A COST BENEFIT ANALYSIS OF DOMESTIC WATER SUPPLY IN MINNA, NIGER STATE, NIGERIA

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DECLARATION

I, MUHAMMED, Yusuf, declare that this thesis titled "A Cost Benefit Analysis of Domestic Water Supply in Minna, Niger State, Nigeria" was written by me and has not been presented either in whole or in part, for the award of any postgraduate degree anywhere else. All literature cited have been duly acknowledged in the references.

MUHAMMED, Yusuf

24-02-2011

DATE

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ABSTRACT

Domestic water supply is grossly inadequate in Minna, Niger State. While access to potable water is estimated at 45%, supply is limited to only about 20% of the population. A significant water gap therefore exists. This research focuses on a cost-benefit analysis of a proposed intervention to improve supply and increase access to piped water. Data used were collected mainly from secondary sources. A socioeconomic survey was done on some households in the study area to gather more data. The contingent valuation method was used to determine consumers' willingness to pay for improved access and supply. The two decision criteria used in the CBA were the net present value (NPV) and the benefit cost ratio (BCR). The costs of the intervention included estimations of the full investment and annual operating costs of new piped water supply facilities. The results show that the main contributor to benefits is the tariff revenues that will be generated. The findings showed an NPV of ₦700.68 million and a BCR of 1.17. These values imply that the proposed intervention is cost-beneficial and profitable. It is recommended that the project be undertaken by the agency responsible.

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GLOSSARY

m^3	cubic metre
Mm^3	million cubic metres
₦	Nigerian Naira
BCR	Benefit Cost Ratio
BT	Benefit Transfer
CBA	Cost Benefit Analysis
CVM	Contingent Valuation Method
IRR	Internal Rate of Return
lcd	litres per capita per day
NPV	Net Present Value
NSWB	Niger State Water Board
WHO	World Health Organisation
UNICEF	United Nations Children's Fund
WSP	Water Supply Project
WTP	Willingness-to-pay

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

The supply of water to urban centres in developing countries poses a serious challenge to institutions charged with the responsibility, not necessarily because of lack of this vital natural resource, but largely due to the economic cost of its provision to an ever increasing population (OFWAT, 2006). The water supply and environmental problems of big cities result from a complex array of circumstances that include not only the availability of the water, characteristics and vulnerability of the environment, but also demographic, legal, administrative, political and behavioural issues.

Rapid urban growth over the past forty (40) years has brought about important implications for the environment. Urban domestic and industrial consumers are using larger amounts of water and consequently depleting the available sources (Franceys, 1997). Yet urbanization and the consequent concentration of population are essential parts of economic growth in developing countries. They help lower unit costs of water supply systems and for many forms of sanitation services. However, the rate of economic investments needed to provide water supply and sanitation falls behind the urban growth. In these countries including Nigeria, the problem is aggravated due to the unplanned nature of the growth of cities. The fact is that one of the greatest challenges posed by fast urbanization rates and population growth is the guarantee of safe adequate and reliable water supply, as well as adequate sanitation conditions to all. Beyond difficulties of reaching a large area with reliable service, a situation that is aggravated if the urban expansion was unplanned and chaotic, it also leads to severe strain on water resources accessibility and on the environment due to water demand and pollution loads.

In 1955, sixty-eighty percent (68%) of the world's population lived in rural areas and thirty-two percent (32%) in urban areas, according to the United Nations Population Fund (1990). In 1995, these figures were changed to 55% rural and 45% urban. By the year 2025, the urban population will represent 60% of global population while 40% will be rural. In some areas the situation is much more critical. For instance, in parts of Africa, 70% of the population lives in cities.

The poor who live in suburbs of cities are hit hardest by shortages in supply because they have to pay high prices for water of doubtful quality. As the population expands, the pressure to increase water supply also increases. The pressure to invest heavily in water supply projects is so great considering also the need to develop other sectors. Also water is rapidly becoming a scarce resource in almost every country. This scarcity makes it both a social and economic good. Users of water range from households with basic needs to agriculturists, farmers, industries, etc. For all these uses the water supply projects to urban centres are being proposed for extension and augmentation.

It is therefore essential to carry out economic analysis of projects so that planners, policy makers, water enterprises and consumers are aware of the actual economic cost of scarce water resources and the appropriate levels of tariff and cost recovery needed to financially sustain it.

The characteristic features of water supply include:

(i) water is usually a location specific resource and mostly a non-tradable output

(ii) Markets for water may be subject to imperfection e.g. physical constraints, high cost of investment, cultural values and concern for resources sustainability.

(iii) Pricing of water is rarely efficient. Tariffs are often set below the average economic cost which jeopardizes a sustainable delivery of water service. If water availability is limited and competition among potential water users (household, industries, and agriculture) is high, the opportunity cost of water is also high.

(iv) Water is vital for human life and therefore a precious commodity. Water supply projects (WSPs) generate significant benefits, yet water is still wasted on a large scale. In Nigeria there is a very high incidence of unaccounted for water (UFW) (about 30% according to a report by the Niger State Water Board in 2000).

(v) Economies of scale in WSPs are moderate in production but rather low in the distribution of water.

Rollins *et al* (1997) observe that water shortages and poverty are frequently linked. When nature does not provide easily accessible water, communities do not thrive and development can be limited. When people have access to abundant water, they can spend their financial resources on other needs.

However, supplying water to communities has become expensive and poor neighborhoods are often not given priority. Poor hygiene and inefficient use of scarce water usually leaves poor neighborhoods defenseless against infectious diseases like hepatitis, cholera, typhoid, etc.

In the developing world, diseases, associated with poor water and sanitation have considerable public health significance. In 2004, it was estimated that 4% of the global burden of disease and 1.6 million deaths per year were attributed to unsafe water supply and sanitation, including inadequate personal and domestic hygiene (WHO 2003). This corresponds to 61 million disability-adjusted life-years lost (DALYs), taking into account burden of disease due to both morbidity and mortality. While there have been improvements since the 1980s, in 2004 an estimated 1.1 billion people were without access to safe water sources and 2.6 billion people lacked access to basic sanitation (WHO & UNICEF 2006). Nearly 80% of the people using water from unimproved sources are concentrated in three regions: sub-Saharan Africa, Eastern Asia and Southern Asia. In sub-Saharan Africa progress was made from 49% coverage in 1990 to 56% in 2004. For sanitation overall levels of use of improved facilities are far lower than for drinking-water - only 59% of the world population had access to any type of improved sanitation facility at home in 2004 (from 49% in 1990) (WHO & UNICEF 2006).

In order to increase the rate at which new populations have access to improved water supply and sanitation services, further advocacy is needed at international and national levels to increase the resource allocations to these services, and at population level to increase service uptake.

In the current climate where poverty reduction strategies dominate the development agenda, the potential productivity and income effects of improved services is a significant argument to support further resource allocations to water supply and sanitation.

Potable water is not only a defense against sickness; it is also a basic element in the quality of life. In areas not served by municipal systems, considerable effort is required to bring water to homes, carrying heavy containers from wells, trucks or streams, waiting in line, walking long distances to the source and using precious fuel to boil water. Many hours are spent by household members in this daily chore. Children miss school, women and men cannot take care of their infants properly and people are frequently late for work. Obtaining water at home represents a significant leap forward towards a better life.

1.2 Statement of the Research Problem

The area around Minna has significant water resources that could be harnessed to meet the needs of the inhabitants but supply is poor in most parts. While access to potable water is estimated at 45%, supply is only about 20% of required demand (NSWB). Water infrastructure – waterworks, storage reservoirs, pump stations and distribution networks are poorly maintained and therefore operate below capacity. A significant "water gap" therefore exists between demand and supply. An economic appraisal is attempted in this study in order to estimate the cost of improvement required to reduce the water gap.

The proposed intervention aims to increase piped water supply to households within Minna from its present coverage of 45% to about 70% by the year 2013 and 80% by 2018. This forms the basis of the demand forecast as shall be seen in Chapter Three. The forecast will be used to further formulate and design the project. The project is designed to meet the 2018 project demand forecast of 4.5 million m^3 per year. The utility will supply water of good quality at adequate pressure 24 hours per day.

In estimating the costs and benefits of the proposed project, two (2) main alternatives were considered. The first scenario was to maintain the status quo i.e. the existing situation. As the population increases, the number of households that lack piped water will also increase thereby resulting in an increase in the water supply gap.

