the CVM scenario is implemented and i = 0 is the condition before the CVM scenario is implemented. The jth respondent's discretionary income as indicated by yj, zj is the m-dimensional of vector of household characteristics and attributes, and εij represents that part of utility that is known to the respondent but unknown to the researcher. Applying the assumption that consumers are rational, the respondent chooses the alternative that provides the greatest utility. The jth respondent answers 'yes' to WTP at a given bid level tj if the utility at i = 1 is greater than the utility at i = 0 such that

$$v_1(yj - tj, zj, \varepsilon_{1j,}) > v_0(y_j, z_j \varepsilon_{0j}) \qquad 5.7$$

The random parts of the preferences are unknown to the researcher and therefore only statements about their probability may be made. The probability of a ''yes' response is that the respondent is better-off at i = 1 such that $v_1 = v_0$ and probability is

$$Pr(yes_j) = \Pr(v_1(y_j - t_j, z_j, \varepsilon_{1j}) > v_0(y_j, z_j, \varepsilon_{0j})) \qquad 5.8$$

The probability framework as stated above forms the basis for the empirical models used in this study.

5.15 ESTIMATING WILLINGNESS TO PAY

Binary choice models such as logistic and probit models are commonly used in environmental valuation studies to predict dichotomous outcomes. A study conducted by Carlsson and Johansson-Stenman (2000) used a two equation

probit model estimate the Willingness to Pay for improved air-quality in Sweden.In this study the estimated marginal effects for income and education were found to be positive and statistically significant which implies that an increase in these variables increases the probability of having a positive WTP.

Wang and Mullahy (2006) made use of a two part probit model to estimate firstly, the probability of an individual having any positive WTP and secondly, the level of WTP of the respondents with a positive WTP. According to this model total expected WTP equals the product of the probability of positive WTP and expected WTP which is conditional on the respondents with positive WTP. The model found that age has a negative relationship with the probability of a positive WTP. In line with the other studies Wang and Mullahy (2006) found that income has a positive relationship with the probability of positive WTP. Education was found to be positive but statistically insignificant. Wang and Mullahy (2006) also found that people responding to open-ended questions tended to have a lower probability of positive WTP.

In this section WTP is estimated using a regression analysis. The aim of a regression analysis is to determine the factors which cause the variation of the dependent variable namely, WTP. In this thesis a basic OLS regression could not be used to estimate WTP since WTP is a censored dependent variable. Using a basic OLS regression would yield negative WTP values which would not make sense from a theoretical point of view. In assessing an individual's willingness to pay for the reduction of air-pollution the researcher made use of an open-ended elicitation format wherein respondents could indicate if he/she is willing to pay for reduced air-pollution (i.e. "yes" or "no" answer) and how much he/she is willing to pay. WTP is regarded as a qualitative regressand i.e. a person is either willing to pay or not. The response variable can take only two values namely 1 if the person is willing to pay and 0 if not. As indicated above, the WTP variable is binary in nature. In order to analyse the dichotomous choices made by the respondents a logistic model is used as it is considered the most appropriate for this type of study. A logistic regression can be expressed as follows:

$$WTP = \beta_1 + \beta_2 x_i + u_i \qquad 5.9$$

Where WTP = 1 if the household is willing to pay and 0 if not.

X = representative of any variable (e.g. income) influencing willingness to pay.

In this study the following logistic probability function was used to analyse the household's dichotomous choices.

$$Pi = f(WTPi) = \frac{1}{1+e^{WTPi}} = \frac{1}{1+e^{-(xi\,\beta)_i}} i \;=\; i,\ldots\ldots n \qquad 5.10$$

Where P_i = is the probability that the ith household (as represented by head of household) will make a certain choice (i.e. answer = "yes") given the desired level of socio-economic characteristics contained in x_i and β is a vector of parameters. Therefore if 1 represents the probability that an individual will answer "yes" to the question asking whether he or she will pay for improved air-quality then 1-P_i will be the probability associated with answering "no". Thus,

$$1 - Pi = \frac{1}{1+e^{-WTPi}} \qquad 5.11$$

To estimate the odds ratio in favour of answering 'yes' or 'no 'the ratio of both probabilities must be calculated. The odds ratio is the ratio of the probability that an individual will answer 'yes' to the probability that he will answer 'no'.

$$\frac{p}{1-p_i} = \frac{1+e^{WTP_{i_1}}}{1+e^{-WTPi_I}} = e^{WTP_i} = e^{x_i}\beta \qquad 5.12$$

By taking the natural log of equation 5.12 the odds ratio in favour of those answering 'yes' becomes a linear function of x_i where x_i is a vector of subjective individual preferences for improved air quality and of their socio-economic characteristics. This can be expressed as follows:

$$Log\left\{\frac{p_I}{1-p_i}\right\} = WTP_i = x'_i\beta \qquad 5.13$$

The parameter vector β, cannot be interpreted as the direct effects on the probability of being in favour of reduced air pollution, rather, the parameters measure the change in the odds ratio for a change in a unit of an explanatory variable. The direct effects on the probabilities can be obtained by estimating the marginal effects. The underlying statistical model for the estimation of marginal effects is based on latent and continuous observable variable referred to as WTP_i* (Loureiro & Umberger, 2003:291). In the context of this thesis this could be interpreted as an individual's concern about improved air-quality. The observable variable as modeled by Loureiro and Umberger, (2003:291) represents a response to the dichotomous choice. The model can be represented as follows:

$$WTPi = I(0, \infty)\ (WTPi*), \qquad 5.14$$

Where $I_{(0,\ \infty)}$is an indicator variable that restricts the observable WTP to the positive domain, and $WTPi* = x_i'\beta + \varepsilon_i$. Therefore,

$$WTPi = \{\tfrac{1}{0}\}\ if\ WTPi* = x_i'\beta + \varepsilon_i \qquad 5.15$$

The ε_i represents independent and identically distributed random variables following a logistic distribution. A positive response will be observed if and only if the latent variable is greater than zero, on the other hand, a negative response (i.e. a 'no' answer) will be observed when the latent variable is less than or equal to zero. The logit model can thus be represented as follows

$$WTP = Log(\tfrac{Pi}{1-P_i}) = \beta_1 + \beta_2 X_2 + \beta_3 X_3 + ...\beta_N X_N + \varepsilon_i \qquad 5.16$$

In this study the model above (5.16) is adopted as stated below with the dependent variables as explained in **Table .5.5**

$$WTP = Log(\frac{p_i}{1-p_i}) = \beta_1 + \beta 2EDU + \beta 3EMP +$$

$$\beta 4Gender + \beta 5HHSize + \beta 6INC + \beta 7AGE + \varepsilon_i \quad 5.17$$

Table 5.5: Description of variables

Dependent variables	
WTP = $Log(\frac{p_i}{1-p_i})$	The logistic formula stated in terms of the probability that WTP = 1 if the household is willing to pay (p_i), and = 0 otherwise (1-p_i)
Independent categorised variables	
EMP	Employment status of the head of household
GEN	Gender of the head of household (Male = 1, Female = 0)
MAR	Marital status of the head of household (Married = 1, Not Married = 0)
Independent continuous variables	
EDU	Educational level of the head of household
HHSize	Household size – number of people in the household
INC	Household income (monthly)
AGE	Age of the head of household
Error term	
ε_i	The error term that follows a logistic regression

5.16 SUMMARY AND CONCLUSION

It is important that environmental assessment be conducted before undertaking any major project in order to establish the impact of such proposed projects on the environment. Human activities may lead to environmental degradation such as pollution (including air-pollution). It is on

this background that environment legislation is often promulgated to minimise the negative impact of human actions on the environment. This chapter began by providing a brief background to environmental legislation in South Africa. Secondly, it highlighted the importance of economic analysis over simple financial analysis through discussing Cost-benefit analysis (CBA). CBA is a valuation technique used to measure the efficient allocation of public resources. The CBA technique is much broader and covers the total social cost and benefits of interventions unlike financial analysis which considers only the financial aspects on an intervention.

The chapter also distinguished between indirect and direct valuation techniques. The indirect techniques discussed in this chapter are Hedonic pricing method, travel cost method, replacement cost method, averting expenditure method and cost of illness method. The direct methods discussed are the choice-experiment method and the Contingent valuation method. Whilst the study made use of a survey-based method such as the contingent valuation, it is shown in the last section of the chapter that such methods also do have their own limitations and objections have been raised against using such methods to value public goods. In conclusion, the chapter advocates for the use of Contingent valuation as it is the most suitable method to deal with goods which are not traded in any market. The chapter concluded by discussing the model which forms the basis of the estimation of WTP in this study.

CHAPTER 6

SOCIO-ECONOMIC ANALYSIS OF AIR POLLUTION IN BOPHELONG

6.1 INTRODUCTION

This chapter begins by providing a statistical analysis of the socio-economic characteristics of the population of Bophelong. The results of the survey are compared with the result of a similar survey conducted in Bophelong during 2009 (Slabbert & Sekhampu, 2009). The socio.–economic analysis is divided into three broad categories, namely, the demographic profile, labour force and attitudes of respondents towards environmental issues. The demographic section analyses aspects of the population such as gender distribution, marital status, composition of member of family, age distribution and education. The labour force section analyses the characteristics of the population in terms of employment status, duration of unemployment, sectors of employment, type of skills that the unemployed have, and the type of skills training required by the unemployed. The environmental section profiles the characteristics of the population in terms of assessing the attitudes of inhabitants towards the environment, assessing their perception on the type of action required to address environmental concerns, and establishing inhabitants' perceptions regarding responsibility for clean air.

In addition, the chapter looks at the impact of air pollution on the community through analysing the number of people affected by pollution related ailments. The second part of the chapter quantifies (through the Contingent valuation method (CVM) households' willingness to pay for reduction of air pollution in Bophelong. Quantifying the social cost of pollution would be beneficial to policy-makers through assisting them with information during environmental policy formulation process. In the last section of the chapter a regression was run on factors expected to influence willingness to pay bids. Because of a large number of zero bids a logistic regression was used where the willingness to pay was stated as either zero (not willing to pay) or one (willing to pay) instead of the basic OLS regression. Utilisation of basic OLS would

have produced negative willingness to pay values which would not be theoretically valid.

6.2 SURVEY DESIGN

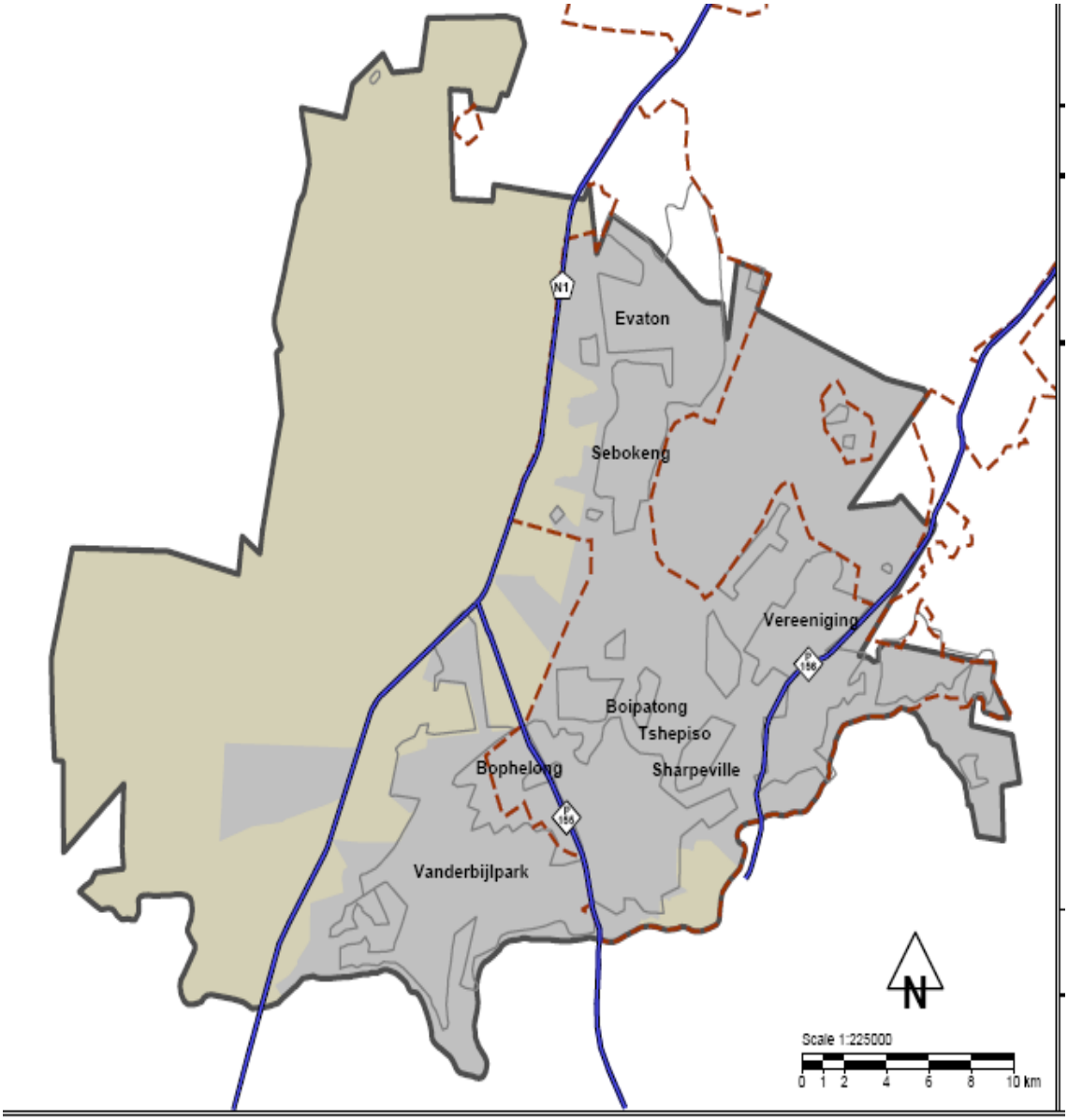
Approximately 300 households were visited and personally interviewed by trained fieldworkers. Of the 300 households interviewed in the survey only 285 were analysed. Fifteen questionnaires were destroyed due to incompleteness, largely due to the reluctance of respondents to answer questions pertaining to income. This survey has to a large extent attempted to adhere to the steps and guidelines of conducting a Contingent valuations survey as outlined in Chapter 5. Information was obtained mainly from the head of the household, spouse and children above the age of 18. The questionnaire made use of an open-ended question to elicit respondents' willingness to pay. Open-ended questions are deemed desirable as they generally manage to overcome the problem of starting point bias and secondly, they tend to provide a more conservative result as they tend to produce lower WTP than referendum type questions (Carlsson & Johansson-Stenman, 2000:662-663).The survey made use of probability sampling which is more statistically acceptable than convenience sampling. Face-to-face interviews were conducted at the homes of the respondents as home is the place where respondents are more likely to feel comfortable and are expected to provide well thought-out responses.

6.3 GEOGRAPHICAL LOCATION OF BOPHELONG

Bophelong Township is situated within the Emfuleni Local Municipality. Emfuleni Local Municipality is the biggest of three local municipalities that make up the greater Sedibeng District Municipality. The other two municipalities are Lesedi Local Municipality in Heidelburg and Midvaal Local Municipality in Meyerton. Emfuleni stretches about 120 km from east to west. It is bordered by Free State Province's Metsimaholo Local Municipality in the south, Midvaal to the east, Johannesburg Metropolitan area to the north, and the Northwest town of Westonaria to the west. Bophelong Township is located approximately 70 km south of Johannesburg and is linked to Johannesburg by two major routes, namely, the Golden Highway and N1 Highway. The

township was founded in 1955 mainly to accommodate Black labourers needed for industry in the Vaal region (IDP, 2007:7).

Figure 6.1 Geographical location of Bophelong



Source: Demarcation Board, 2008:6

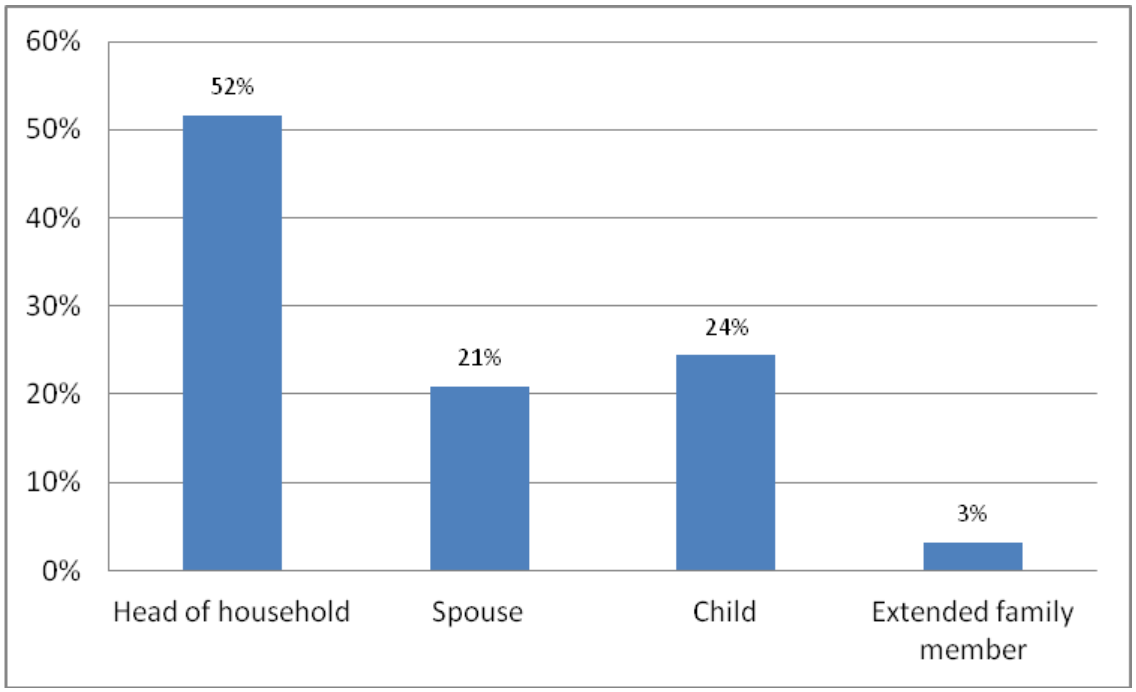
6.4 PROFILE OF THE POPULATION OF BOPHELONG

This section provides an analysis of the population of Bophelong. The analysis is divided into three broad categories, namely, the demographic profile, the labour force profile and the environmental profile.

6.4.1 Demographic profile of Bophelong

The demographics of Bophelong are analysed in terms of gender distribution, marital status, composition of households, age distribution and education.

Figure 6.2: Position of respondent



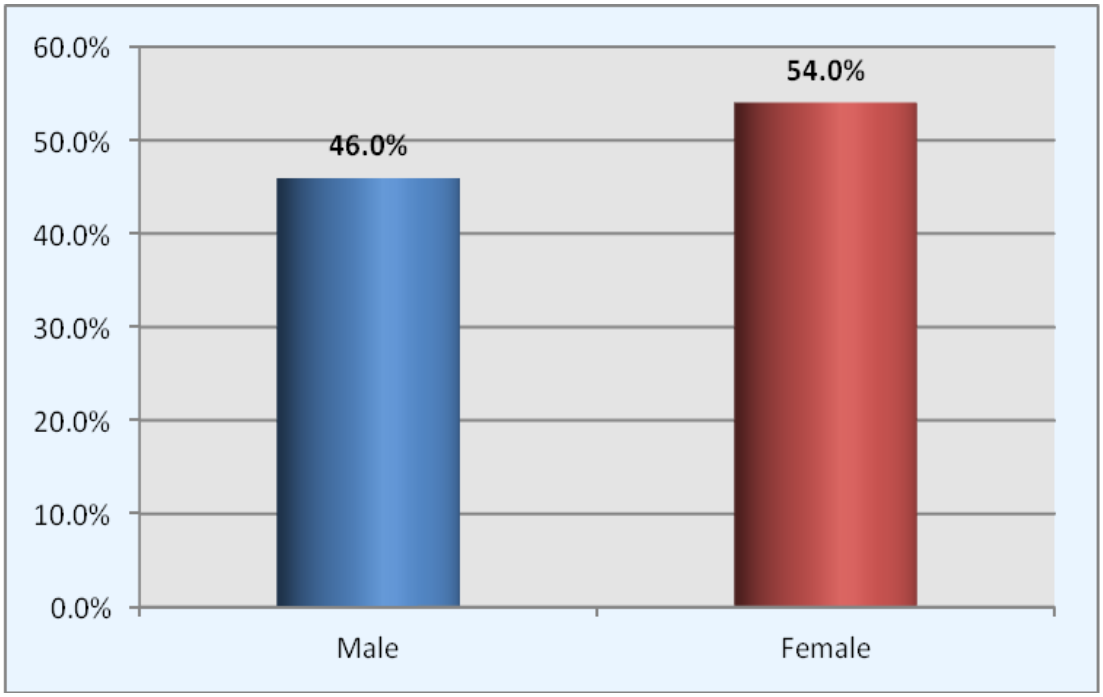
Source: Survey Data, 2012

Figure 6.2 above shows the respondents' position in the family during the site visit in 2012. Heads of households accounted for 52 percent of the respondents whilst 21 percent of the respondents were spouses. Child respondents who were mostly post-school unemployed youth accounted for 24 percent of the respondents. About 3 percent of the respondents were extended family members.

Figure 6.3 shows the gender distribution of the sampled population. According to the survey data 54 percent of the population was female whilst 46 percent was male. These figures are in line with other survey-based studies conducted in the area and also closely resemble the national figures. In the survey conducted by Slabbert and Sekhampu (2009:7) the gender distribution was estimated at 47 and 52 percent for males and females respectively. The national mid-year population estimates for Africans

published by Stats SA (2011:4) shows a national gender distribution of 48.4 percent and 51.6 percent for males and females respectively.

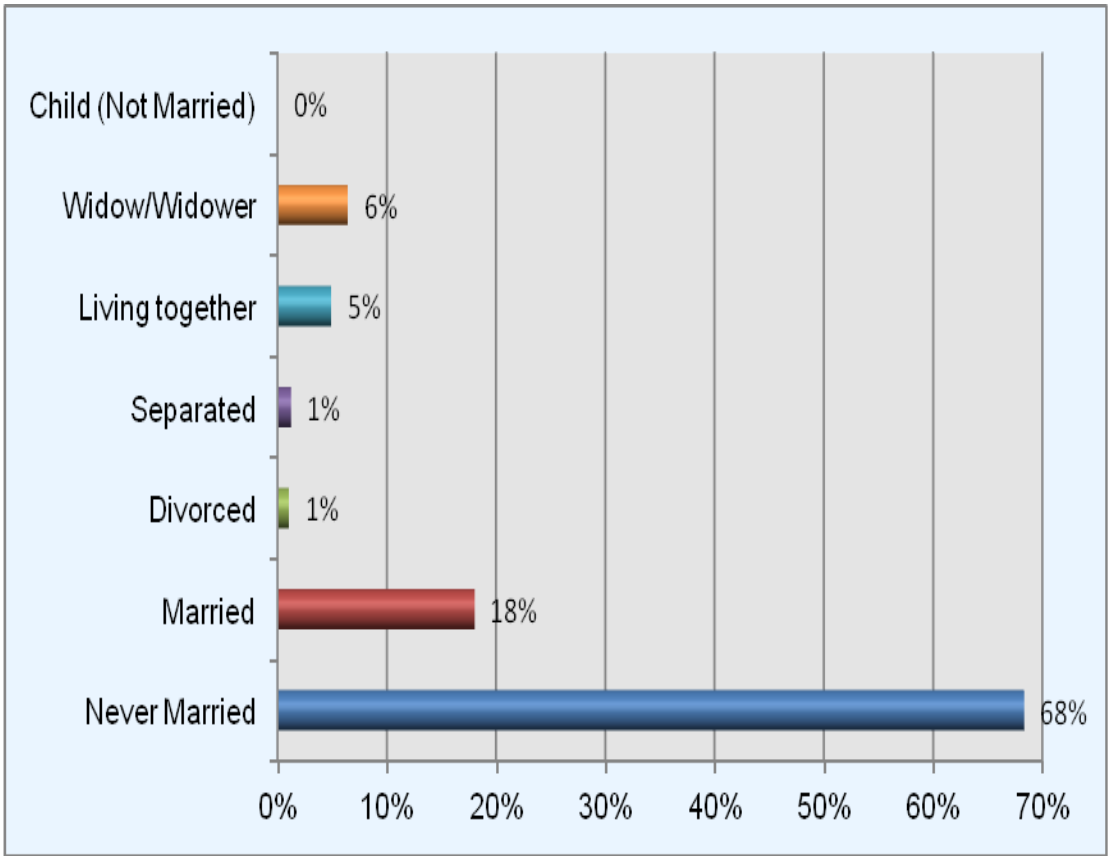
Figure 6.3: Gender distribution of population



Source: Survey Data, 2012

Figure 6.4 below shows a high prevalence of single parent mostly female-headed households in Bophelong. A survey conducted by Dubihlela (2010:61) among female-headed households in Bophelong revealed that only 10 percent of the respondents indicated that they were married. A comparative figure for the never married category for the entire sample population was estimated at 29 percent. These statistics show that single parent families are more likely to be headed by females than males. These figures will negatively impact on the income in the township as women are more likely to be affected by poverty than men (Slabbert & Sekhampu, 2009:16). Todaro and Smith (2011:237) also indicate that females are generally more likely to be poorer than their male counterparts; this is partly because the earning potential of women is generally less than that of men.

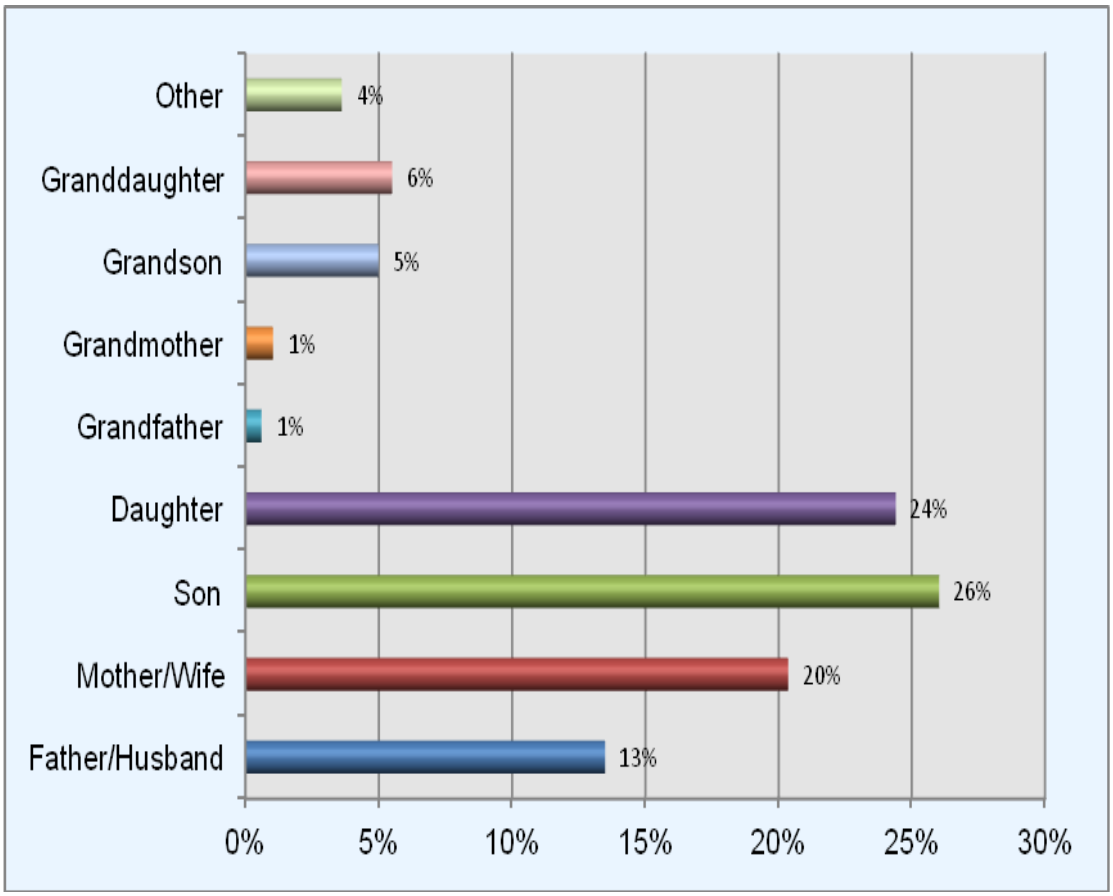
Figure 6.4: Marital status of the population



Source: Survey Data, 2012

Approximately 13 percent and 20 percent of the population indicated that they were either father/husband mother/wife respectively. This further confirms the findings in **Figure 6.4** that the majority of household in Bophelong are headed by females. The composition for son and daughter is 26 percent and 24 percent respectively.

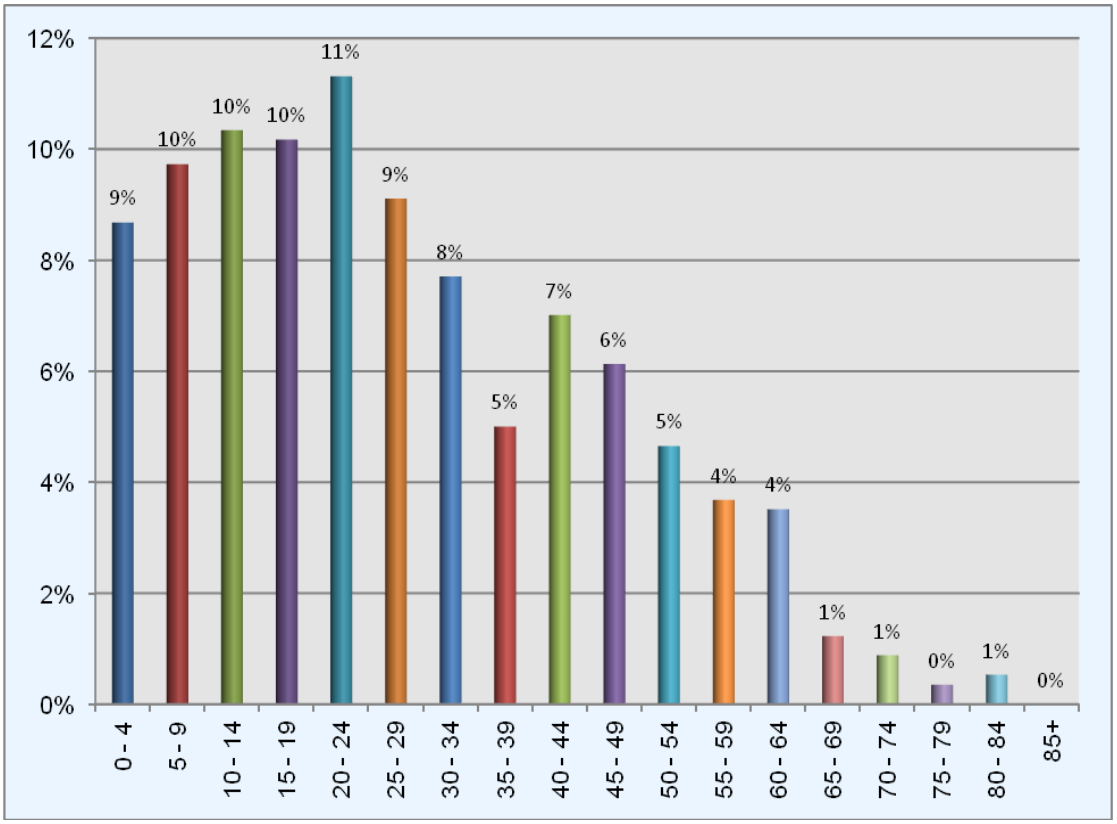
Figure 6.5: Composition of members



Source: Survey Data, 2012

Of the sampled population, 72 percent is below the age of 40 which is considered the age at which people in general are most productive. This compares favourably with the survey of 2009 conducted in the area which found that 77 percent of the population was below the age of 40 (Slabbert & Sekhampu, 2009:7). Stats SA's midyear population estimates shows that nationally, 79 percent of the African population is below the age of 40 (Stats SA, 2011:9). Almost 30 percent of the sampled population are children below the age of 15. This situation indicates a high dependency ratio (i.e. the proportion of young people under the age of 15 to the working population). This situation makes it more difficult for the working population to support those who are not working thereby increasing the likelihood of the existence of poverty in many households (Todaro & Smith, 2003:276).