The second strategy was the construction of boreholes to augment existing supply in strategic areas where shortages of household water are more acute. This alternative will increase access to water to about 50% but also has some short comings. It is not particularly convenient to go out to fetch water because time and labour would have to be spent. The borehole may dry up in the dry season months thereby depleting supply. The Niger Sate Rural Water and Sanitation Board estimates that it costs about ₦500, 000 to construct a good borehole. It also estimates that a borehole can serve sustainably an average of sixteen (16) household families of six (6) members each. With the population of the city estimated at 200,000, it follows that about 2000 boreholes will be needed for the improvement. The cost of this option will be about ₦1 billion.

1.3 Aim and Objectives

The aim of this research is to undertake a cost –benefit analysis of domestic water supply in Minna with a view to determining whether the net social benefit accruable to the project justifies the investment involved. Towards this end, the specific objectives are to:

1. estimate the volume and cost of present demand
2. estimate the cost of improvement required in the water supply system
3. estimate the benefit in economic terms that will be obtained as a result of the improvement.
4. compare the cost of improving water supply and the value of the benefit of such improvement in order to ascertain the maximum net benefit of the intervention. This will be achieved by applying evaluation criteria (net present value and the benefit cost ratio).

1.4 Research Questions

The study attempted to provide answers to the following questions:

(i) What is the present and projected volume of water required by households in Minna i.e. what is the shortfall?

(ii) What is the cost in economic terms of improving the supply system in order to meet the shortfall?

(iii) What are the expected benefits from such an improvement (i.e. is the project worth undertaking at all?)

1.5 Scope and Delimitation of Study

This research focuses on economic appraisal of the value of water. It takes into account the social and environmental implications of a water supply improvement scheme over a period. It is assumed that a least cost analysis has been carried out and the proposed intervention is the preferred option. The findings of the study were based primarily on data collected from records available at the Niger State Water Board..

1.6 Significance of the Research to Management

The costs (and expected benefits) of an environmental improvement project is of critical importance in decision making. Because several development projects are always competing for scarce resources at the same time, a cost benefit analysis is often a powerful tool in identifying the project with the highest net social benefit. This often helps in resource allocation. It also gives room for informed decisions to be taken, thereby leading to sustainable planning and efficient management.

Although several cost benefit studies have been conducted on water supply projects, this research is further expected to equip managers, decision makers and researchers with inputs for decisions on how much capital investments are justified relative to expected benefits in the water supply sector.

1.7 Description of Study Area

Minna, the capital city of Niger State, is located 150 km to the northwest of Abuja, Nigeria. According to the latest census figures, (National Population Commission, 2006) it has a population of about 200,000 persons. It is located within latitude 9^0 37'N and longitude $6^0$33'E.

The relief is a geographical base of different basement complexes of mainly gneiss. The north-eastern part of the town is a continuous steep outcrop of granite that limits urban development.

In most parts of the town, ferruginous soils predominate because of the basement complex. The vegetation is grassland with scattered trees and shrubs, though urbanization and increase in human activities have profoundly modified the natural vegetation around the town. The population of Minna has grown in recent times at a rate of between 2.5-4% as a consequence of the rural-urban drift.

The existing water supply system in the town had 15,000 connections which provided approximately 45% of the population with water.

The economy of Minna is based mainly on trading. No heavy industries that require large amounts of water are in the town, but there are a number of educational institutions with significant student enrolment. The main source of non-piped water is shallow groundwater, obtained through open wells and boreholes. Recently there has been a rapid increase in the number of water vendors popularly referred to as "mai ruwa".

2.2 Brief History of CBA

The history of cost-benefit analysis (CBA) shows how its theoretical origins date back to issues in infrastructure appraisal in France in the 19th century. The theory of welfare economics developed along with the "marginalist" revolution in microeconomic theory in the later 19th century, culminating in Pigou's *Economics of Welfare* in 1920 which further formalised the notion of the divergence of private and social cost, and the "new welfare economics" of the 1930s which reconstructed welfare economics on the basis of ordinal utility only. Theory and practice remained divergent, however, until the formal requirement that costs and benefits be compared entered into water-related investments in the USA in the late 1930s. After World War II, there was pressure for "efficiency in government" and the search was on for ways to ensure that public funds were efficiently utilised in major public investments. This resulted in the beginnings of the fusion of the new welfare economics, which was essentially cost-benefit analysis, and practical decision-making. Since the 1960s CBA has enjoyed fluctuating fortunes, but is now recognised as the major appraisal technique for public investments and public policy.

The routine estimation of monetary values reflecting changes in environment assets as well as environmental services is only a part of the recent developments in environmental CBA. The uncertainty of environmental losses has led to emphasis on how precaution could enter into decision making in several ways e.g. sustainability constraint.

The rule of market economics is that the value of a commodity or service depends on its use. Given the predominance of markets in resource allocation and development decisions, and the use of market prices as the measure of value for most goods and services, environmental economists have developed a particular perspective on 'value' appropriate for environmental resource management that allows consideration of 'non-market values. The 'use value' of resources in terms of production and consumption is only a part of the multiple social value offered to society and therefore underestimates total economic value which includes non-use value.

Cost Benefit Analysis is an information support tool for decision making on competing priorities. In the field of environmental management, it is applied to help net environmental action priorities by identifying and measuring the costs and benefits of say, water supply improvement option and resources management strategies. It provides inputs for decisions on how much capital investment is justified relative to expected benefits. Under ideal conditions, decisions should focus on projects and measures that maximize the net social benefit. In economic terms, this requires an estimate of the marginal benefit of water supply improvement and marginal cost of the investment (Hanley and Spash, 1995).

Environmental cost benefit analysis entails the economic appraisal of policies and projects that have the deliberate aim of improving the provision of environmental services or actions that might affect the environment as an indirect consequence. Although the principles of CBA have remained largely the same, the practice of carrying out appraisals has undergone a transformation over the past two decades. Nowhere is this more the case than for environmental applications.

2.3 Application of CBA in the Provision of High Quality Water

Water is a basic human need. Irrigation, industry, municipal supply, etc are some of the multitude of uses of water. Over the years, the needs of a rapidly growing population for water supplies resulted in a continuing increase in demand for water facilities ranging from simple shallow wells in rural areas to piped systems in urban areas. Since everyone needs access to potable water, WSPs are always included in the development programs of developing countries.

CBA is increasingly being used in the water sector to justify investment needs and improvements of water quality (and other serviceability parameters). It provides a structured comparison of all the costs and benefits when deciding on the optimum level of water quality improvement schemes.

The economic regulator of the water companies in England and Wales, OFWAT, supports the wider application of CBA and is increasingly encouraging water companies to adopt this approach in justifying their investment needs (Consultation Paper RD 04/06) (OFWAT, 2006). One of the most important elements of this approach is the need to measure the willingness-to-pay of the consumers under different levels of service to optimise the social net benefit delivered by a project.

In addition, the UK Water Industry Research (UKWIR) report on "Acceptability of Drinking Water to Customers" (07/CU/02/3) sought among other things to formulate interventions and seek funds to address aesthetic aspects (including discoloration and particles, taste and odour, and hardness) of drinking water quality. A vital part of the project was the development of an appropriate methodology for justification of investment to improve aesthetic water quality by using customer WTP and CBA (http://www.ukwir.org/ukwirlibrary/91494).

The US Safe Drinking Water Act (SDWA), as amended in 1996, requires that whenever the Environment Protection Agency (EPA) proposes a national primary drinking water regulation, it must publish a CBA. Components of the analysis include treatment design, unit treatment costs and national costs, model systems development, baseline estimates, data quality objectives and benefits analysis. The SDWA also requires that the EPA fully consider both quantifiable and non-quantifiable benefits that accrue due to drinking water regulations; these benefits must be compared with the projected costs of the regulations.

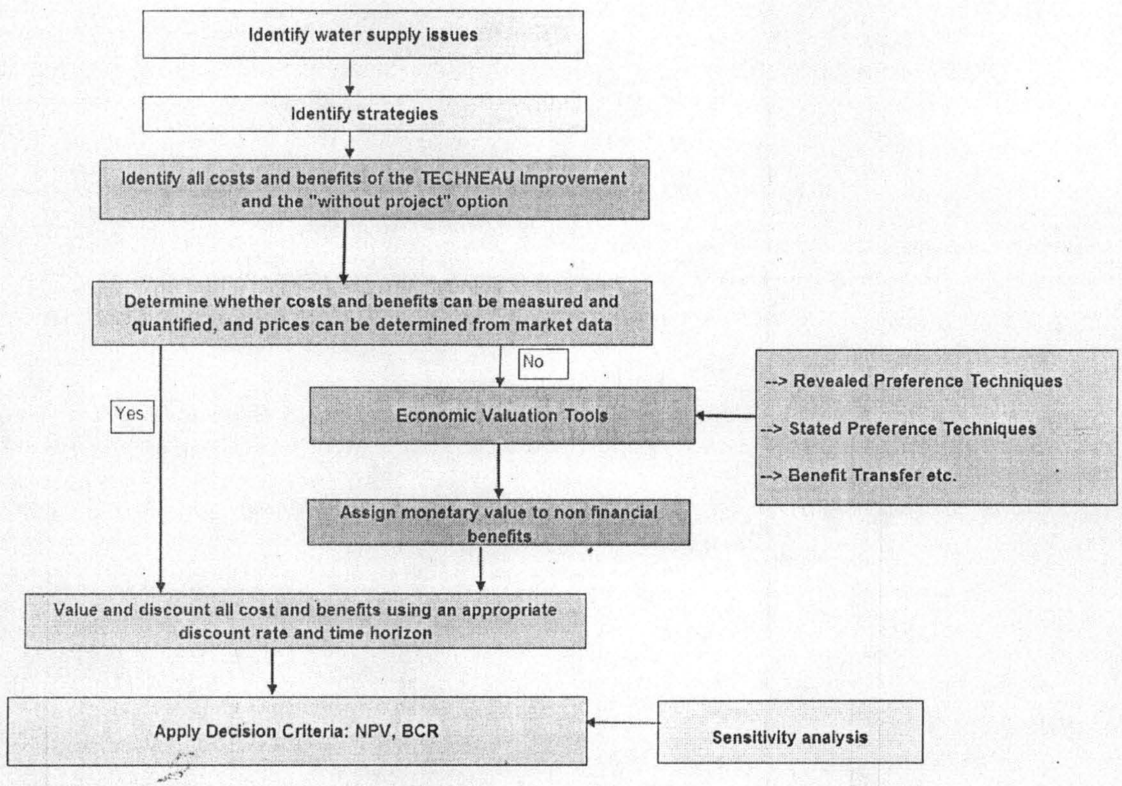

Fig.2.1 Stages in the development of a CBA model

Source: Hanley and Spash, 1995

Before any project appraisal is done, it is necessary for the design team to get acquainted with the area where the project is identified. This is done to acquire knowledge about the physical features, present situation regarding existing facilities and their use constraints against their optimal use, the communities and users, especially their socio-economic conditions etc.

In his appraisal of an improved water supply facility in Haapsalu, Estonia, Markandya (2003) stated among others that some of the objectives of a cost-benefit analysis of a water supply project include learning the importance of careful demand estimation in designing the project to be appraised and also taking into account the environmental benefits that can change the picture. In assessing the results, the economic rate of return was based on:

1. Changes in consumer and producer surplus
2. Health benefits
3. Willingness to pay for improved water supply
4. Amenity benefits

In his appraisal of a water supply improvement scheme in Canada, Anand (2007) identified the following surveys that must be undertaken before project appraisal:

i. **Reconnaissance Survey**: - to collect basic information of the areas and to have discussions with the beneficiaries and key persons involved in the design, implementation and management of the project.

ii. **Socio-economic Survey**: - to get detailed information about the household size, earnings, activities, present expenditures for water supply facilities, along with health statistics and water related diseases, etc. It is important to analyse the potential project beneficiaries, their preferences for a specific level of service and their willingness to pay for the level of service to be provided by the project.

iii. **Contingent Valuation Method**: - Anand (2007) again observed in his appraisal of a water supply and sanitation project in Canada that an important contribution in arriving at the effective demand for water supply facilities, even where there are no formal water charges, is the contingent valuation survey. This is based on questions put to households on how much they are willing to pay (WTP) for different levels of water quantities. These data help in building up some surrogate demand and estimate benefits from a WSP.

iv. **Survey of existing water supply facilities**: - knowledge of the present water supply sources, treatment (if any) and distribution is also needed. It is also necessary to know the quantity and quality of water and any constraints and bottlenecks which are coming in the way of the optimum use of the existing facility.

Using the information taken from the survey results, and other secondary data sources, effective demand can then be estimated. Two important considerations are:-

(i) Effective demand is a function of the price charged. This is ideally based on the economic cost of water provision to ensure optimal use of the facility, and neither over-consumption nor under-consumption, especially by the poor should recur. The former leads to wastage contributing to operational deficits while the later leads to loss of welfare to the community.

(ii) Reliable water demand projections, though difficult are key in the analysis of alternatives for determining the best size and timing of investments.

Approaches to demand estimation for urban and rural areas are usually different in the urban areas, the existing users are normally charged for the water supply, while users in rural areas may not be charged.

Powers and Valencia (1980) in their appraisal of a water supply project in Brazil noted that cost items and the way they are to be treated in project economic analysis are as follows:-

i. **Sunk Costs**: They exist in both with-project and without-project situations, and are not additional costs for achieving benefits. They are therefore not to be included.

ii. **Contingencies**: As the economic benefit-cost analysis is to be done in constant (or real) prices, the general price contingencies should not be included.

iii. **Working Capital**: Only inventories that constitute real claims on the nation's resources should be included in the project economic costs. Other items of working capital reflect loan receipts and repayment flows are to be excluded.

iv. **Transfer Payments**: Taxes, duties and subsidies are not to be economic costs.

v. **Externalities**: Environmental Costs arising out of a project activity is an instance of such costs. It may be necessary to internalize this external cost by including all the relevant effects and investments.

vi. **Opportunity Cost of Water**: If for example, a drinking water project uses raw water diverted from agriculture, the use of this water for drinking will result in a loss for farmers. These costs are measured as the opportunity Cost of water which equals the 'benefit foregone' of the use of the water for agriculture.

vii. **Depreciation**: The stream of investment assets includes initial investments and replacements during the projects life. This stream of expenditure, which is included in the benefit-cost analysis, will generally not coincide with the time profile of depreciation and amortisation.

In the GPA Strategic Action Plan for Water and Sewage (2000), it was found that once demand forecasting has been done, it is necessary to arrive at the output which a WSP should provide. The existing facilities may not be optimally used due to several reasons, among them:

- Inadequate management system, organizational deficiency and poor operation and maintenance leading to deterioration of the physical assets.
- Any bottlenecks in the supply networks at any time starting from the raw water extraction to the households and other user's end.

Before appraisal, it is necessary to take measures to ensure optimal use of the facilities. These measures should be both physical and policy related. The physical measures include leakage control, replacing faulty valves and pipes, and adequate maintenance and operation etc, policy measures can be charging an economically efficient tariff and implementing institutional reforms, etc.

The output required from the proposed WSP should only be determined after establishing the gap between the future needs based on the effective demand and the restored output of the existing facilities ensuring their optimal use. Attention needs to be focused on the identification and possible application of instruments to manage and conserve demand such as tariffs, fiscal incentives, pricing raw water, etc.

Compared to investment projects in some sectors, it has proved difficult to measure the benefits of investments in water supply. WSPs are usually justified because of the necessity of water.

Despite the importance of WSPs, the difficulty involved in identifying and quantifying their economic benefits has resulted in a lack of a standard approach for their economic evaluation. An important principle underlying the economic analysis of projects is to determine whether the net benefit from the resources allocated to the project would exceed, or at least be equal to, the net benefit to the economy that could be expected if these resources were made available for the next best alternative use. Cost Benefit Analysis is an economic tool which is used to judge whether the benefits outweigh the costs. This approach however presupposes that costs and benefits can be identified, quantified and valued in money terms (Anderson and Settle, 1978).

The strongest and most frequent argument put forward for expenditure on domestic water supplies is the observed correlation between better water and health; several studies have shown that differences in water quantity or quality are associated with differences in morbidity (Saunders and Warford, 1976). It has become a practice to justify these projects in terms of the influence of health factors on economic output. If benefits can be identified, quantified and valued, cost benefit analysis should be conducted (Peskin and Saskin, 1985).

A very good example is the study conducted by Hutton *et al* (2007) in which water supply and sanitation interventions in 10 developing countries were appraised. Their evaluation focused primarily on the health benefits that accrued to the affected communities in terms of healthy life days due to absence of water-borne diseases. Their study revealed that a range of options are available in improving water supply. Their analysis was based on changes in water supply service levels. Incremental cost analysis was employed, while estimations of costs were extended to cover those not presently connected to urban water supply. Incremental costs consist of all resources required to put in place and maintain the interventions, as well as other costs that result from the intervention. According to them, knowledge of the health effects of the project is important not only for a cost effectiveness analysis but also for a cost benefit analysis as some important benefits depend on estimates of the health effects.

Over recent decades, compelling evidence has been gathered that significant and beneficial health effects are associated with improved water supply and sanitation.