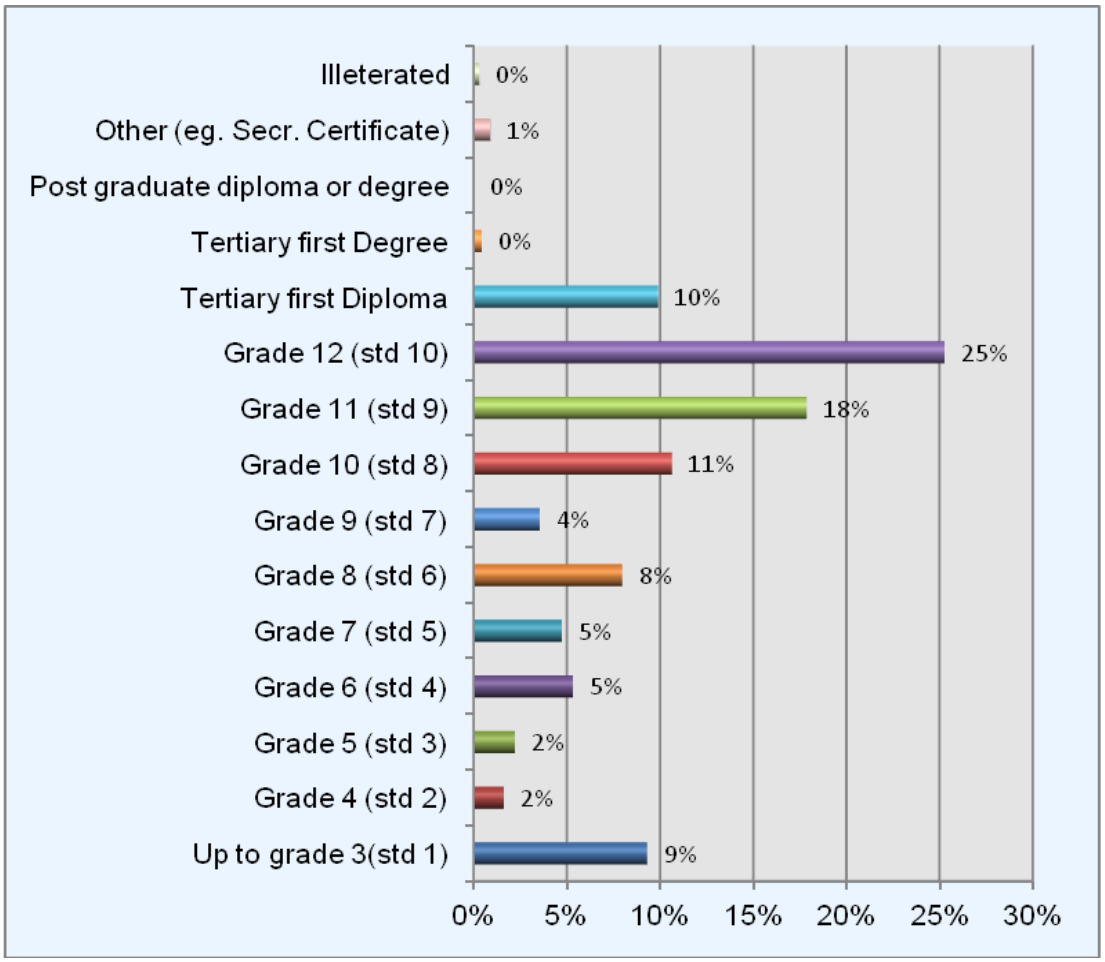
Figure 6.6: Age distribution of population



Source: Survey Data, 2012

Figure 6.7 shows that only 36 percent of the respondents, who were no longer studying, possessed a qualification of Grade 12 and higher. Approximately 10 percent of the population has a degree or diploma. This is also in line with the 2009 survey which found that 32 percent of the post-school population has attained a qualification of Grade 12 and higher, whilst only 11 percent had a degree or a diploma. This situation further entrenches poverty in the community of Bophelong. This is so because access to higher education affords an individual an opportunity to earn a higher income. Access to better paying jobs is also determined largely by a person's level of education (Todaro & Smith, 2011:377).

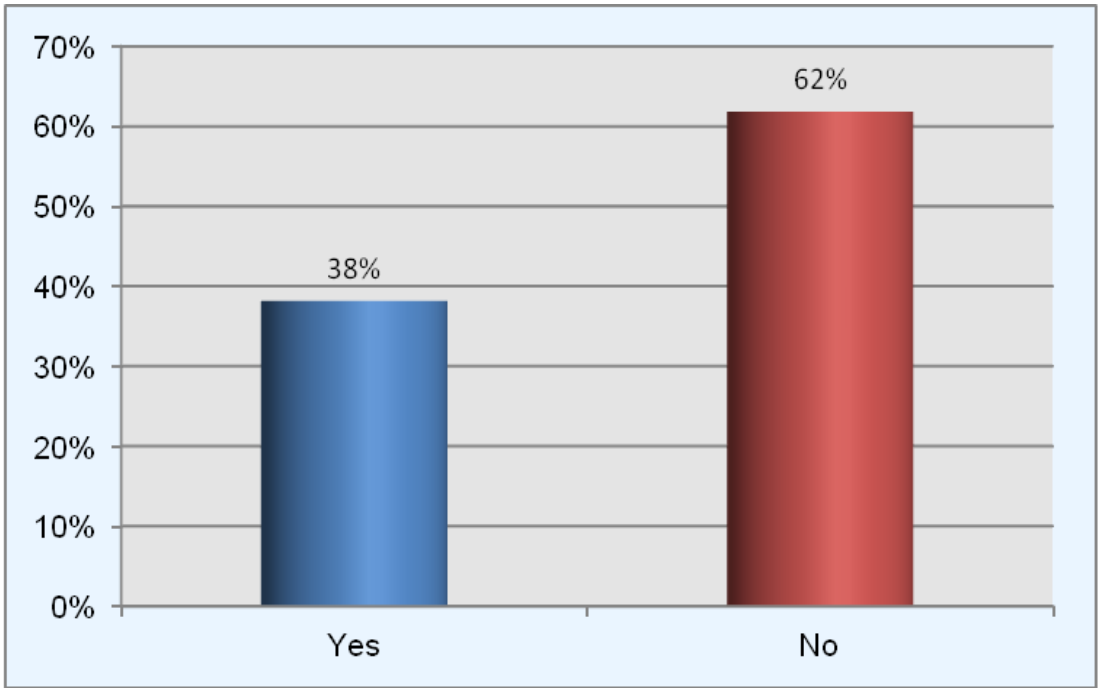
Figure 6.7: Qualifications of those not studying



Source: Survey Data, 2012

Approximately 62 percent of the population does not have a senior certificate. In the survey conducted by Slabbert and Sekhampu (2009:17), about 89 percent of the population had no senior certificate. The data shown in **Figure 6.8** shows an improvement in the educational levels in Bophelong over a three year period (2009-2012). This indicates that more and more people in Bophelong are realising the benefits of improving their educational qualifications.

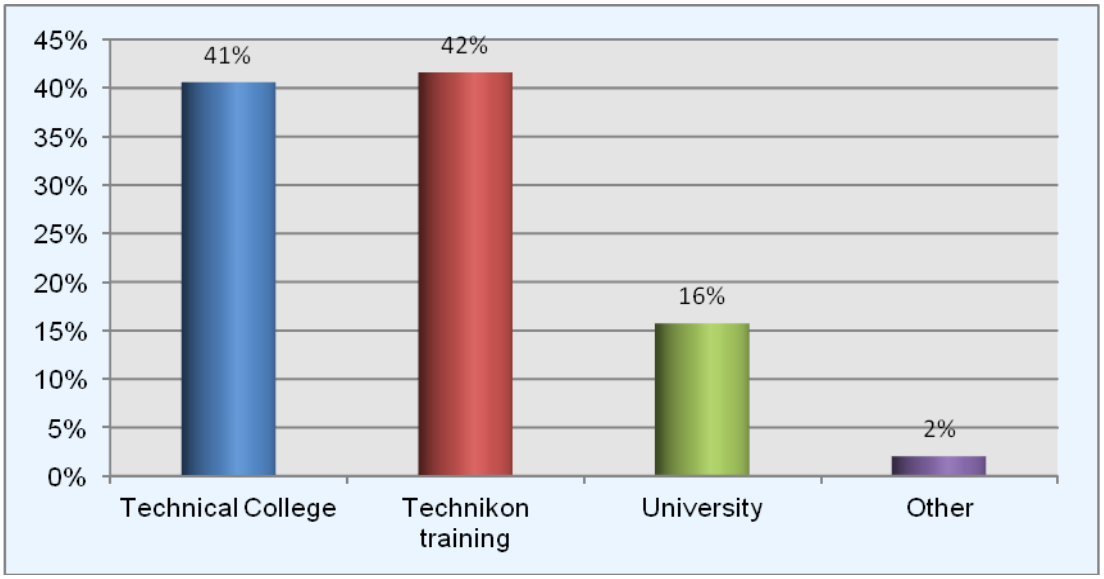
Figure 6.8: Population with senior certificate



Source: Survey Data, 2012

Figure 6.9 below shows that 83 percent of the population prefers to further their studies through technical and technikon training (now referred to as Universities of technology). This is in line with the levels of educational attainment in **Figure 6.8** above. Some of the programmes offered by these institutions do not require a senior certificate.

Figure 6.9: Preference to study further

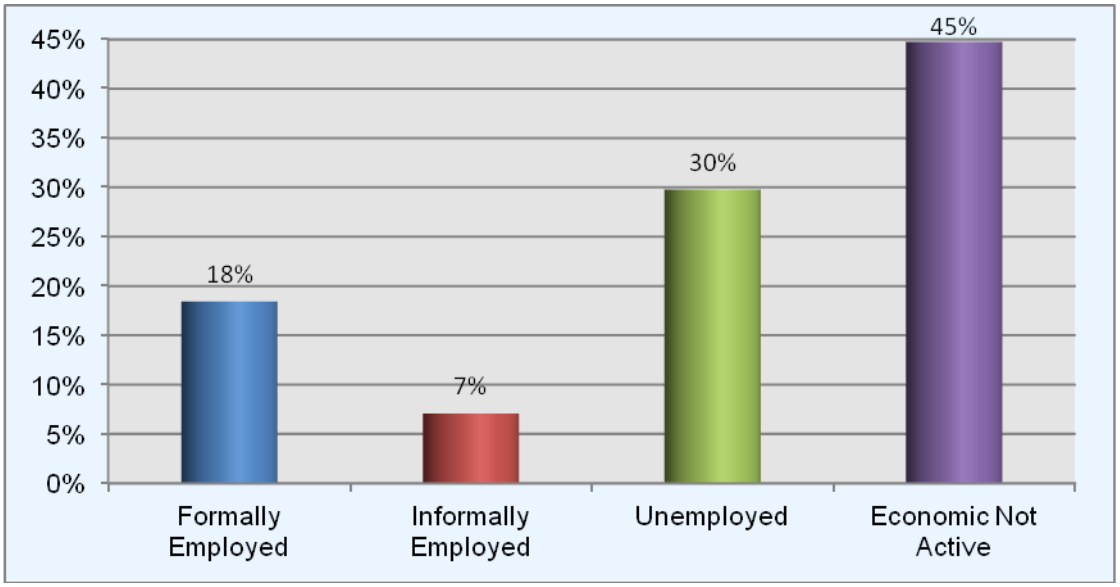


Source: Survey Data, 2012

6.4.2 Labour Force: Bophelong

The unemployment rate in Bophelong is calculated at approximately 54 percent. The unemployment rate is calculated by dividing the number of unemployed persons by the total number of people who are willing and able to work (i.e. the labour force) (Mohr *et al.,* 2008:66). This shows a decrease from the 2009 survey which showed an unemployment rate of approximately 62 percent.

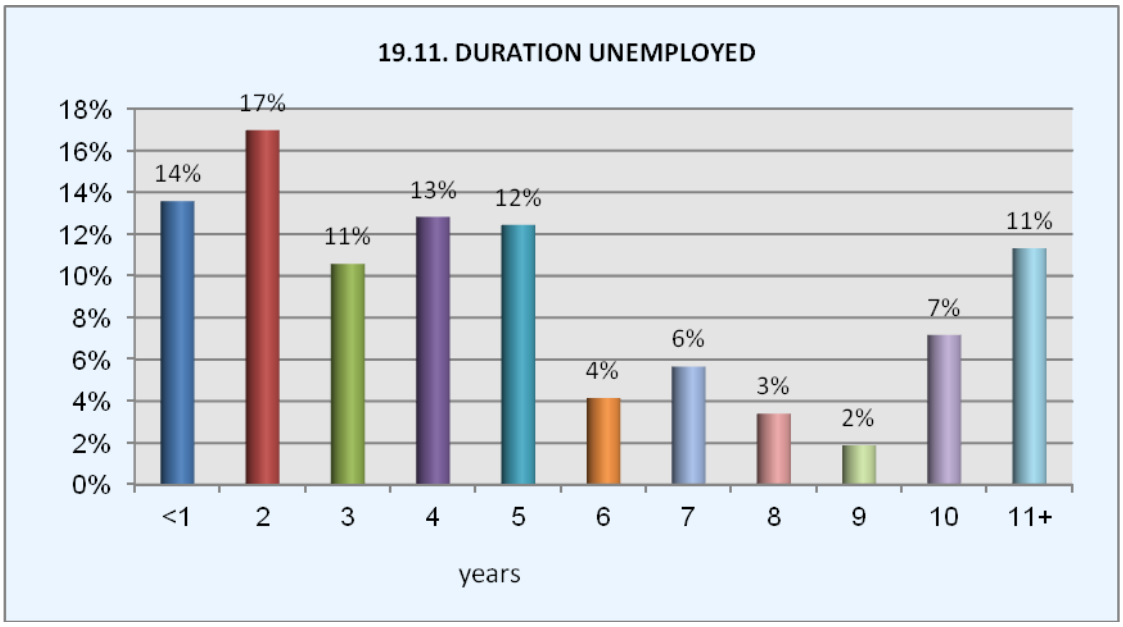
Figure 6.10: Employment status of the population



Source: Survey Data, 2012

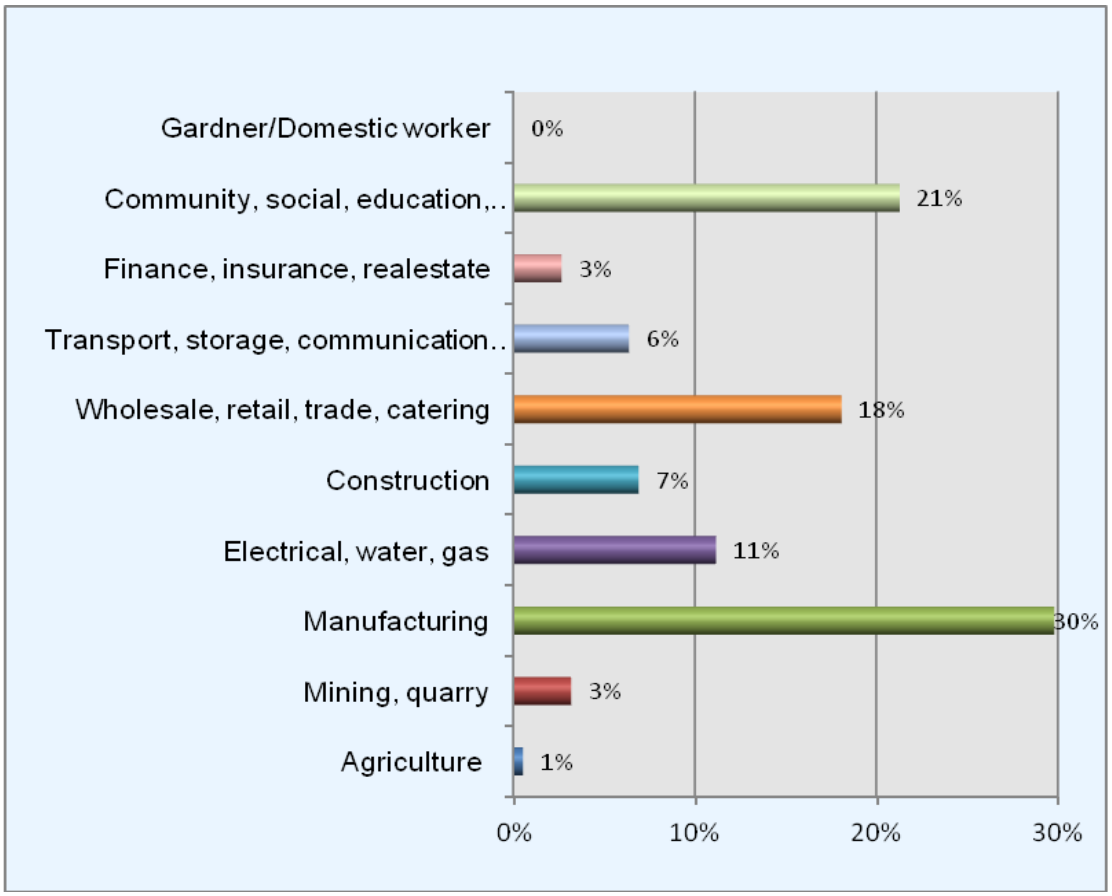
Figure 6.11 below shows the duration of unemployment in years. About 14 percent of the unemployed were unemployed for a period of one year or less, whilst 18 percent of the population has been unemployed for a period of more than 10 years. In 2009 the same percentage of the population i.e. 14 percent were unemployed for a period of one year or less whilst 28 percent were unemployed for more than 10 years.

Figure 6.11: Duration unemployed



Source: Survey Data, 2012

Figure 6.12: Sector of employment

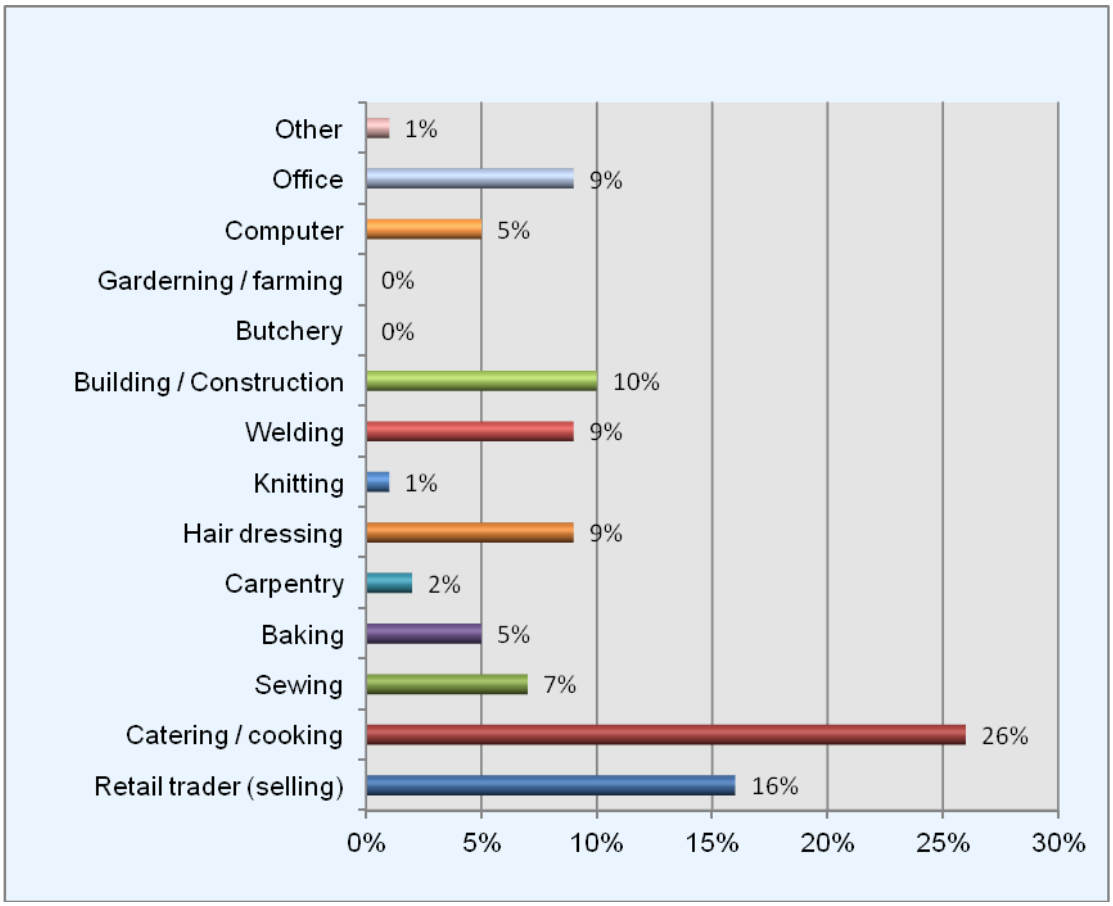


Source: Survey Data, 2012

Figure 6.12 indicates the sectors in which the employed people of Bophelong are working. Approximately 30 percent of those employed work in the manufacturing sector. About 21 percent work in the community social and education sector. In 2009, only 9 percent of the population were employed in the manufacturing sector, whilst the same percentage of the population was employed in the community, social and education sectors.

As with the 2009 survey, the 2012 survey also found that the majority of the unemployed has cooking and catering skills. In 2009, 25 percent of the unemployed possessed these skills compared to 26 percent in 2012.

Figure 6.13: Skills of unemployed

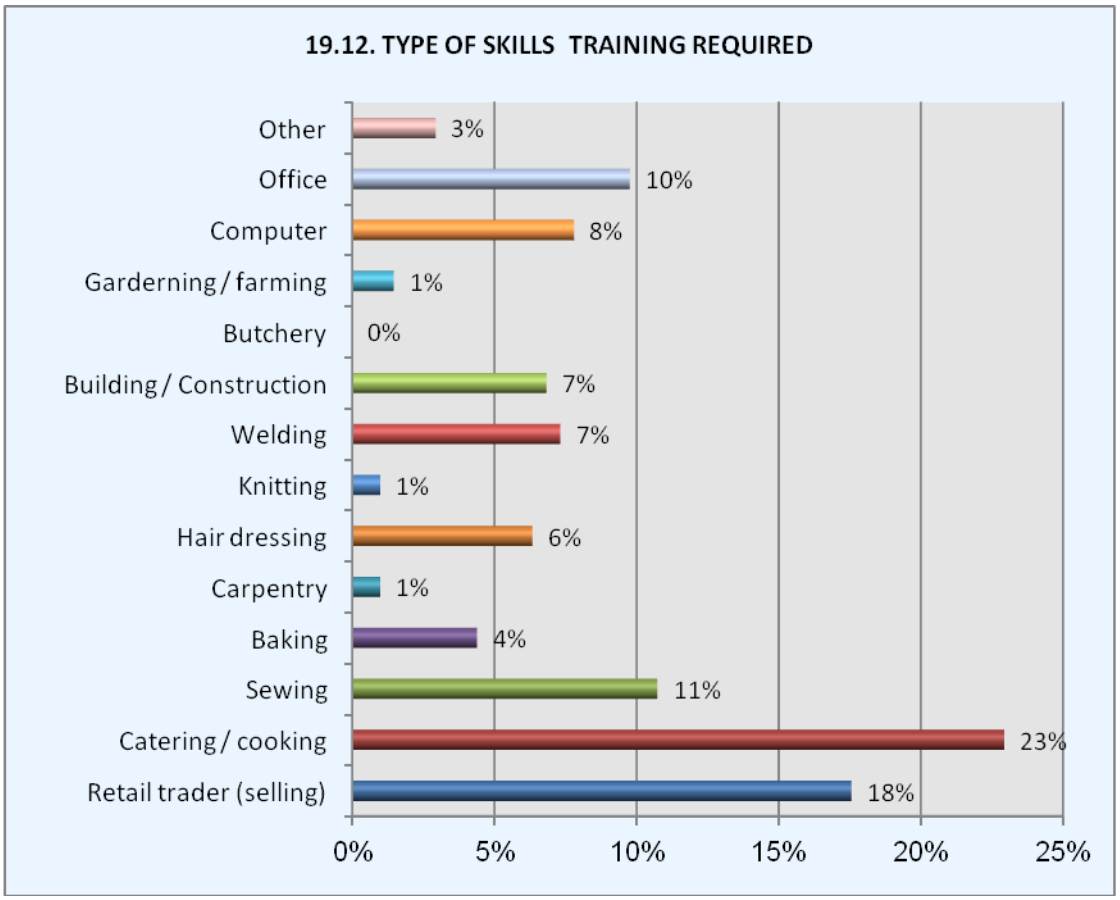


Source: Survey Data, 2012

The survey results indicate that many of the unemployed people require training in areas in which they already possess some skill. **Figure 6.13** shows that 26 percent of the unemployed have skills in catering and cooking, whilst an almost similar percentage require skills training in that field. Similarly, 16

percent of the unemployed have retail trade skills and 18 percent require training in that field. A strong positive correlation exists between the information in **Figure 6.13** and that in **Figure 6.14**.

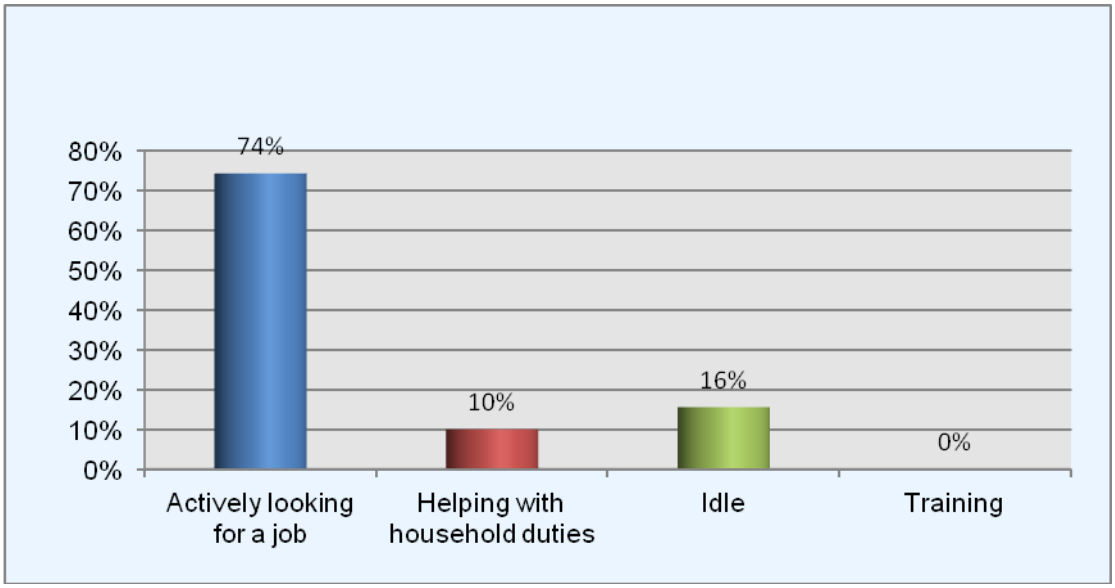
Figure 6.14: Type of skills training required



Source: Survey Data, 2012

As shown in **Figure 6.15** the majority of the unemployed population is actively seeking employment, with only 16 percent sitting idle. This shows that the official definition of unemployment (i.e. the strict definition) is the most appropriate for recording unemployment statistics in the area.

Figure 6.15: What the unemployed is presently doing

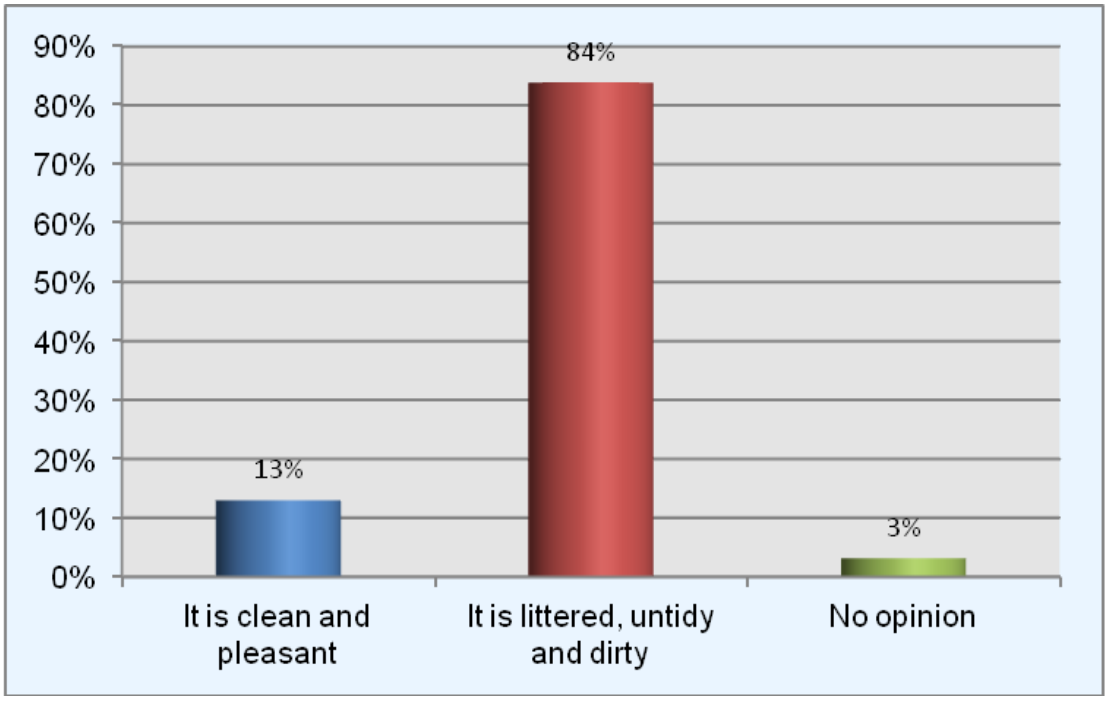


Source: Survey Data, 2012

6.4.3 Environmental Issues

Bophelong Township is a low-income settlement afflicted by high levels of unemployment and poverty. The unemployment rate as calculated in the survey conducted in this study is 54 percent. Educational levels are also low with only 36 percent of the population out of school having qualifications of Grade 12 and higher. There is a positive correlation between poverty and environmental degradation. Beall *et al.* (2002:833) reflects on this positive correlation by stating that poor people are seen as villains as they tend to perpetuate environmental degradation. This section provides an environmental analysis for Bophelong Township. The profile covers aspects such as perceptions of the population about their living environment, the community's views regarding who should be responsible for a cleaner environment, the degree to which the population is affected by pollution related diseases, evaluating the community's willingness to pay for a reduction in air pollution etc.