One common practice in justifying the economic viability of water supply projects is to estimate first the financial internal rate of return (FIRR) and use it as the lower limit of the economic internal rate of return (EIRR) (Ali, 1986).

Pearce and Nash (1981) argue that like other social projects, it is difficult to assess the benefits of investments in water supply. The benefits to be gained from water supply systems, while in most cases identifiable, are difficult to measure. In order to carry out a BCA, it is necessary to follow a sequence of interrelated steps.

2.4 The Concept of Opportunity Cost

Opportunity cost is the benefit foregone from not using a good or resource in its next best alternative use. To value the benefits and costs, the opportunity cost measured in economic prices is the appropriate value to be used in project economic analysis.

The opportunity cost of water may vary from zero to a very high figure. If the water in the area is abundant, the opportunity cost of using such water is zero, but if, on the contrary, the water is scarce and an urban water supply scheme has to use water by taking it away from say, agricultural or industrial use, the opportunity cost of water will be equal to the value of net agricultural or industrial production lost by directing water from these alternative uses.

2.5 Analytical Framework for a Cost Benefit Analysis of Water Supply Projects

The process of economic analysis can be seen as a sequence of actions. First it is necessary to identify the need or demand for the project. The second step is to establish whether the proposed project provides the least cost way of attaining the objectives. With the project costs and benefits carefully quantified, the next step is to ascertain whether the net benefit expected from the resources allocated would be in excess of or at least equal to, the net benefits to the economy that could be expected if these resources were made available for the next best alternative project.

This consists of three phases namely (i) identification of economic costs and benefit (ii) quantification and evaluation of economic costs and benefits (iii) application of investment criteria. It is worth emphasizing at this point that demand forecasts and least cost analysis are necessary whether the economic benefit expected from the proposed investment are available or not (Lee, 1969).

2.5.1 Demand Forecasting

The demand analysis or forecast establishes the need for the project and provides the basis for the estimation of the benefits. Some of the factors that enter the demand function for water according to Tadle (1990) include (a) population (b) income level (c) price or tariff (d) water use habits etc.

The effective demand for water is the quantity of water demanded of a given quality at a specified price. The analysis of demand for water, including realistically forecasting future levels of demand, is an important and critical step in the economic analysis of water supply projects. The definition of effective demand mentions the "demand for water of a certain quality". The quality of the product 'water' is not easily explained and a number of characteristics are normally included in defining it, including chemical composition (e.g. WHO standards), taste and smell, water pressure, reliability of supply, accessibility and convenience. The first two characteristics determine the quality of water in the stricter sense. The other characteristics define water quality in its broader sense.

Findings from research e.g. WHO (2000) have shown that households with high incomes are normally able and willing to pay more for a given quantity of water than households with lower incomes.

Some other determinants of the demand for water, apart from price and income include but are not limited to the following:

1. Population: population, especially population growth, is a very important factor in determining future demand. Population growth may consist of natural growth, or in certain case, migration (e.g. from rural to urban areas). Small differences in demographic trends have large effects on water consumption. For example, all other factors remaining constant, an annual population growth of 2% over a period of 20 years results in an increase in consumption of approximately 50%; whereas an annual growth of only 1.5% generates an additional consumption of about 35% over the same period (Hutton *et al*, 2007).
2. Access to, and cost of alternative sources: if water from other sources of good quality is readily available, people will generally be less interested to displace their current sources. For example where shallow groundwater of good quality is available throughout the year and when households have their own dugwells, people may be

inclined to apply for a connection to a new piped system especially if the price of piped water is higher than the unit cost of water from the alternative source.

3. Availability and quality of service: if existing water supply companies provide a fully satisfactory service to their consumers, households not yet connected will usually be more interested in connecting to an expanded water supply system.
4. Size and type of industry: logically, size and type of industry will to a large extent determine the quantity of future consumption of water.
5. Industrial growth: economic and regional/urban development may strongly influence the future demand for water.
6. Legal obligations: in certain countries, industries must apply for a permit to make use of alternative sources or are obligated to connect to piped systems, if available.

The demand for water is often analyzed for relatively homogenous groups of users. In many cases, a distinction is made between domestic and non-domestic users. For the purpose of this research, domestic households only are considered.

Some studies, e.g. Asian Development Bank Report on Water and Sanitation (1990), have shown that the use of water can be understood as a response to the environment in which the consumer lives. Improvement in the living environment would produce discrete changes in the demand function for water. According to Brox *et al* (2003), a very beneficial way of determining whether the demand function for water should include price as one of the variables, is through a survey approach termed "contingent valuation method". In this approach, a hypothetical market for the public good is constructed to estimate market demand. The use of contingent valuation method, which is conducted through household survey and source observation, allows one to collect information on what economic variables are likely to be part of the demand function. Pearce *et al* (1989) argue that CVM is a feasible method of estimating individuals' willingness to pay (WTP). The household interview may consist of the following (i) basic demographic and occupational family data and information on where the family sources its water (ii) location of each water source (iii) perceptions of the water quality at each source (iv) the number of times each family member went to each source per day (v) information on health and education of the family members.

2.5.2 Least Cost Analysis

This is the first step in the two stage optimization procedure of economic analysis. It provides the basis for determining the most efficient alternative in terms of a specific objective. The quality of water to be provided by the project is determined either from (a) the government's targets as in additional supply from meeting previously suppressed demand or (b) division of supply from existing source to a more efficient alternative. According to Mitchell and Carson (1984), another common objective is the improvement of supply. Alternatives are therefore compared based on economic costs, with the least expensive one chosen as the best alternative.

2.5.3 Identification and Quantification of Benefits

As emphasized in all writings on cost benefit analysis, benefits are not synonymous with monetary resources on account of the following (i) market prices are not necessarily economic prices (ii) projects may produce externalities (iii) market prices underestimate benefit where consumer surplus is significant (iv) project boundary is likely to be wider when estimating economic profitability viz financial profitability. Thus a firm's receipts and expenditures are not an economy's benefits and costs (Mullick, 1987).

The first step in identifying benefits is to determine the output of a project which refers to goods and services that become available as a result of the project. This is done through the 'with- and without- principle' (Ali 1989). What matters are effects which are truly caused by and would not occur in the absence of the project. Only incremental effects associated with the project should be counted. Explicitly distinguishing the with and without demand and supply situations is important in making the distinction between benefits in existing and new market and therefore in identifying and quantifying benefits between resource cost savings in existing markets and additionality of supply measured by willingness to pay in new markets. An existing market is defined as the present consumers of water at a particular site plus the natural growth of consumption which occurs independently from the project (Ali, 1989).

Resources cost saving is the first type of quantifiable benefit which a water supply project may provide. The second type of benefits is from the additional supply of water. It accrues from two sources (i) existing markets where consumers switch from some other sources of water e.g. vendors, to the project e.g. piped system and (ii) new markets or induced demand which develop as a result of the project.

Schofield (1987) argues that for economic benefits in water supply projects to be appropriate, it should be possible for the alternative method of supplying water to be utilized in the future in the absence of the project. Alternative water supplies which are hypothetical and are not actually initialized cannot be used as a basic for estimating benefits which are reflected in resources released.

2.5.4 Identification and Quantification of Economic Costs

Similar to the identification of benefits, the objectives of the proposed projects provided the standard against which costs are defined. Thus anything that reduces the real income is economic cost. Economic costs comprise opportunity costs or foregone welfare as a result of diverting resources from other uses to the ones under analysis e.g. proposed projects. The correct estimation of costs requires a clear definition of the project 'boundary' which includes all facilities that will be used for realizing the benefits (Desai, 1992). The determination of the project boundary, on the other hand, will depend on the identification and quantification of benefits. Thus all costs which have to be incurred for realizing the benefits attributed to the project have to be taken into account. In addition, economic costs should refer to the difference between what the costs would be with the project and what they would be without the project.

The project total cost can be classified into (a) capital or installation costs (b) operation, maintenance and replacement costs and (c) user's costs. Capital costs will include costs of construction, engineering and administration, cost of land relocating facilities and land development.

After construction, the project has continuing costs of operation, maintenance and replacement. In addition, users may be required to bear associated costs.

2.5.5 Valuation of Economic Benefits and Costs

Once the streams of benefits and costs of a project are properly identified and quantified, the next step is to evaluate such streams in terms of their contribution to overall economic efficiency. The real costs to society of the resources needed for a water supply project are in principle, scarcity prices which are determined by supply and demand.

Monetary valuation is a key component of CBA. Economic values expressed in monetary terms, if properly determined, will reflect people's preferences and can thus be used as weights to inform any policy analysis or decisions. After identifying all relevant costs and benefits, the next step is to assign monetary values to the costs and benefits of each option in terms of the price level prevailing in the year in which the project is appraised.

It is however difficult to place monetary values on non-financial benefits such as health benefits or aesthetic benefits. For example, it is not possible to quantify or estimate in real monetary terms the value of an elimination of odour in water supply or the value of human lives potentially saved due to improvements in water quality. This is because a market does not exist, or market prices are not directly observable or easy to estimate. Many water quality benefits cannot be directly measured through the market system; therefore non-market methods have been developed to assess them. Consequently, a number of economic valuation tools and techniques can be employed to estimate the value that is placed on these non-market goods.

The following section gives a summary of the economic valuation techniques that can be employed to estimate the value that customers or users place on an improvement in water quality.

2.6 Using Economic Valuation Techniques to Measure Benefits of an Improvement in Water Supply

Economic valuation refers to the assignment of monetary values to non-marketed assets, goods and services. Reliably estimated monetary values for non-marketed goods will reflect people's willingness-to-pay for (or accept) certain changes. WTP represents the expected payment a user is willing or prepared to pay for a given service/product or a given change in service level or product attribute. It is the price at which they would be indifferent between having the service/product or the money. An individual would not purchase the service/product at an amount greater than his/her WTP. In the context of a water utility, WTP represents the amount that a customer would be willing to pay for proposed improvements in water services over a defined baseline of service.

The two main valuation techniques for estimating WTP are:

- Revealed Preference – market prices and hedonic pricing; and
- Stated Preference Methods – contingent valuation and choice experiment.

The Revealed Preference technique infers or derives the value of non-market goods and services from market prices or market transactions. The Stated Preference methods ask people to directly or indirectly state their values in a hypothetical setting. Stated Preference valuation techniques are increasingly being used as means of establishing monetary values for impacts which do not themselves have observable monetary values. These have been extensively used in the field of transport, where it was first established, and it is now being used in a number of other public sector fields, such as environment, health, housing, leisure and education.

Stated Preference valuation techniques are mostly employed in eliciting customers' WTP for a change in water service levels. These techniques construct demand functions for consumers through the use of surveys/questionnaires.

2.6.1 Contingent Valuation

In Contingent Valuation Methodology (CVM), consumers are asked to state their WTP for a specific package of improved water services. It is a useful methodology if there is a specific package for the consumer to consider. The most essential aspect of CVM is creating a realistic scenario, which has accurately priced water supply 'options' that reflect the level or prices the water service provider would have to charge in order to provide the service. The respondent is asked about their preferences and is effectively asked at what price they would be willing to 'buy' the water, based on the level, quantity and quality of service. However, there are limitations to this approach because it relies on customers' answers to direct questions on the subject; it is susceptible to considerable bias because of the tendency to encourage 'tactical' responses. There is a risk of consumers answering strategically, whereby respondents understate or overstate their valuation of the product or service in question. For example, respondents might suggest that they are unwilling (or unable) to pay anything more to discourage regulatory agencies or water companies from putting prices up. Various techniques have been developed to try and eliminate biased response. In particular, the way that the CVM scenario is presented to the respondents and how WTP questions are asked can be specifically designed to reduce bias.

2.6.2 Choice Experiment

In a Choice Experiment, a survey respondent is presented with two or more options for service levels and associated price and is asked to state which option he/she prefers. Thus respondents make a choice among a number of options each with defined attributes. A monetary value is included as one of the attributes so that when individuals make their choices, they implicitly make trade–offs between both the level of the attributes in the different alternatives along with the costs associated with each one. Different service levels and prices are specified in a number of experiments to provide the variation that is necessary for identifying an estimate of the marginal utilities of each attribute. A series of experiments is presented to each respondent, with the experiments varying over respondents. Respondents' choices reveal their WTP (or otherwise) for improved service. Statistical analysis of the responses, using discrete choice models, provides estimates of the WTP.

Choice Experiment is the preferred method when searching for the value of individual attributes of a product or service. It is useful when information on relative values for different characteristics or attributes of a non-market good is needed, as compared with CV in which the number of scenarios that can be considered in one study is limited. Relevant aspects of water supply attributes (including issues such as water quality and reliability of water supply) to be included in each choice set is determined through a series of exploratory and qualitative focus group discussions. The information from the focus group will form the basis of designing the Choice Experiment, such as which service attributes to include in the experiment, how attributes are to be described and the levels that each attribute could take. Thus the initial focus group discussion helps in selecting relevant water supply attributes that matter most to end-users of the schemes. The attribute levels should be realistic and span a range over which respondents can be expected to have preferences (Pearce *et al*, 2002).

Attribute levels should include "without project" or the 'status quo' level and a range about the existing level in order to elicit WTP for a gain and WTP to avoid a loss. However, it is argued that there can be tendency for respondents to prefer the status quo over changes in service levels in either direction due to various factors such as risk aversion and/or disutility to change. To mitigate this, it is essential that attributes of each option are stated in absolute terms rather than relative to the respondents' current situation (Hensher *et al*, 2004).

2.6.3 Undertaking a WTP survey

The WTP survey sample should be representative of the region or area under consideration. Though the sample size depends on the population, there is usually a need for a sample size of at least 500 to 600 to ensure statistical validity of results. It is essential to describe the criteria for choosing the sample. These criteria are defined by the objective and expected output of the survey. A typical survey questionnaire should have the following components: socio – economic characteristics of the respondents, awareness and perception of water quality issues, bill payment, etc., and choice sets for estimating the WTP for improved water quality. The inclusion of respondents' socio – economic and demographic characteristics (e.g. sex, age, income, etc.) in choice modelling allows for the impact of different user characteristics on WTP to be assessed.

There are different methods available for performing the WTP interviews. The preferred method is by face-to-face interviews. However, this is the most costly and time-consuming, thus it is often more effective to use other methods, such as postal or telephone surveys. A combination of postal and follow-up face-to-face methods is very effective. Carrying out a WTP survey can have significant time and costs implications. Cost and time elements depend on factors such as the method used to elicit customers' WTP (whether CVM or choice experiment), number of field workers and consultancy team (cost of labour), sample size (number of households), time required to design questionnaires and train field workers, etc. Also it is much cheaper to administer WTP surveys in developing countries than in industrialised countries. Enumerators are relatively cheap; therefore the cost of surveys is normally considerably less than they would be in a developed country.

In general, it is not possible to set out a blueprint for the amount of time and resources that are required for a WTP survey. This will depend on the size of the project area, the size of the random sample deemed necessary to gauge demand accurately, and whether the results are to be used to set tariff and subsidy (depending on the mode of water supply system) or just to provide useful information on preferred options and affordability.

2.6.4 Benefit Transfer

Another approach to estimating non – market benefits is the use of benefit transfer (BT). BT is used to estimate economic values by transferring available results from one study with similar impacts to the project being evaluated but completed in another location or context. It is often used when it is too expensive and/or there is too little time available to conduct an original valuation study, yet some measure of benefit is needed. In undertaking a BT approach, it is important to ensure that the service parameter being valued is comparable to the service parameter valued in the existing study. Also, the characteristics or demographics of the relevant population should be comparable. Although this approach satisfies time and budget constraints, it is important to note that it can only be as accurate as the initial study.

2.7 Discounting the future streams of Costs and Benefits

All costs and benefits are to be evaluated at present values using an appropriate discount rate and planning horizon of the analysis. The choice of discount rate can have a significant effect on the evaluation of costs and benefits when the time horizon is long. This is based on the principle that a given amount of money is always more valuable sooner than later, since this enables one to take advantage of investment opportunities. Thus more importance is placed on costs and benefits that occur now than those that arise in the future. When applied to monetary values, the discount rate should reflect the opportunity cost of capital or revenue.

When applied to benefits, it is still appropriate to apply a discount rate since benefits are normally preferred now rather than in the future. However, care needs to be taken since a high discount rate can be contrary to a goal of sustainability. For example, using a discount rate of 6% would mean that environmental benefits of 100 units in Year 10 would have the same value as environmental benefits of 56 units today. However, changing the discount rate to 3.5% would mean environmental benefits of 100 units in Year 10 would be worth 71 units today. This seems a reasonable compromise between representing a preference for early benefits and not valuing future benefits too lowly. It is also important to make sure that the benefits in the future are sufficient to meet mandatory standards.

A company's cost of capital is usually the preferred rate for assessing the costs relevant to them. This is the private opportunity cost of capital and it is the rate of return on the most valuable alternative project given up. However when evaluating projects which have broad impacts on society, the capital market is not always the best arbiter on which to make such a decision. Higher discount rates normally result from using the private opportunity cost of capital which can "discount away" some of the long term environmental and social impacts or benefits of water project. The social discount rate is the preferred discount for such a case as it takes into account ethical consideration, i.e. all things being equal, society values its ability to consume in the future as highly as it values current consumption.