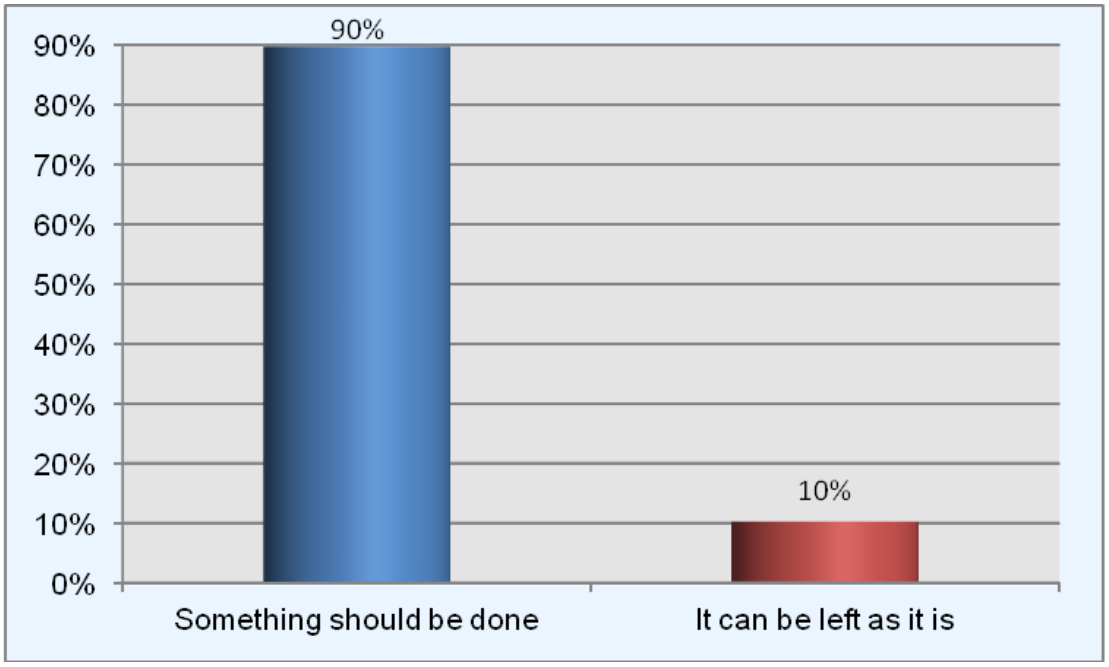
Figure 6.16: Perceptions about the environment



Source: Survey Data, 2012

The questionnaire also asked residents to state their opinion about the condition of the environment. Approximately 84 percent indicated that they consider the environment to be littered and untidy and that something should be done about it, whilst only 13 percent felt that the environment is clean and pleasant and as such should be left as it is. These results compare favourably with the 2009 survey in which 81 percent of respondents were of the opinion that the environment is littered and untidy whilst 18 percent felt that it is clean and pleasant (Slabbert & Sekhampu, 2009:25).In a survey conducted by Nova Institute (2009) in seven townships that fall under the jurisdiction of the Emfuleni Local Municipality (including Bophelong), 94 percent of the respondents indicated that they are concerned about air pollution. The results above show that residents of Bophelong, in line with the residents of other townships in the area, are increasingly becoming aware of the importance of environmental amenities such as clean air.

Figure 6.17: What should happen to the condition of the environment



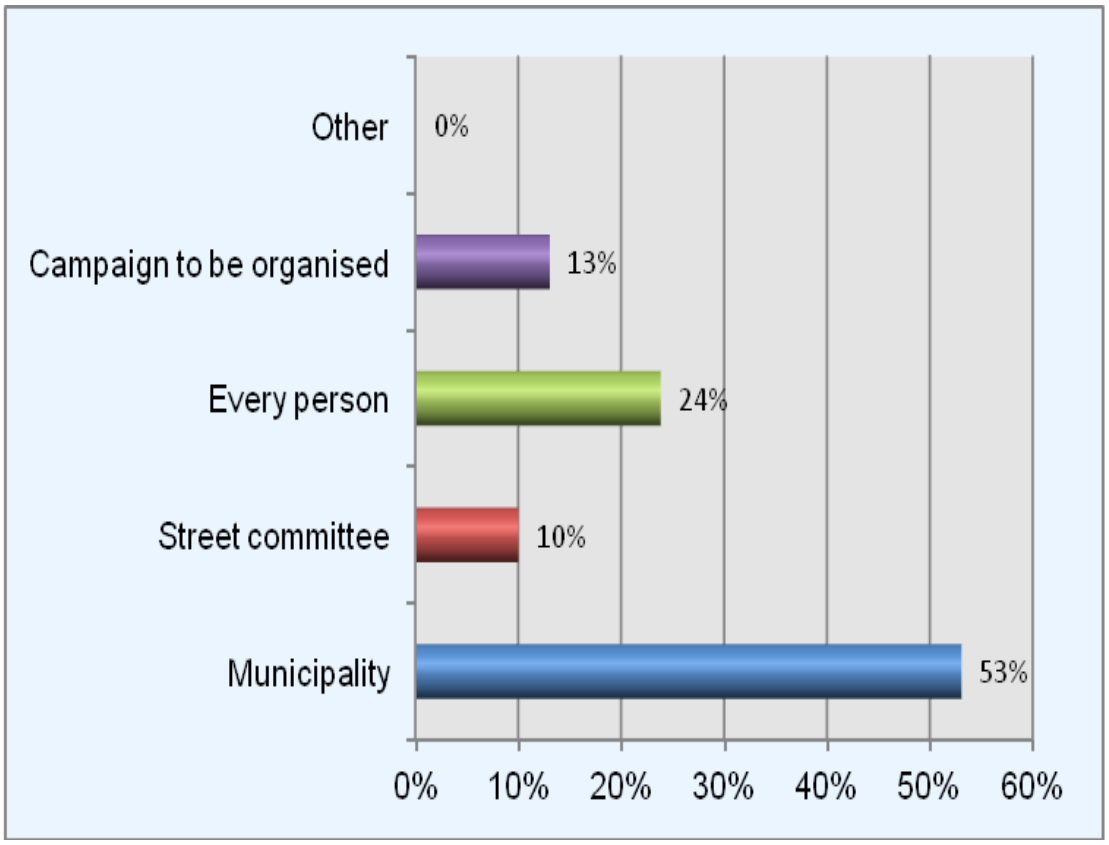
Source: Survey Data, 2012

It is clear from **Figure 6.17** that residents of Bophelong believe that they are exposed to dangerous levels of air pollution. In line with this belief, approximately 90 percent of the population indicated that some action needs to be taken to clean the environment and 10 percent felt that the environment could be left as it is. In the 2009 survey, 96 percent of the population was of the opinion that some action needs to be taken whilst 4 percent felt that nothing should be done.

As shown in **Figure 6.18** the majority of those who felt that the environment is untidy, (53 percent) were of the opinion that the municipality should be responsible for cleaning the environment, whilst 24 percent were of the opinion that everyone must take responsibility. In 2009, 51 percent of the population regarded the municipality as being responsible for cleaning the environment. Given that residents believe that the greatest impact of air pollution on their health comes from industrial sources (Nova Institute, 2009), it is logical that they would expect that the government should bear the burden of the social cost of pollution. Implicit in the statement above is that the government should levy pollution taxes on polluting industries since it is the role of the government to deal with issues associated with market failure,

among them, external costs imposed on residents by polluters. According to the Pigouvian theory such a tax will be the equivalent of the difference between marginal private benefits and marginal social costs (Dragun, 1985:113).

Figure 6.18: Accountability for a clean environment

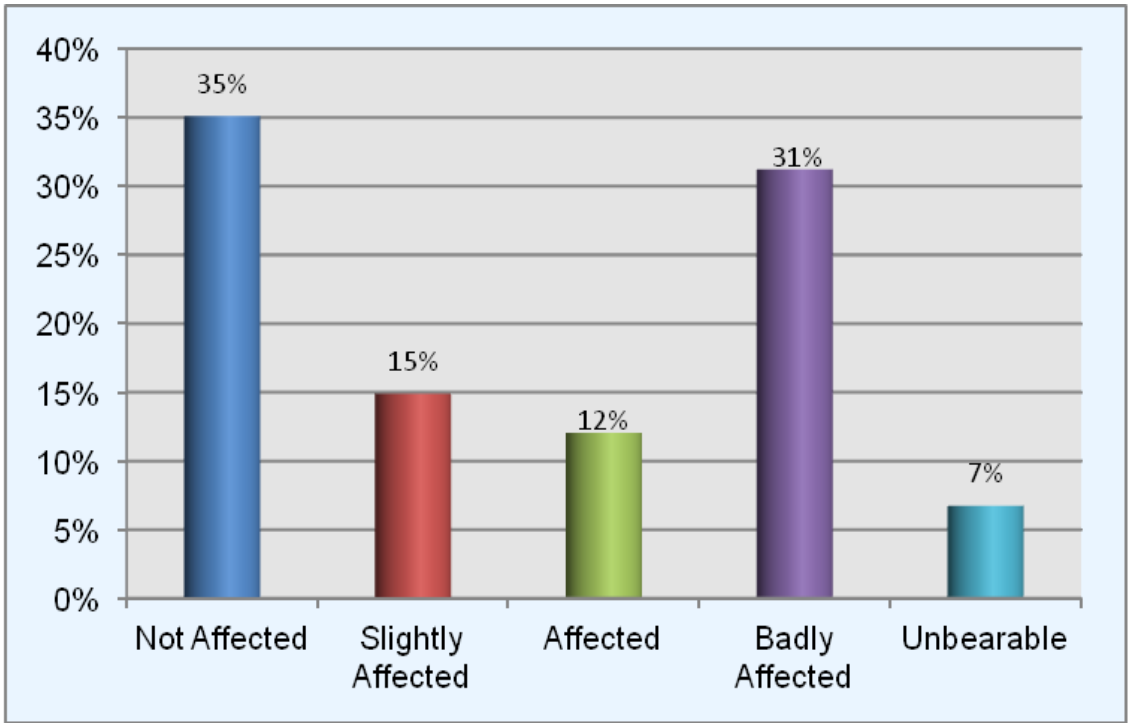


Source: Survey Data, 2012

With regard to air pollution, **Figure 6.19** shows that 35 percent of the respondents indicated that they were not affected by pollution, whilst only 31 percent indicated that they were badly affected, and 7 percent felt the situation was unbearable. Statistics in the same category in 2009 showed that 44 percent of the population indicated that they were not affected by pollution whilst 35 percent indicated that they were badly affected. Approximately 10 percent felt that the situation was unbearable. Although the residents of Bophelong are aware that they stay in a polluted area as indicated in **Figure 6.16** they seem to be unaware of the potential link between health and air pollution. Bickerstaff and Walker (1999:135) indicate that the link between air

quality and health is generally unclear and people may ascribe symptoms of asthma, headaches, fatigue, irritability etc. to other causes. In addition, although people might be aware of the existence of excessive pollution in their area, they may be reluctant to accept the potential for adverse effects to themselves (Bickerstaff &Walker, 1999:135).

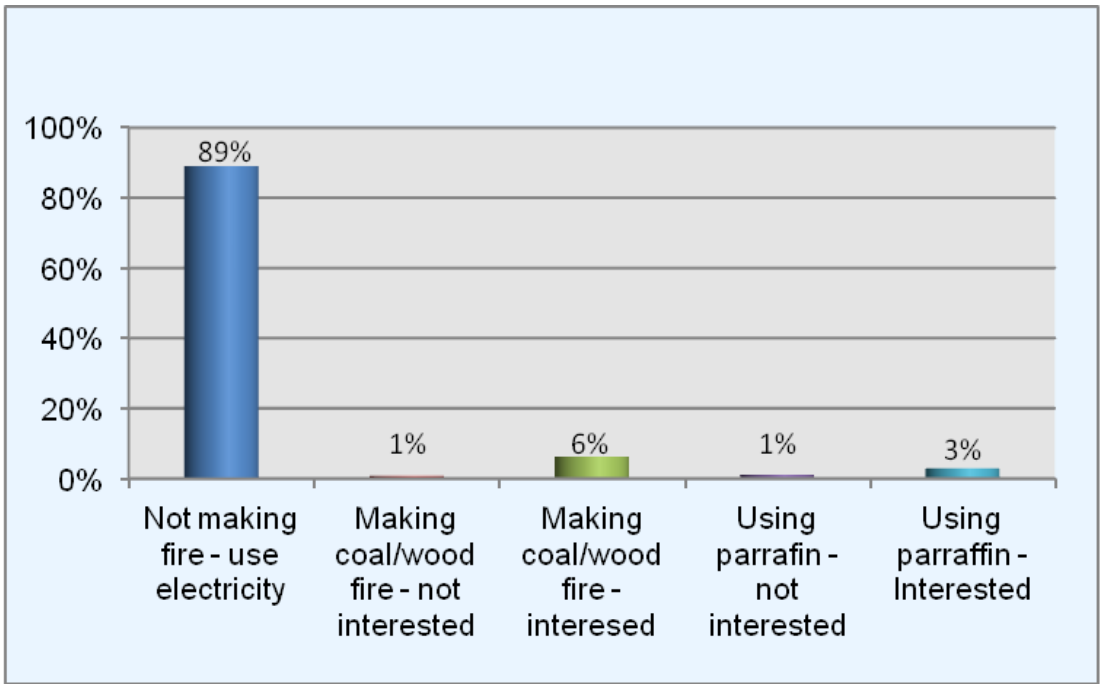
Figure 6.19: Population affected by air pollution



Source: Survey Data, 2012

Figure 6.20 shows that 89 percent of the population in Bophelong makes use of electricity for cooking and heating purposes. The majority of those who are not using electricity for cooking and heating are interested in learning about new technologies in cooking and heating. The 2009 survey reflect a similar pattern with 90 percent usage of electricity. All the houses that were visited by the fieldworkers for the purpose of this study were electrified. Approximately 11 percent of the respondents do not use electricity for cooking and heating. This could be probably because the residents consider electricity to be expensive and the free basic electricity offered by the government is not sufficient to meet all their electricity needs. Bond (1999:51) indicates that the provision of electricity without providing sufficient subsidy would not lead to behaviour change by the poor.

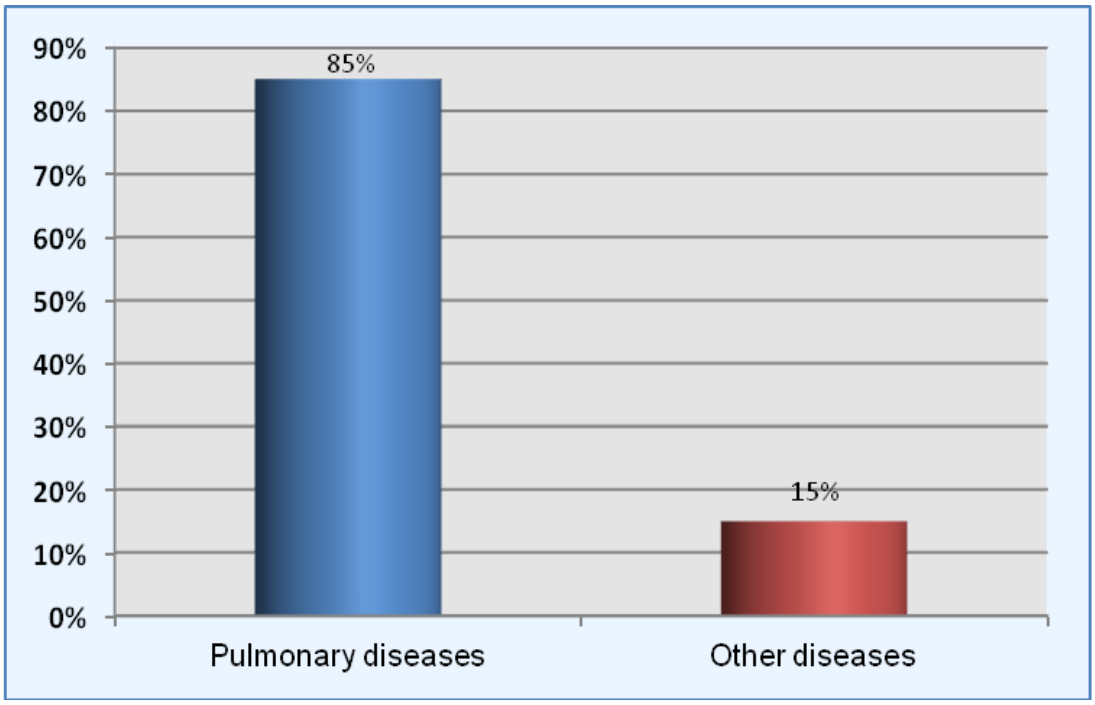
Figure 6.20: Interest in new heating and cooking technologies



Source: Survey Data, 2012

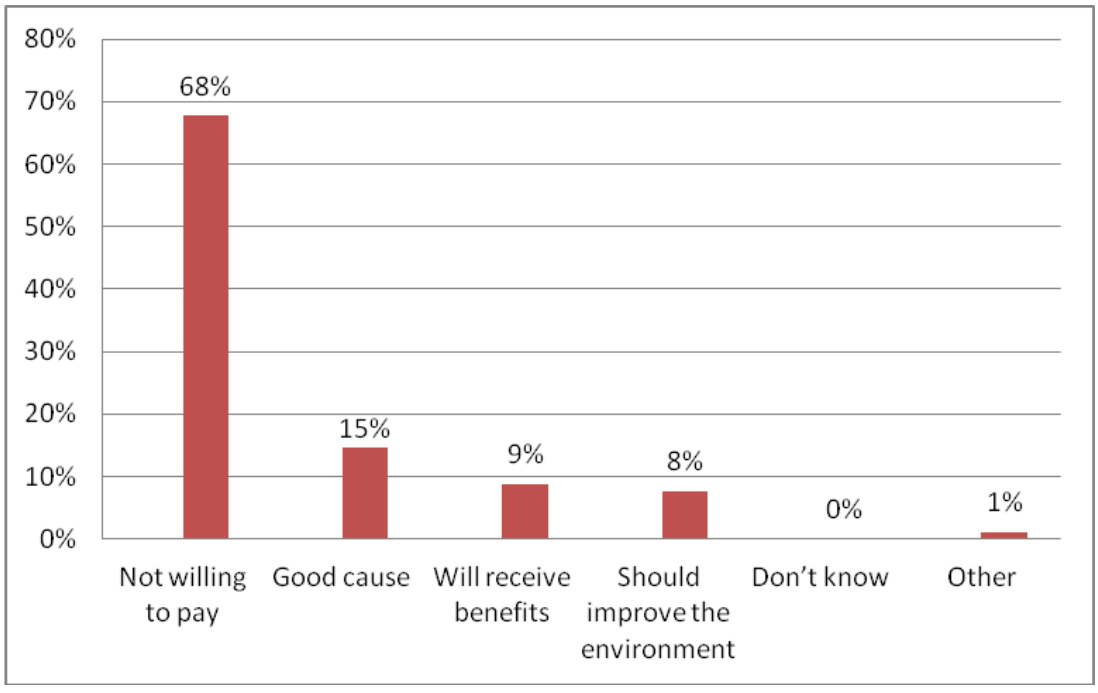
In spite of the fact that 50 percent of the population indicated that they were either slightly affected or not affected at all, **Figure 6.21** below reveals that of those suffering from pollution related ailments, approximately 85 percent suffered from pulmonary ailments thereby suggesting that air pollution is a major cause of sicknesses in the community. Many of the respondents who indicated that they suffer from pulmonary illnesses indicated that they were suffering from ailments such as tuberculosis (TB) asthma and pneumonia. These types of ailments can be linked to exposure to air pollution (WHO, 2002:9). The average amount spent on medical consultations for the sampled population was calculated at approximately R500 per year. Consultation takes place on average on a bi-monthly basis.

Figure 6.21: Pollution related sicknesses



Source: Survey Data, 2012

Figure 6.22: Reasons for willingness to pay



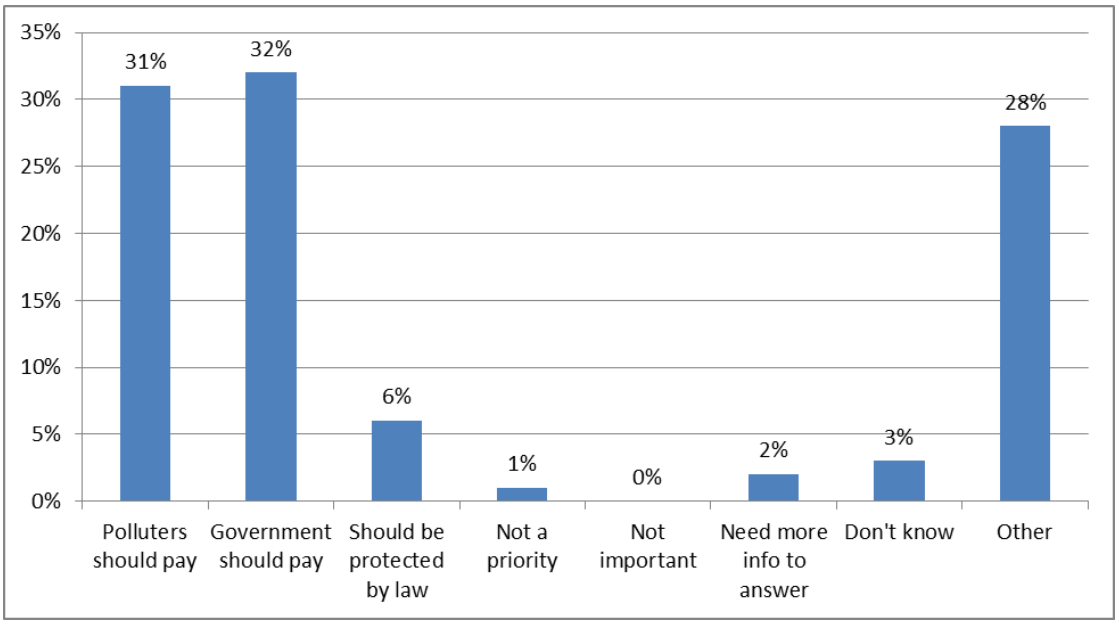
Source: Survey Data, 2012

In keeping with the results of **Figure 6.18**, approximately 68 percent of the respondents indicated that they are not willing to pay for a cleaner

environment. In adherence to the Contingent valuation literature, a follow up question was asked in instances where respondents indicated a zero response. There are several reason why a large percentage of residents were not willing to pay or expressed low bids for the reduction in air pollution in their area, firstly, one reason cited for not willing to pay as indicated in **Figure 6.23** below is that the respondents either felt that polluters should pay (31 percent) or it is the responsibility of government to pay (32 percent). Secondly, one of the problems with the Contingent valuation method is that respondents may not understand the hypothetical question being asked and may therefore, struggle to attach any monetary value to the environmental good being valued (Chanel *et al*., 2006:821). Thirdly, the survey made use of an open-ended question format. Open-ended questions are known to produce conservative estimates of willingness to pay and may even produce a high number of zero bids (Venkatachalam, 2004:106).

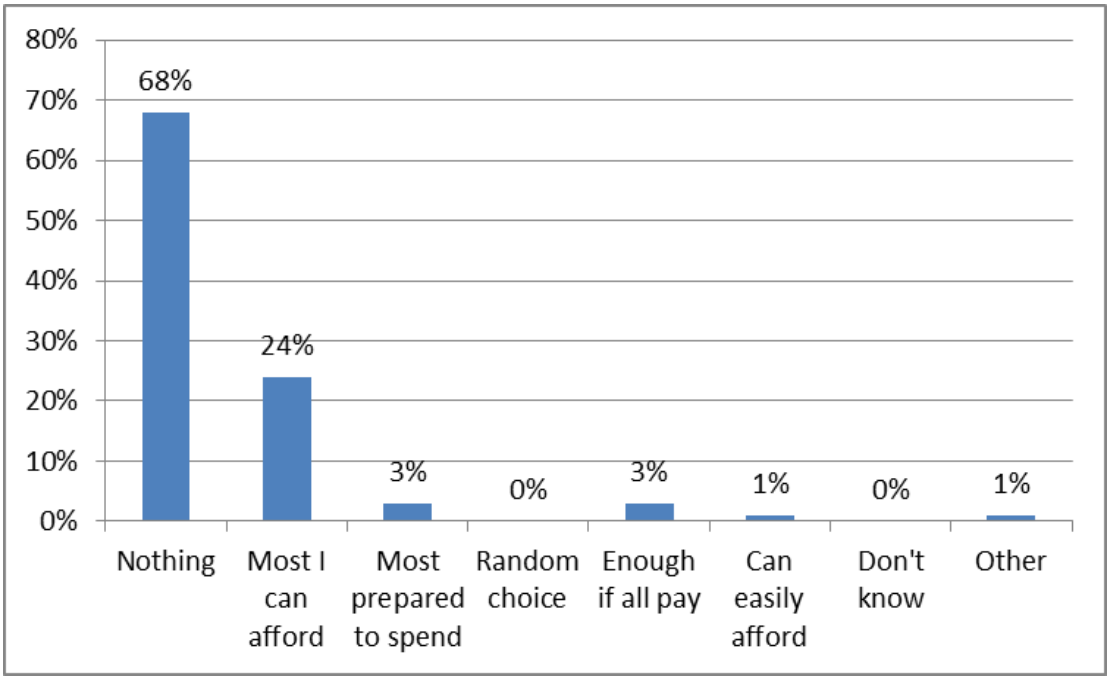
The study made use of the open-ended format because it did not want to overestimate the social cost of air-pollution in Bophelong. Fourthly, the open-ended elicitation format made use of a willingness to pay question rather than willingness to accept question. A willingness to pay question generally yield lower estimates than willingness to accept because the willingness to pay is tied to the respondent's ability to pay which is not the case with willingness to accept (Beder, 2005:5). Fifthly, willingness to pay may also be affected by various factors such as lack of information about the good being valued and opinion. For instance, many of those who indicated that they are not affected by air-pollution stated low willingness to pay bids as opposed to those who indicated otherwise. Lastly, with Bophelong being a low-income settlement it would be expected that the estimated willingness to pay would be lower as willingness to pay is a function of ability to pay.

Figure 6.23: Reasons not willing to pay



Source: Survey Data, 2012

Figure 6.24: Reasons for choosing amount



Source: Survey Data, 2012

Of those who were willing to pay, 24 percent indicated affordability of their stated bid as the main reason they were willing to pay for a reduction in air pollution in Bophelong

A mean monthly rand value of R11 was stated. This is the average amount households are willing to pay to have a cleaner environment. Approximately 28 percent of the population cited affordability as their main reason for choosing the amount they were willing to pay

6.5 DATA ANALYSIS

Table 6.1 reports on descriptive statistics for variables included in the survey. The mean WTP to reduce air pollution in Bophelong is approximately R132 per annum (the annual figure was obtained by multiplying the mean WTP of approximately R11 by the number of months in a year). The annual social cost of pollution in Bophelong can be calculated by multiplying the mean annual WTP with the estimated total population of Bophelong. Bophelong's population was estimated at 49 408 in 2009 (Slabbert & Sekhampu, 2009:2). The annual social cost of pollution in Bophelong is thus estimated at R6 521856.

Table 6.1: Descriptive statistics

Variable	Description	Mean	Std. Dev.	Min	Max
EDUCATION	Educational level of the head of household	6.610526	3.370214	1	14
EMPLOY	1if employed	0.45614	0.526421	0	1
GENDER	1 if male	0.564912	0.496641	0	1
HHSIZE	Number of people in the household	4.091228	1.845844	1	13
INCOME	Net monthly household income	2249.014	3825.137	0	40000
MARITAL	1 if married	0.554386	0.497908	0	1
WTPC	WTP measured as a continuous variable	11.20351	28.31962	0	200
WTPD	1 if respondent is willing to pay	0.392983	0.934446	0	1
AGE	Age of the head of household	48.29825	13.48886	20	84

Source: Calculated from Survey Data, 2012

The logit model used in this section was discussed in **Chapter 5. Section 5.16**.The model is specified as follows:

$$WTP = Log(\frac{Pi}{1-P_i}) = \beta_1 + \beta 2EDU + \beta 3EMP +$$

$$\beta 4Gender + \beta 5HHSize + \beta 6INC + \beta 7AGE + \varepsilon_i \qquad 6.1$$

In **Table 6.2** below, the expected signs of the coefficients are based on economic theory and on the results of other environmental studies carried out in the past.

Table 6.2: Description of the variables with expected signs

Independent categorised variables	Description	Expected sign
EDU	Educational level of the head of household	+ highly educated individuals are expected to have a positive influence on WTP
EMP	Employment status of the head of household (Employed = 1, Unemployed = 0)	+ Employed people are expected to have a higher WTP than those who are not employed
GEN	Gender of the head of household (Male = 1, Female = 0)	+Male respondents are expected to have a positive influence on WTP
MAR	Marital status of the head of household (Married = 1, Not Married = 0)	+Married people are expected to have a positive influence on WTP
Independent continuous variables		
HHSize	Household size – number of people in the household	- The higher the number of people in a household the lower is the expected WTP
INC	Household income (monthly)	+ The higher the household income the higher the expected

		WTP
AGE	Age of the head of household	- WTP tends to vary inversely with age

Table 6.3 below is a summary of the results of the logistic regression of equation 5.1. The paragraphs below are a presentation of the discussions and interpretations of the coefficients.

The coefficient between education level of the head of household and WTP for the reduction of air pollution dummy variable was negative. An increase in education level of the head of household was likely to lower the probability of a positive WTP for pollution in Bophelong Township. Statistically, this relation was insignificant and contrary to its a priori expectation. The null hypothesis that education does not have any impact on the probability that a household would be willing to pay for reduction in air pollution could not be rejected even at the 10 percent level of significance since the p-value was more than 10 percent at about 26 percent.

There was a positive relationship between employment status and WTP for reduced air pollution. This means that employed heads of households were more likely to have a positive WTP for pollution in Bophelong Township. This relationship was statistically significant to reject the null hypothesis that employment status could not affect the chance that a household had a positive WTP for the reduction of air pollution. This relationship was significant at the 10 percent level with a p-value of 7.2 percent. Employed people generally have higher incomes than those who are not employed; as a result they tend to be more willing to pay for air pollution reduction.

Gender as represented by sex had a negative relationship with the WTP for the reduction of air pollution. This relationship was statistically insignificant even at the 10 percent level to reject the null hypothesis that sex does not influence WTP for pollution in Bophelong Township. However the negative relationship suggests that males headed households were less likely to have a positive WTP for the reduction of air pollution than females.

There was a negative relationship between size of household and WTP for pollution. The relationship was statistically significant at the 10 percent level of significance to reject the null hypothesis that size of household does not have an influence of the probability that a household pays for reduced air pollution. There was a positive relationship between income of the household and WTP for the reduction of air pollution. At the 10 percent level of significance, the null hypothesis that income levels do not influence the probability that a household pays for reduced pollution was rejected. Higher levels of income were associated with positive WTP for reduced air pollution in Bophelong Township.

There was a statistically insignificant relationship between marital status and WTP for the reduction of air pollution. The relationship however was negative implying that male headed households were less likely to have a positive WTP toreduce air pollution. The age of the head of household is inversely related to WTP and statistically significant at the 10 percent level of significance to reject the null hypothesis that age of the head of household did not have an influence on the probability that a household pays for reduced air pollution. This implies that as age increases the people's probability of a positive WTP on reduction of air pollution diminishes. A similar study by Alberini et al. (1997:55) whose objective was to determine WTP for reducing fatal risk by improving air quality also found that age and WTP were inversely related. Another study by Tanrivermi (1998:84) on WTP and WTA measures in Turkey also found a negative correlation between age and WTP.