The number of years that a project should be discounted over depends on the policy proposal. A number of other factors should be taken into account:

- If the main cost is the purchase of a piece of equipment then the expected lifetime of that equipment could be used.
- If the costs or benefits are likely to appear well into the future, you might want to consider a longer timescale.

2.8 Decision Criteria – Net Present Value, Benefit Cost Ratio

Net Present Value (NPV) is a robust indicator of the financial (and economic) performance of a project. This measures the net benefit of a project, and it is estimated as the summation of the annual net benefit of a project over the period of analysis. In comparing mutually exclusive improvement options, the option that delivers the highest positive net present social benefit is selected. Assuming that the benefits are higher than the costs, then an overall benefit is achieved through implementation of the project.

One way of deciding which option is the most attractive is to choose the option with the highest benefit cost ratio (BCR). By placing monetary values on all benefits and costs, it is possible to rank the options dependent on their ratio of benefits to costs (i.e. the amount of benefits received for every pound spent). If the ratio is greater than 1, the benefits outweigh the costs and the project delivers net present social benefit.

Finally, it is often the case that all benefits accrue from the use of customer WTP. When this is the case, the average WTP for a change in the level of service can be compared with the marginal costs associated with the change. If the WTP exceeds the marginal cost then it is worthwhile.

2.9 Incorporating risks and uncertainty into a CBA Framework

A key step in a CBA is to identify and quantify all relevant costs and benefits as seen from the private and society's viewpoint. The net present value (NPV) is then estimated as the sum of the discounted flows of costs and benefits over the presumed lifespan or timeframe of the project. Without accounting for risks and uncertainties, a NPV above 0 suggests that the project leads to a potential efficiency improvement as benefits exceed costs. Generally, all CBAs utilize variables which can only be assessed or forecasted imprecisely. The risk or uncertainty of the variables included in a CBA will affect the precision of the estimated expected NPV or any economic decision criteria such as the BCR. It is therefore imperative to consider the effects of risk and uncertainty when undertaking CBA.

A "risk assessment" should be included in the analysis in order to deal with the uncertainty that always permeate investment projects. Two main steps should be undertaken: sensitivity analysis and risk analysis:

2.9.1 Sensitivity Analysis

Sensitivity analysis aims to identify the project's critical variables and can therefore be used to assess the sensitivity of the expected NPV to changes in these variables. This is done by letting the project variables or parameters vary according to a given percentage change and observing the subsequent variations in both financial and economic performance indicators, i.e. the NPV and BCR. Parameters should be changed one at a time, while keeping all others constant. The calculation of the changing values can reveal interesting information, by indicating what percentage change in the variables would make the NPV (economic or financial) equal to zero.

Sensitivity analysis can address two key questions:

- Would the proposal still be worthwhile pursuing if some of the key assumptions do not eventuate?
- Are there actions that can be taken to reduce the risks before accepting a particular option?

Sensitivity analysis can help in forecasting uncertainty and in assessing and treating project risks. A common approach is to test combinations of key variables in three scenarios: a pessimistic scenario, most probable or base scenario, and an optimistic scenario. Consequently this approach can be used to test the robustness of the analysis as well as allowing for uncertainty about future cash flows.

2.9.2 Risk Analysis

Assessing the impact of given percentage changes in a variable on the project's performance indicators does not say anything about the probability with which this change may occur. Risk analysis deals with this. By assigning appropriate probability distributions to the critical variables, probability distributions for the financial and economic performance indicators can be estimated. This enables the analyst to provide statistics on the project's performance indicators, e.g. expected values, standard deviation, coefficient of variation, etc.

The first step in applying risk analysis to a CBA is to identify the key parameters whose variation have significant effects on the outcome: this can be done by sensitivity analysis. The probability distribution of each chosen parameter should then be estimated using methods ranging from sophisticated statistical analysis of past experience to educated guesses. The next step is to estimate the correlation between the chosen variables. Examples of correlated parameters are discount rate and net present value. The next step is to simulate the analysis or run the model a large number of times with the different values of the chosen parameter each time. For example, while the complete CBA calculation is carried out about 1000 times, determining and recording the NPV (or other indicator) each time. The final step is to present and interpret the results of the simulation. One or more output parameters, normally the CBA indicator such as the NPV or BCR, will have been recorded for each iteration, and the probability distribution of the output parameter's values can be presented as a histogram, as a cumulative curve or as a table of descriptive numbers such as mean, standard deviation, quartiles, deciles and extremes.

It should be noted that while it is always possible to do a sensitivity analysis, the same cannot be said for risk analysis. In some cases (e.g. lack of historical data on similar projects) it may prove rather difficult to come up with sensible assumptions on the critical variables' probability distributions. In such cases, a qualitative risk assessment should be carried out to support the results of the sensitivity analysis.

Because conditions in the economies of developing countries are far from being perfectly competitive, costs and benefits cannot be measured in terms of market prices. Real or economic prices are now used to estimate the real costs to society of the resources required for the project (Pearce and Nash, 1981). Other estimates i.e. shadow prices are necessary. Several techniques of computing shadow prices have been proposed e.g. the Little and Mirlees (LM) method which uses foreign currency as the numeraire by which costs and benefit of projects are evaluated while not involving an explicit use of shadow exchange rate (SER).

The best known approach is the UNIDO approach which uses domestic currency as the numeraire and employs a shadow exchange rate to derive estimates of social costs and benefits (United Nations Industrial Development Organization Guideline for project Evaluation, 1972). It is also known as the willingness to pay numeraire (Ali, 1989). The basic difference between the methods depends on the choice of numeraire, i.e. the unit of account used to measure benefits and costs.

James and Lee (1971) argue that water supply is a notable example where project benefits cannot be measured directly and where the key to efficient investment decision making lies in setting prices equal to economic costs. The role of shadow pricing is to provide an estimate of the absolute economic cost of incremental supplies of water.

In his study, Roupgides (2007) stated the main objective of his work as the application of CBA to evaluate the ITER nuclear plant in France. His main focus was the examination of the social benefits derived from the application of nuclear technology. In the absence of data from other nuclear sites and the method of evaluation he used was Benefit Transfer (BT). He obtained a positive CBA.

Sagdieva (2003), in her study, used a contingent valuation method (CVM) in assessing the value people place on implementation of more efficient technologies for household heating systems and improved changes in energy service in a rural area in Azerbaijan. She argues that CVM has become one of the most widely used non-market valuation techniques.

In his conclusions, Simons (2000), observed the economic value of the non-use values of inter-tidal areas created by managed realignment. The method to put monetary figures on values which he used was Benefit Transfer (BT). Conclusions drawn were that:-

(i) The inclusion of non-use values in cost-benefit analysis can make a difference in the benefit/cost ratio.

(ii) When the value of the hinterland, which is to be protected in high, these non-use values form only a small part of the total benefit and the difference in the benefit/cost ratio is not significant.

Stewart (2002) examines the financial costs of water supply in the Northern Ireland through operation and maintenance and the future maintenance costs. The environmental costs were assessed depending on the water source and collection method, while the social aspects of water charging are dealt with in the proposed charging model for Northern Ireland. The average incremental cost of water was estimated. He found that environmental costs in Northern Ireland were relatively small because the water is mostly collected from natural sources.

2.10 Measures of Project Viability

In any situation involving project choice, the proposal to be selected is the one which produces the greatest net benefit. This is done through the application of certain investment decision criteria. Such criteria aim to place benefits and costs occurring in different years on an equal basic and to express the project desirability in a way that permits comparison of alternative investments. No single criterion will always lead to the correct investment decision. As stated earlier in this chapter, there are three (3) criteria widely employed in investment decision making; (a) net present value (NPV), (b) benefit cost ratio (B/C ratio), (c) internal rate of return (IRR).

The net present value (NPV) is measured as the present value of benefits (PVB) less the present value of costs (PVC), where benefit and cost streams are discounted at the opportunity cost of capital. Thus any project is profitable from an economic viewpoint if the NPV is greater than zero. If one is to choose among alternative ways of constructing a water supply system, the correct rule is to choose the alternative with the highest NPV.

The benefit cost ratio (BCR) is measured as the present value of benefits (PVB) divided by the present value of costs (PVC), discounted at the opportunity cost of capital. A project is said to be economically feasible if the BCR is greater than or equal to one.

The alternative approach to investment appraisal is to calculate the internal rate of return (IRR) and compare it directly to the opportunity cost of capital, achieved by setting the discounted value of net benefits stream equal to the initial capital outlay and finding the value of the discount rate. The rule for accepting the project is that the estimated internal rate of return should be equal to or greater than the opportunity cost of capital.