Table 6.3: Results of Logistic Regression

Wtplogistic	**Coef.**	**Std. Err.**	**Z**	**P>|z|**
Education	-0.05877	0.051952	-1.13	0.258
Employmentstatus	0.574409	0.319449	1.8	0.072
Sex	-0.13893	0.344321	-0.4	0.687
Sizeofhousehold	-0.15012	0.084596	-1.77	0.076
Income	8.72E-05	4.85E-05	1.8	0.072

Maritalstatus	-0.19252	0.35614	-0.54	0.589
ageofheadofhoushold	-0.02341	0.013493	-1.73	0.083
_cons	1.100534	1.09494	1.01	0.315

Source: Calculated from Survey Data, 2012

The logistic regression model specified in the equation above was evaluated using the Likelihood Ratio test which is operationalised using the Chi-Square. Table 6.4 summaries the results of the log likelihood test. The Log likelihood was 161.27. The Log likelihood Ratio test as measured by the Chi-Square was 25.8 with a p-value of 0.0005. That means even at 1 percent, the null hypothesis that the model was not a good fit is rejected in favour of the alternative hypothesis that the model was a good fit.

Table 6.4: Log-Likelihood Ratio Test for the Logistic Regression

Logistic regression	**Number of obs**	**274**
	LR chi2(7)	25.8
	Prob > chi2	0.0005
Log likelihood = -161.27051	Pseudo R2	0.0741

Source: Calculated from Survey Data, 2012

Table 6.5 is a summary of marginal effects as calculated as elasticities. As **Table 6.5** shows, the choice to have a willingness to pay or not was inelastic to changes in education levels. The elasticity between education and WTP for pollution in Bophelong was inelastic at -0.256. An increase in education by one unit however had the possibility of lowering the WTP as evidenced by the negative sign.

Employment status was also inelastic in influencing the WTP for reduced air pollution in Bophelong. The employment status elasticity of WTP was 0.15, therefore, employment status could not be regarded as a very important factor that influences the level of WTP in the area. However, there was a positive elasticity meaning that those who were employed were more likely to have a positive WTP for reduced air pollution in Bophelong.

Table 6.5: Marginal Effects reporting elasticities

	ey/ex	Std. Err.	Z	P>|z|	[95% Conf.	Interval]
Education	-0.25567	0.230419	-1.11	0.267	-0.70728	0.195946
employmentstatus	0.146747	0.07565	1.94	0.052	-0.00152	0.295017
Sex	-0.04969	0.124649	-0.4	0.69	-0.294	0.194617
Sizeofhousehold	-0.42625	0.247223	-1.72	0.085	-0.9108	0.058294
Income	0.0979	0.048435	2.02	0.043	0.002969	0.192831
Maritalstatus	-0.07518	0.141086	-0.53	0.594	-0.35171	0.201344
Ageofheadofhoushold	-0.7785	0.456018	-1.71	0.088	-1.67228	0.115278

Source: Calculated from Survey Data, 2012

The elasticity of WTP due to gender was estimated at -0.049. This implies that gender as represented by Sex in the table above did not have any significant influence on the WTP. However, males were less likely to have a positive WTP than females since the sex elasticity of WTP for reduced air pollution was negative In the study by Carlsson and Johansson-Stenman (2000) the marginal effects for gender were found to be significant but with opposite signs. The reported marginal effects in the Carlsson and Johansson-Stenman (2000) study were -0.054, which implied that men have about 5 percentage units' lower probability of a positive Willingness to Pay than women.

Again size of household was also inelastic although it was negative. Households with higher numbers of inhabitants were less likely to have a positive WTP compared to those with small members. The size of household elasticity of WTP for pollution was -0.426.

The income elasticity of WTP was about 0.1 which was inelastic. Those with higher income levels however were more likely to have a positive WTP for pollution compared to those with lower levels of income. Marital Status also was inelastic and negative. Households whose head was married were less likely to have a positive WTP for reduced air pollution compared to those with single heads. Lastly, age of the head of household also was inelastic in influencing the WTP for pollution in Bophelong. This means that although the relationship was inelastic, older people were less likely to have a positive WTP compared to younger people.Wang and Mullahy (2006) also found that age has a negative relationship with the probability of a positive WTP, which

implies that as age increases people's probability of having any positive Willingness to Pay for the reduction of air-pollution decreases.

6.6 SUMMARY AND CONCLUSION

This chapter provided a socio-economic analysis of air pollution in Bophelong. The analysis was divided into three categories, namely; demographic factors, labour force and environmental issues. The analysis found that Bophelong can be characterised as being poor as most of the variables analysed fit the description of a poor community as described by different measures of poverty. Bophelong can be considered poor both in terms of absolute and relative measures of poverty. Although the survey did not aim to measure the levels of poverty in Bophelong, assessment of relative measures of poverty such as provision of adequate infrastructure, access to basic services such as health and educational facilities categorises Bophelong as a poor community due to poor access to these services.

The main objective of the survey was to quantify the willingness to pay for the reduction of air pollution in Bophelong through the use of Contingent Valuation method. Such measures are important to policy-makers as they assist them with information pertaining to environmental policy formulation. There are a variety of valuation techniques that can be used to value non-market goods such as air-pollution. These techniques were discussed in Chapter 3. But the Contingent Valuation method was chosen as it is deemed to be suitable for this type of study. The Contingent Valuation method makes use of surveys to elicit respondents to an improvement in environmental quality by asking willingness-to-pay and willingness-to-accept type of questions. These questions can be asked in a variety of formats such as open-ended or referendum type questions.

In this study an open-ended format question was asked to elicit respondents' willingness-to-pay. An open-ended type of question was preferred over the referendum type question as open-ended questions tend to generate a more conservative response and consequently a lower willingness-to-pay (Carlsson& Johansson-Stenman, 2010:663). Furthermore a willingness-to-pay

question was preferred over a willingness-to-accept question as willingness-to-pay questions are subject to budgetary constraints and respondents are therefore less likely to overestimate their bids. The mean willingness-to-pay for the reduction of air pollution in Bophelong was estimated at R132 per annum. The annual social cost of air pollution in Bophelong was calculated at R6 521 856.

CHAPTER 7

SUMMARY, CONCLUSION AND RECOMMENDATIONS

7.1 INTRODUCTION

The aim of this study was to value the social cost of air pollution in Bophelong. Bophelong is located in the municipal area of Emfuleni which is bordered by the Free State municipality of Metsimaholo to the south and Johannesburg Metropolitan municipality to the North. Metsimaholo Local Municipality and Emfuleni Local Municipality are home to major industries, namely, the Arcelor-Mittal plant in Vanderbijlpark, adjacent to Bophelong and Sasol chemical plant in Sasolburg approximately 10 km from Bophelong. In addition, there are other downstream industries located closer to these two major plants. It would be expected from the scenario described above, that the residents of Bophelong would be victim to pollution emanating from industrial activity taking place within close proximity from their place of residence. In April 2006, the Minister of Environmental Affairs and Tourism declared the Vaal Triangle an air-shed priority area in terms of the National Environmental Management Act (39/2004). Although the residents of Bophelong Township indicated that most of the pollution affecting them comes from industries, economic literature reveals that most of the pollution affecting township residents actually emanate from domestic sources.

7.2 THEORETICAL BACKGROUND TO THE STUDY

It was shown in this study that there is a link between poverty and environmental degradation. Pollution is considered to be more a consequence of poverty than affluence. While there are other views that regard economic growth as a major contributor to pollution due to the pressure exerted on the environment as a result of production and consumption processes, the dominant view in the literature is that economic growth is a pre-condition for preserving the environment. It is on this basis that a comprehensive discussion of poverty was provided in the study in order to bring a proper understanding of this concept. Poverty was covered through explaining the

three main approaches to its definition, namely, the absolute approach, the relative approach and the subjective approach. Absolute poverty is mainly an income measure of poverty, wherein households are identified as being poor on the basis of a shortfall in income related to a pre-determined threshold level of income referred to as the poverty line. Relative poverty on the other hand is a more multi-dimensional measure of poverty which considers several aspects of poverty other than just income. According to the relative approach to poverty, a person is considered poor when he / she lack certain commodities which are considered to be the norm in the society in which he / she lives. The subjective approach to poverty invokes the poor to express their own feeling about their own situation in relation to poverty, that is, people should state whether they are poor or not and what poverty means to them. Chapter 2 continued to discuss the factors that determine poverty. The World Bank (2005:132) categorises the various determinants of poverty under different characteristics as follows:

- Regional characteristics – this comprise factors such as location, resource base, weather patterns, environmental management and regional governance and management;

- Community characteristics – community characteristics are considered in terms of aspects such as access to public goods and services, such as proximity to schools and medical facilities, availability of infrastructure such as piped water and social structure and social capital;

- Household characteristics – these are described in terms of the size of the household, dependency ratio, Gender of head of household, assets, which typically include land, tools and other forms of production, Income and employment status of the members of the household and health and education status of household members, and

- Individual characteristics – individual characteristics are described in terms of age, education, employment, and health status.

Bophelong's profile in relation to the determinants described above does not reflect a good picture. Bophelong is a Black residential area established in the 1950s with the purpose of accommodating Black workers who provided labour to industries around the Vaal Triangle area, particularly for the Iscor (now Arcelor-Mittal) factory. Such areas were largely neglected by the then government which resulted in their infrastructure being (and remaining) largely underdeveloped. Household and community characteristics are also not favourable. Many families are headed by females. There is a significant level of the youth population thereby leading to a high dependency ratio, and the unemployment rate is high coupled with low levels of education. All these factors contribute negatively towards any measures aimed at alleviating poverty in the area.

Different methods of measuring poverty were also discussed. These measures were discussed in terms of poverty lines and poverty indices. There are basically two approaches to poverty measurement, namely, the absolute approach and the relative approach. The absolute approach measures poverty in terms of income. A poverty line is selected and households are declared as being poor on the basis of a shortfall in income related to the poverty line. The relative approach on the other hand, measures poverty in terms of non-income indices such as infant mortality rates, life expectancy, education levels etc., that is, poverty is described in terms of the average resources available in a given community. The absolute poverty approach is the one that is commonly in use in many developing countries since most people in these countries fail to achieve a minimum acceptable material standard of living due to a lack of income.

Several of these poverty lines have been in used in South Africa over the recent past. The poverty lines discussed in this study were the following: the Poverty Datum Line (PDL), The Minimum Living Level (MLL), Supplementary Living Level (SLL), Household Subsistence Level (HSL), Household Effective Level (HEL), Upper and Lower bound poverty line, Food Insecurity poverty line, Human Development Index (HDI) and multiple deprivation indices. The HSL is the most commonly used poverty line in South Africa today. The HSL

is defined as an estimate of theoretical income needed by an individual household to maintain a defined minimum level of health and decency in the short-term and is calculated at the lowest cost of a basket of necessities of adequate quality (Slabbert, 1997:42-43).

Several poverty indices were also discussed, namely, the headcount index, which measures the proportion of the population below the poverty line, the poverty gap index, which measures the degree of poverty by way of measuring the extent of the shortfall of income below the poverty line and expresses it as a percentage of the poverty line, the squared poverty gap, which measures the degree of poverty amongst the poor and the human development index, which unlike the indices described above, is a relative measure of poverty and measures poverty along three key deprivations namely, life expectancy, basic education and access to basic services such as health facilities and sanitation. There are various poverty reduction policies which can be implemented to alleviate poverty. The policies discussed in this study are minimum wages, social security, negative income tax, and in-kind transfers. The issue of inequality was also touched upon.

Chapter Three concentrated on the discussion of pollution and the theory of social cost. There is a positive correlation between poverty and pollution. Pollution is described as the introduction into the environment of substances or energy liable to cause hazards to human health, harm to living resources and ecological systems, damage to structure or amenity or interference with legitimate use of the environment (Kidd, 1997:121). Although there are different kinds of pollution, this study concentrated mainly on air pollution as the main focus of the study. Different types and sources of air-pollution were discussed. These sources are particulates, sulphur dioxide, ozone, carbon monoxide, nitrogen oxide and lead. The effects of pollution were also discussed in terms of environmental effects, health effects and socio-economic effects. Environmental effects encompass factors such as acidic disposition, visibility reduction, ozone depletion, climate change etc. Health factors entail various forms of child and adult respiratory illnesses, and non-respiratory diseases such as cancer, hypertension, diabetes, HIV/AIDS etc.

The socio-economic status of a person does also affect his/her vulnerability to pollution. Socio-economic factors such as employment status, education levels, access to health facilities and housing can determine if a person is more or less vulnerable to pollution. Energy choices of the community also have an influence on levels of pollution. Despite the fact that hundred percent of the formal dwellings in Bophelong are electrified there is still a significant utilisation of coal and fuel-wood as sources of energy. Various factors are considered responsible for this type of behaviour namely, oil prices, housing, electricity supply and income. Expensive oil prices have a direct bearing on the prices of other cleaner fuels such as, paraffin and gas, thereby leading poor consumers to substitute the use of such fuels with low grade biomass fuels. Houses that are thermally uncomfortable will also have a direct bearing on energy use. The construction of energy efficient houses will have positive spin-offs in as far as energy utilisation is concerned. Unreliable electricity supply can encourage the use of dirty fuels as a form of back-up. Expensive electricity on the other hand can encourage users to substitute electricity for other forms of energy which may not necessarily be cleaner.

The second part of **Chapter 3** dealt with the theory of social cost. Firstly, a distinction was made between private costs and social costs. Private costs are those incurred by individuals making the decision leading to the action, whereas social costs are those incurred by society as a whole irrespective of who made the decision leading to the action. Social cost is therefore, expected to be higher than private cost as it includes both private costs and external costs. External costs are costs inflicted on third parties, such as pollution. External costs are not included when calculating production costs but they nonetheless constitute a cost to third parties. Two theories dominate the social cost literature namely, the Pigouvian approach and the Coasian theorem.

The Pigouvian theory favours government intervention to rectify the distortions between private costs and marginal social costs. These distortions occur as a result of market failure which is described as a situation where markets-for a variety of reasons- fail to allocate resources efficiently. According to this

approach externalities may be resolved through the application of taxes, regulations and subsidies. These taxes have become to be known in economic literature as Pigouvian taxes. The Pigouvian tax is levied to close the gap that result from the divergence between marginal social costs and marginal private costs. This method attempts to attach to a non-market good, which would then imply that producers have to internalise these goods when estimating their production costs.

The Coasian theorem on the other hand, favours the application of market systems to decide the efficient allocation of resources. The Coasian theorem holds that government should only intervene where bargaining between two parties does not yield the desired outcome. According to the Coase theorem, for as long as property rights are clearly defined and transaction costs are zero or negligible, bargaining would produce the desired results. Lack of clearly defined property rights and the presence of transaction costs tend to complicate the negotiations process thereby impeding efficient main criticism against the Coasian theorem is its assumption of zero transaction costs. Critics of the Coasian theorem maintain that in the real-world transaction costs always exist. Other critics of this theorem such as Hahnel and Sheeran (2009) have also shown that even without rejecting the assumptions of the theorem, the theorem will still not apply in the real world due to the presence of what they refer to as perverse incentives. Social cost theory provides a theoretical justification on why externalities have to be charged whilst the valuation techniques discussed in **Chapter 5** provides the tools for doing so.

Chapter 4 concentrated on the related issues of air pollution abatement strategies, renewable energy and sustainable development. For the human race to survive it has to ensure its sustainability into the future. This sustainability can be achieved through, amongst others, the use of renewable resources. Renewable energy sources are cleaner and as a result less damaging to the environment e.g. solar energy. This chapter began by providing a historical overview of air-pollution abatement strategies in South African townships. The strategies discussed were devolatilised coal, low-smoke fuel stoves, low smoke fuels and electrification. Other than

electrification which is a continuing process, all of the air pollution abatement strategies were unsuccessful. Electrification is still being continued as one of the air pollution abatement strategies. However, authorities often find that communities still continue to use coal as a source of energy despite electrification efforts. This can be attributed to the low income of consumers in the townships which makes them unable to afford electrical appliances. If electricity is not sufficiently subsidised consumers will be tempted to use other forms of energy as a supplement.

The chapter proceeded by discussing some of the more recent air pollution abatement efforts such as Basa-njengo-Magogo method wherein coal is lit from top-down instead of the conventional bottom-up approach. This method tends to generate fewer emissions as smoke rises through the hot area and is thus burnt. Other abatement strategies discussed are electrification, construction of energy efficient housing and upgrading of biomass fuels. The positive and negative impacts of these intervention strategies were also discussed. Aspects of renewable energy such as sources of renewable energy, importance of renewable energy, and factors that hinder renewable energy development were discussed.

The chapter concluded by discussing the concept of sustainable development. Todaro and Smith (2011:784) describe sustainable development as a pattern of development that permits future generations to live at least as well as the current generation generally requiring at least a minimum environmental protection. Two approaches to sustainable development were also discussed namely, the integrated view and the future-oriented view. Successful environmental policies should be aimed at reducing inequalities in society as inequalities lead to environmental degradation and as a result hamper sustainable development. Several policy options that can be used to improve the living conditions of the poor were discussed. The policies discussed are, proper resource pricing, community involvement, property rights and resource ownership, raising the economic status of women, industrial emission abatement policies and improving economic alternatives for the poor. Lastly the chapter discussed several constraints that may hamper successful

sustainable development. These constraints were described as constraints of physical condition and laws of nature, constraints of human nature and human goods and constraints of time.

Chaper 5 of the study discussed economic valuation techniques. The importance of attaching a monetary value on human actions that degrade the environment was discussed in this chapter. There are several valuation techniques that can be used to measure the negative impact of human actions on the environment. These techniques can be direct and non-direct in nature. The direct techniques are also referred to as the stated preferences methods whilst the indirect techniques are referred to as revealed preferences methods. Several indirect techniques used to measure non-market goods were discussed. The hedonic pricing method considers differences in property prices as a reflection of the environmental benefits associated with a particular market transaction. This method was not chosen for this study as it relies heavily on an established property market and townships do not have such well-developed property markets.

Other revealed preferences methods discussed are, (i) the travel-cost method which uses travel costs, for instance, travel costs to a recreational site are used a proxy for the value of that site, (ii) the replacement cost method, which stipulates that the value of an environmental asset should not exceed its replacement cost, (iii) the averting expenditure method, according to this method consumers may engage in an averting behaviour to respond to respond to environmental degradation, consumers may for instance buy bottled water to mitigate the effects of low-quality water on their health, (iv) the production function approach, according to this method the proxy value for those goods that do not have a market price can be estimated by calculating their contribution to profit, (v) the net factor income approach, this method functions by subtracting the value of inputs in production, other than environmental inputs, implying therefore that the remaining surplus is an estimation of the environmental input, (vi) the cost of illness approach takes into account expenses related to medical care and opportunity cost such as loss of earnings due to illness. Two direct valuation techniques were also

discussed in this chapter, namely, the Choice - experiment method and the Contingent valuation method. When using the Choice-experiment method, a set of hypothetical scenarios is presented to a respondent and he/she has to state his/her preferences of these scenarios. The Contingent valuation method makes use of surveys to enquire about respondents' future behaviour by asking them willingness-to-pay and willingness-to-accept type of questions. The survey information would then be used to estimate a bid function, which is used in the prediction of sample mean or median values. The mean or median values would then be converted into total willingness-to-pay by multiplying the sample mean or median value with the total estimated population. This method has been chosen for use in this study because it is flexible, it is widely used to measure total economic value and, its results are simple to analyse and report. This method however, does have several short-comings which manifest themselves in the form of different kinds of biases, one of those being the strategic bias.

The strategic bias is manifested when the respondent understate or overstate the value in order to influence a particular outcome. In addition, survey-based studies are subject to vulnerability-to-response effects and change in meaning. Vulnerability-to-response effects imply that respondents may be tempted to provide satisfying answers that is, the type of answers that the respondent thinks the interviewer will accept. Change in meaning implies that different words can mean different things to different people. The manner in which a question is phrased is therefore important.

This study preferred to make use of a willingness-to-pay type of question as opposed the willingness-to-accept type. Willingness-to-accept questions tend to result in higher valuations, because they are not subject to budgetary constraints. Willingness-to-pay question on the other hand tend to elicit conservative responses and respondents are not tempted to overstate the estimates. Furthermore, the study made use of an open-ended question as opposed to a referendum type question. Open-ended questions are deemed desirable as they generally tend to overcome the problem of starting-point bias and tend to provide a more conservative estimate.The study made use of

a logistic regression model to estimate the probability of a person having any positive WTP. These details of this model were discussed in Chapter 5.

Chapter 6 provided an analysis of the profile of the population of Bophelong in terms of socio economic and environmental factors. In addition to the profile analysis, an econometric model was specified, a logistic regression model was run, and the results were presented and interpreted. The analysis was done in the manner described below:

7.3 PROFILE OF BOPHELONG POPULATION

The analysis of Bophelong's population is divided into three sections, namely, the demographic section, the labour force section and the environmental section. The demographic section analyses aspects of the population such as gender distribution, marital status, composition of members of family, age distribution and education. The labour force section analyses the characteristics of the population in terms of employment status, duration of unemployment, sectors of employment, the type of skill that the unemployed possess and the type of skills training required by the unemployed. The environmental section assesses the attitudes of the residents towards the environment. Chapter 4 proceeds by analysing the residents' willingness-to-pay for the reduction of air-pollution in Bophelong using the contingent valuation method. Lastly, a regression analysis was performed to determine factors that influence willingness-to-pay bids.

7.3.1 Demographics

Bophelong's population comprises 54 percent and 46 percent female and male respectively. This statistic compares favourably with national gender distribution for Africans as estimated by Stats SA (2011:4) which reflects 51.6 percent and 48.4 percent for females and males respectively. About 63 percent of the population of Bophelong falls under the never married category. This category is most likely to be dominated by female-headed households. This tends to worsen the poverty situation in Bophelong as women are more likely to be poorer than their male counterparts (Todaro & Smith, 2011:237). Of the sample population, 72 percent is below the age of 40. Nationally, 79

percent of the population is below the age of 40. This is the age at which people in general are considered to be most productive. The high percentage of people below the age of 40 leads to a high dependency ratio which in turns results in worse poverty situations. Education levels in Bophelong are very low. Only 36 percent of the population out of school possessed qualifications of Grade 12 and higher. Only 10 percent of the population has a degree or a diploma. Approximately 83 percent of the population would want to further their education through technical and technikon training. If this preference is actualised then the levels of educational attainment in Bophelong would improve as has been the case in the last three years (2009 – 2012).

7.3.2 Labour force

Approximately 54 percent of the population of Bophelong is unemployed. In 2009, the unemployment rate was 62 percent. There has therefore been an improvement in the employment situation in the last three years. The Emfuleni economy has historically been dominated by the manufacturing sector. According to the survey, the majority of those employed, 30 percent are employed in the manufacturing sector. The global recession contributed to a decline in manufacturing jobs in 2009. In 2009, only 9 percent of the population was employed in the manufacturing sector. However, since 2010 there has been an improvement in the level of output in the manufacturing sector. The majority of those who are unemployed can be considered as structurally unemployed as there is mismatch between the skills that the unemployed possess and the skills required by industry.

7.3.3 Environment

Approximately 84 percent of the population felt that the environment is polluted. A similar percentage of respondents felt that something should be done about the environment. However, the majority of the respondents feel that it is the responsibility of the municipality to clean the environment. About 31 percent of the respondents felt that they were badly affected by air pollution, whilst 35 percent felt that they were not affected. The percentage of those who indicated that they were not affected by air pollution can be

attributed to a lack of information on environmental issues. Hundred percent of all formal dwellings in Bophelong are electrified and approximately 90 percent of residents use electricity for cooking and heating. However, about 10 percent of the residents still use other forms of energy such as coal and paraffin for cooking and heating. The majority of those who still use other forms of energy for cooking and heating indicated that they are interested in learning about new technologies in cooking and heating. About 85 percent of the respondents suffer from pulmonary diseases which are mainly caused by air-pollution. About 68 percent of the respondents indicated that they were not willing to pay for a reduction in air-pollution. About 31 percent of those who indicated that they are not willing to pay, felt that polluters should pay, whilst 32 percent felt that the government should pay. Of those willing to pay, 24 percent indicated affordability as the main reason they were willing to pay for reduction of air pollution in Bophelong. The mean annual willingness to pay in Bophelong is R132 and the annual social cost of pollution was estimated at R6 521 856.

7.4 RECOMMENDATIONS

Addressing the poverty situation in Bophelong is the first step towards the eradication of environmental degradation. In developing countries, environmental degradation is associated more with poverty that with affluence. It was shown in this study that a very strong link exists between economic growth and environmental quality. Raising income of the poor would therefore relieve pressure on the environment. Literature findings reveal that domestic sources of pollution contribute more to health impacts than industrial emissions. It is advised that interventions should therefore target domestic sources of pollution. According to Wagner *et al.* (2005:3) a top-down fuel ignition method referred to as Basa-njengo-Magogo could eliminate 25 percent of the total air pollution in the Vaal Triangle. Other recommendations which could be considered would include the following:

- An increase in the provision of subsidised basic electricity, within the budgetary constraints of municipalities, should be seriously considered.

- All newly-constructed houses must take thermal comfort into account, for instance, all newly built houses must be insulated.
- Funding agencies should consider funding projects that result in low-cost and effective energy improvement options.
- Establish links between different government departments responsible for service delivery.
- Integrate environmental management with other national priorities such as poverty alleviation and social transformation.
- Build capacity to enforce compliance with rules and regulations particularly at municipal level.
- Link national policy to local delivery

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ANNEXURE A

THE HOUSEHOLD SURVEY

Maps were obtained for Bophelong Township and sample stratification was designed on account of the geographical distribution and concentration of people in the areas. A questionnaire was designed for obtaining the desired information. The area was divided into different extensions and the questionnaires were apportioned evenly among the inhabited sites. Plots/sites at which field workers were supposed to complete questionnaires were identified individually from the map before the field workers went out. However, where people could not be found for an interview, or where it was impossible to trace the house, a next preselected household was interviewed. Information was obtained from the breadwinner or the spouse.

A total of 300 households were interviewed by 3 fieldworkers. All the households approached were willing to partake in the survey. Of the 300 households interviewed in the survey only 285 were analysed. Fifteen questionnaires were destroyed due to incompleteness.

ANNEXURE B

HOUSEHOLD QUESTIONNAIRE MARCH 2012

N.B.: The information in this questionnaire will be treated in strict confidence. ***(March 2012)***

Townrnship	Section: Old/RDP/Shack	Date:	Questionnaire no:
Street	House number:	Interviewer:	

Please note that the Head of the Household should preferably answer this questionnaire.

A: BACKGROUND INFORMATION

1. What is the position of the respondent in the Household? Cross ×

Head of household	Spouse	Child	Extended family member

2. Gender of the head of Household
M / F

3. How many housing units are on the site?

4. How many people stay permanently in the household?

5. How long have you (respondent) stayed in Vaal Triangle (years)?

B: ENVIRONMENTAL

6. How do you feel about the environment in which you stay? (Mark 2 options) ×

1. It is clean and pleasant	2. It is littered, untidy and dirty	3. Indifferent – No opinion	4. Something should be done to clean it	5. It can be left as it is

7. If you feel it should be cleaned up, who should take the initiative and responsibility? (× More)

1.The municipality	2. A street committee	3.Everyone should be made responsible	4. A campaign should be organised	5. Other: explain

8. Are you prepared to pay monthly to have your environment cleaned up?

Yes	No

9. How do you experience, especially in winter, the smoke levels (air pollution) in your area?✖

1. Not affected	2. Slightly affected	3. Affected	4. Badly affected	5. Unbearable (Severely Affected)

10. What energy source do you normally use for cooking and heating?

	Always	Often	sometimes	Never
Electricity				
LPG Gas				
Solar				
Coal				
Firewood				
Paraffin				

11. If you are making fire for cooking & heating purposes, would you like to be introduced to technologies that will reduce the smoke levels at your house? ✖

1. Not making fire: using electricity for cooking & heating	2. Making coal / wood fire: but not interested	3. Making coal / wood fire: And interested	4. Using paraffin: Not interested	5. Using paraffin: Interested

12. How much are you willing to pay monthly to have your environment smoke-free?

a) What % of the smoke pollution do you think comes from industry? ☐ and coal ☐ fires?

b) Number of persons in your household whose health is affected by air pollution? ☐

c) What are most of them suffering from? (e.g. coughing, asthma, etc)

_____

13. How many times in a year do you consult a doctor due to pollution related ailments? ☐

14. How much do you spend (per annum) on medical consultations due to pollution-related ailments? E.g. Asthma ☐

15. What is the main reason you would not be prepared to pay to have your environment smoke-free?

- o Polluters should pay
- o Government should pay
- o The environment should be protected by law and I should not have to pay for it
- o The air-pollution in Bophelong is not a priority
- o Air-pollution in Bophelong is not important
- o I need more information to answer this question
- o Don't know
- o Other_____

16. What is the most important reason why you would be prepared to contribute towards the reduction of air-pollution in your area?

- o It is a good cause
- o I would receive some personal benefit from paying
- o We should improve the environment for future generations
- o Don't know
- o Other_____

17. Why have you chosen R_____ (insert willingness to pay value response given in Q11) as the maximum you are prepared to pay to reduce air-pollution in your area?

- o It is the most I can afford
- o It is the most I am prepared to spend on environmental issues
- o It is a random choice
- o This would be enough if everyone paid the same amount
- o I can easily afford this amount
- o Don't know
- o Other_____

D: How does your household spend their income monthly? Bought where?

Item	Rand per month	Name of shop	Town	Market	
Housing (Rent/Bond/Mortgage)					1
Water					2
Firewood					
LPG Gas					
Electricity					3
Other energy (coal, paraffin etc)					4
Food Maize meal…….. Bread…… Meat…….. Vegetables……. Milk…… Other food……					5
Cleaning materials					6
Cigarettes & Tobacco					7
Beer, wine & spirits					8
Transport: Taxi……		Total			9

Minibus…… Car…… Other……..					
Clothing					10
School					11
Entertainment					12
Medical Expenses					13
Insurance					14
GAMBLING: Lotto.....					15
Horseracing……..					16
Casino Other					17
Savings					18
Licenses (e.g. TV, Vehicle)					19
Rates and taxes					20
Housekeeping Services (e.g. Garden)					21
Telephone……					22
Cell……..					23
Car Repayment					24
Loan repayments					25
Furniture					26

Other: Specify					27

D: EMPLOYMENT & EDUCATION STATUS

18. How does your household earn their income monthly?

1. Number of people in the household								
2. Composition of members (Code list 2)								
3. Age of each member in years								
4. Sex (Male = 1; female = 2)								
5. Marital Status (code list 5)								
6. Highest qualifications (still at school) (Code list 6)								
7. Qualifications (not at school) (Code list 7)								
8. Employment Status (Code list 8)								
9. Sector of employment (Code list 9)								
10. **(10 – 17 for <u>unemployed</u> only)** Skills of unemployed (list 10)								
11. Duration of unemployment in years								
12. Willingness & type of Skills Training required (code list 10)								
13. What is the Unemployed doing presently								
14. Do you have matric ?								
15. If persons would like to study further: preferences (list 15)								
16. Preferences to start self-sustaining activities (list 10)								

17. Minimum wage required to take a job								
18. **Income:** Wages/salaries per month (Take home pay) Formal								
19. Pension/Remittance								
20. Child Grant from Government								
21. Other Grants from Government								
22. Help (family/relatives/etc) Also help in kind								
23. Informal activities								
24. Subsidies (e.g. Housing)								
25. Interest/dividends								
26. Other (Specify)								