2.11 Economic Analysis and Environmental Management

Expansion in water supply and pollution, emerging from the twin processes of urbanization and economic development are central environmental concerns in all developing countries. Often the responsible government and municipal authorities, faced with pressing obligation to pursue development objectives are constrained in implementing effective environmental management measures by the need to ensure that developmental commitments are not compromised (Freeman, 1993).

In addition to the underlying economic pressure on the environment, inadequate management capacities, financial constraints and the limited awareness of the true value of the environment compound the scale and severity of the impacts.

As has already been mentioned, the rule of market economics is that the value of a commodity or service depends on its use. Given the predominance of markets in resource allocation and development decisions, and the use of market prices as the value for most goods and services, environmental analysts have developed a particular perspective on 'value' appropriate for environmental resources management that allows consideration of non-market values. The 'use' value of water resources in terms of supply and consumption is only a part of the multiple social values offered to society and therefore under-estimates total economic value which included the non-use value (Pearce, 1996).

Resource valuation methods differ in terms of what they attempt to measure. Some aim to measure value directly, while others aim to measure the indirect contributions of different social and economic activities. For values of resources that can be measured directly, market based behaviour is most appropriate while for indirect and non-use values are measured by applying proxies (United Kingdom Water Industry Research (UKWIR), 2006).

2.12 Financial and Economic Analyses

Financial and economic analyses have similar features. Both estimate the net benefit of an investment project based on the difference between the with- and without -project situation (Foster, 2002).

However, the concept of financial net benefit is not the same as that of economic net benefit. While the former provides a measure of the commercial viability of the project on the project operating entity, the latter indicates the real worth of a project to the country (Tadle, 1990). The two concepts are however complementary. For a project to be economic viable, it must be financially sustainable. If a project is not financially sustainable, there will be no adequate funds to properly operate, maintain and replace assets; hence the quality of water service will deteriorate, eventually affecting economic benefits (Schofield, 1987).

The basic difference between the financial and economic benefit cost analysis is that the former compares benefits and costs to the enterprises in constant financial prices while the latter compares the benefits and costs to the whole economy measured in constant economic prices (Luken, 1985).

Since CBA is an economic tool for evaluating all relevant costs and benefits of an investment, reflecting the total impact of a project on society as a whole. It started out of a need to quantitatively assess whether a business or society at large would experience a net benefit from a given project. The methodology entails the systematic estimation of all benefits and costs of a contemplated course of action in comparison with other course(s) of action.

CBA considers gains and losses to all members of the community who are affected by the project being considered. The analysis should not concentrate solely on the financial implication of a project but other tangible and intangible externalities must be assessed (Kim and Cho, 2004).

The key elements of a CBA include (i) allowing a comparison between alternative options, benefit and costs need to be valued in a consistent manner (ii) discounting future costs and benefits (iii) valuation of benefits and costs that have no clear monetary value should represent peoples behaviour and choices (iv) the analysis of a project should include the without- project option. This is the situation that would occur if current schemes continued and no new interventions were introduced (v) a performance or decision criteria is required. The common criteria used are the Net Present Value (NPV) and Benefit Cost Ratio (BCR).

The development of cost information, while challenging, is fairly well understood. Assessment of benefits, by contrast, is less well understood in connection with water supply. The benefits of regulatory action are reflected in improvement in human welfare.

In developing CBA model, the following key elements of the appraisal should be identified (Pearce, 1996).

- A base case or " without project" scenario which represent the current service level and current cost with the water service provider. This should be compared with the 'with project' scenario.
- Planning period / horizon for the appraisal
- Identify and estimate costs over the period including operating and capital expenditures, social and environmental cost
- Identify and estimate benefit to the water supplier, consumers and society as a whole. This involves deriving customer benefit in monetary terms of these improvements through a customer willingness to pay survey.
- A discount rate to connect future rates to present values
- Risk sensitivity analyses to integrate risk and uncertainty into the framework.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Method of Data Collection

In line with the aim and objectives of the study as outlined in Chapter One, a reconnaissance/socio-economic survey was conducted on some households in Minna area. This was done in order to obtain important information from the beneficiaries of the proposed intervention. Data on household size, earnings, activities and present expenditures for water supply facilities and health statistics (Hanley and Spash, 1995) were collected. A simple questionnaire (see Appendix) was administered to the respondents. The results are shown at the beginning of the next chapter. The questions were drawn with the aim of seeking different responses and confirming the information supplied. Such questions ranged from those with short answer form "yes" or "no" to multiple-choice. Other data were obtained from secondary sources like the Niger State Water Board, the National Population Commission, the Niger State Ministry of Health, etc.

In arriving at the total effective demand for water supply, the contingent valuation method (CVM) was used. This was based on questions put to households on how much they were willing to pay (WTP) for the use of different levels of water quantities (Wedgwood and Sanson, 2003). Of prime importance in achieving objective 1 for this study is the estimation of the population to be served over the period of the project. The volume and cost of present water demand is a function of the number of persons and their willingness to pay for the water. Also important is the present household expenditures on water (supply costs). The information obtained from the reconnaissance/socio-economic survey was used to deal with objectives 1 and 2 as spelt out in Chapter One.

3.2 Estimation of Population to be served

The population of the service area was estimated at 200,000 people (NPC, 2006) with an annual growth rate of 3%.

3.3 Estimation of Present Water Consumption

The consumption per non-connected household per month was estimated on the basis of daily quantities of water collected from a specific source. For connected households, the survey revealed some quantity collected from secondary sources (wells, boreholes etc). The average consumption per household was obtained by multiplying per capita consumption by the average number of persons in the household.

3.4 Estimation of Present Supply Cost of Water

The present supply cost of water was divided into collecting time and cash expenditure on water. The survey showed that households spend time to collect water. The value of time was then determined on the basis of the observed wage rate for unskilled labour in construction work.

The expenditure on water was determined by obtaining the average cost per cubic metre of water as sold by water vendors in the town.

3.5 Estimation of New consumers/ Beneficiaries of the Project

The number of new consumers was obtained by deducting the existing population served from the target population to be served. The number of new connection was deduced by dividing the total number of new consumers by the average household size of 6 people.

3.6 Estimation of Total Demand/ Required Capacity for the Improvement

The total piped water demand, which is the shortfall, was obtained by adding up the total demand for both existing and new consumers. This demand forecast was used in estimating the overall cost of the project.

3.7 Estimation of the Costs of the Project

The investment in the project was apportioned into (i) traded (ii) unskilled labour (non-traded) and (iii) other non- traded components. According to NSWB (2000), the components of the costs of the project included (i) source development (ii) water treatment (iii) ground storage (iv) elevated storage (v) pump station (vi) distribution system (vii) sanitation and drainage and a host of others. The financial costs were broken down by conversion factors according to the GPA Draft Recommendations for Decision Making in Water Projects (2000).

3.8 Estimation of the Benefits of the Project

3.8.1 Estimation of Tariff Revenues to Government

This was deduced by multiplying the cost of a unit m^3 of water supplied by the project by the total number of new beneficiaries /connections.

3.8.2 Estimation of Resource Cost Savings to Consumers

This was deduced by comparing the average cost of obtaining water from non-connected sources with the cost of the piped water from the project.

3.8.3 Estimation of Health and Environment Benefits

This was calculated by deducing the loss of income from work days lost as a result of illness in the working population. A second step was the estimation based on the cost of treating water borne disease like cholera and diarrhea. The avoided cost in this case translates to a benefit. Environmental benefits were estimated based on the average willingness to pay for cleaner environment and sewerage facilities.

3.8.4 Estimation of Time Cost Savings

The value of time saved as a result of a piped system was estimated on the basis of the observed wage rate for unskilled labour in construction work.

3.8.5 Estimation of Amenity/Recreational Benefits

This was deduced by the average willingness to pay of an individual to visit a garden or swimming pool in Minna.

3.9 Project Lifetime

The projected lifetime of the intervention was estimated to be 20 years (2008-2028) but 2018 is the year in which the net benefits are expected to reach a maximum i.e. no further increase in benefits from 2018 are expected till the lifetime of the project is over.

3.10 Prices and Currency/ Choice of Numeraire

In this study the domestic price numeraire was used. All prices were expressed in constant values of the base year, 2008. The currency was the Nigeria Naira (₦).

3.11 Discount Rate

A standard discount rate of 10% which is nearly equivalent to the social opportunity cost of capital (SOCC) in developing countries was used in all the estimations (Freeman, 1993).

3.12 Cost Benefit Analysis

The CBA of the proposed project was carried out by comparing all the expected estimated cost and benefit streams over the life of the project. The discount rate chosen was 10%.

3.13 Evaluation Criteria

The criteria used for evaluating the result of the CBA were the net present value (NPV) and the benefit cost ratio (BCR).

CHAPTER FOUR

4.0 RESULTS

The results of the reconnaissance/socio-economic survey are first presented here before the results used in achieving the aim and objectives of the study.

Table 4.1 Average Household Size of Respondents

Household size (persons)	Percent (%)
1-5	45
6-10	36.2
11-15	4.3
16-20	2.7
Above 20	11.8
	100

Source: Authors Field Survey (2008)

Table 4.2 Occupational Status of Respondents

Occupation	Percent (%)
Trading	19.7
Farming	9.4
Civil servants	52.9
Other	20
Total	**100**

Source: Authors Field Survey (2008)

Table 4.3 Average Monthly Earnings of Respondents

Income (₦)	Number of respondents	Percent (%)
Below 5000	24	8.5
5000-10000	56	19.6
10000-15000	63	22.3
15000-20000	46	16.3
Over 20000	94	33.3
Total	293	100

Source: Authors Field Survey (2008)

Table 4.4 Sources of Water Supply (Non-Connected Households)

Source	Number of respondents	Percent (%)
Neighbor	30	11.1
Borehole	65	24.1
Open well	95	35.2
Vendor	80	29.6
Total	**270**	**100**

Source: Authors Field Survey (2008)

Table 4.5 Regularity of Piped Water (Connected Households)

Frequency	Percent (%)
Daily	12.5
Weekly	20.2
Twice weekly	45
Fortnightly	2.3
Seldom	20
Total	100

Source: Authors Field Survey (2008)

Table 4.6 Water Related Diseases

Disease	Number of respondents	Percent (%)
Typhoid	145	52.8
Dysentery	45	16.1
Diarrhea	50	17.9
Cholera	25	8.9
Other	15	4.3
Total	**280**	**100**

Source: Authors Field Survey (2008)

Table 4.7 Financial and Economic Cost of Household Water from various sources in Minna

	% of water consumed	Financial cost (₦/m³)	Cost Breakdown			Economic cost (₦/m³)
			Traded	Non Traded		
				Labour	Equipment	
			1.11	0.65	1.00	
Neighbour	15	6,200	20%	40%	40%	5,468
Borehole	20	1,250	30%	60%	10%	1,029
Open well	40	1,200	10%	80%	10%	877
Vendor	25	6,300	20%	50%	30%	5,336
	100%					
Average		3,737				3,177

Source: Authors Field Survey (2008)

Table 4.8 Population and Coverage

	Unit	2008	2009	2012	2017	2018 2028
Population Growth	%	3%	3%	3%	3%	
Population in Service Area	person	200,000	206,000	225,101	260,952	260,952
Coverage (percent/Target)	%	45%	51%	70%	80%	80%
Population served with Project	person	90,000	105,060	157,571	208,761	208,761

Sources: Author's Field Survey (2008), Niger State Water Board; National Population Commission, 2006 census figures

Table 4.9 Demand for Household Water in Minna without the Proposed Project

	Unit	2008	2009	2012	2017	2018 2028
Existing consumers						
Number of connections		15,000	15,000	15,000	15,000	15,000
Persons per connection		6	6	6	6	6
Persons served		90,000	90,000	90,000	90,000	90,000
Increase in per capita demand			0.5%	0.5%	0.5%	
Total per capita demand	lcd	100	101	102	105	105
Per capita piped water consumption	lcd	85	85	85	85	85
Per capita water consumption (other sources)	lcd	15	16	17	20	20
Total piped water consumption	000cm^3	2,792	2,792	2,792	2,792	2,792
Total water consumption (other sources)	000cm^3	492	510	588	644	644
Total water demand	000cm^3	3,284	3,302	3,380	3,436	3,436
Consumers of water from other sources						
Number of persons		0	15,060	67,571	118,761	118,761
Increase in per capita demand	%	0	0.5%	0.5%	0.5%	-
Per capita demand (other sources)	lcd	78	78	80	82	82
Total water demand (other sources)	000m^3	0	429	1,962	3,536	3,536

Source: Author's Field Survey (2008)

Table 4.10 Demand for Household Water with the Proposed Project

	Unit	2008	2009	2012	2017	2018 2028
Existing Consumers						
Persons per connection		15,000	15,000	15,000	15,000	15,000
Number of connections		6	6	6	6	6
Persons served		90,000	90,000	90,000	90,000	90,000
Per capita piped water demand	lcd	85	101	102	105	105
Total piped water demand	$000m^3$	2,792	3,318	3,350	3,449	3,449
New Consumers						
Persons to be served		0	15,060	67,571	118,761	118,761
Persons per connection		-	6	6	6	6
Number of connections		-	2,510	11,252	19,794	19,794
Per capita piped water demand	lcd	-	101	102	105	105
Total piped water demand	$000cm^3$	-	555	2,516	4,552	4,552
Total						
Total piped water demand	$000cm^3$	2,792	3,873	5,866	8,001	8,001
Peak factor		1.15	1.15	1.15	1.15	1.15
Required Capacity	$000cm^3$	3,211	4,454	6,746	9,201	9,201

Source: Author's Field Survey (2008)

4.1 Estimated Costs of the Proposed Minna Water Supply Project

4.1.1 Calculation of Economic Project Costs

The investment cost of the project has been apportioned into (i) traded (ii) unskilled labour (non-traded) and (iii) other non traded components as summarized in Table 4.4.

Table 4.11 Conversion of Financial Investment Cost (₦ millions, 2008 prices)

	Financial Cost	Breakdown			Economic
		% Traded	Unskilled Labour	Other	Cost
Conversion Factor		1.11	0.65	1.00	
Source Development	144.00	70%	15%	15%	147.53
Water Treatment	20.60	60%	20%	20%	20.52
Ground Storage	2.88	40%	20%	40%	2.80
Elevated Storage	12.96	40%	20%	40%	12.62
Pump Station	5.40	70%	20%	10%	5.44
Distribution System	144.0	40%	20%	40%	140.26
Sanitation & Drainage	25.20	50%	20%	30%	24.82
Consulting Services	79.20	70%	0%	30%	85.30
Investigations	1.44	25%	0%	75%	1.48
Institutional Support	43.20	50%	0%	50%	45.58
SUB TOTAL	478.88				486.35
Contingencies at 8%	38.31				38.90
Grand Total	**517.19**				**525.25**

Sources: Author's Field Survey (2008); GPA Draft Recommendations for Decision Making in Water Projects (2000)

NOTE: Conversion factor 1.11 is used to shadow-price the tradable component while conversion factor 0.65 is used to shadow price the unskilled labour component.

Table 4.12 Project Investment and Disbursement Profile

	Total (₦m)	Disbursement in Project Years (%)			
		2008	**2009**	**2010**	**2011**
Source Development	144.00	40%	40%	20%	0%
Water Treatment	20.60	40%	30%	30%	0%
Ground Storage	2.88	20%	50%	30%	0%
Elevated Storage	12.96	20%	50%	30%	0%
Pump Station	5.40	40%	50%	10%	0%
Distribution System	144.0	20%	60%	10%	10%
Sanitation & Drainage	25.20	30%	30%	20%	20%
Consulting Services	79.20	50%	40%	10%	0%
Investigations	1.44	50%	40%	10%	0%
Institutional Support	43.20	20%	30%	30%	20%
SUB TOTAL	478.88				
Contingencies at 8%	38.31				
Grand Total	**517.19**				

Source: Authors Field Survey (2008)

Table 4.13 Project Costs (₦ millions, 2008 prices)

	Unit	2008	2009	2010	2011	2018 2028
Investments						
Source Development		57.60	57.60	28.80	0	0
Water Treatment		8.24	6.18	6.18	0	0
Ground Storage		0.58	1.44	0.86	0	0
Elevated Storage		2.59	6.48	3.89	0	0
Pump Station		2.16	2.70	0.54	0	0
Distribution System		28.80	86.4	14.4	14.4	0
Sanitation & Drainage		7.56	7.56	5.04	5.04	0
Consulting Services		39.60	31.68	7.92	0	0
Investigations		0.72	0.58	0.14	0	0
Institutional Support		8.64	12.96	12.96	8.64	0
Physical Contingencies at 8%		12.52	17.08	6.46	2.25	0
Total Investment		**169.01**	**230.66**	**87.19**	**30.32**	**0**
Operation & Maintenance						
Labour		0	2.05	2.55	2.78	3.22
Electricity		0	3.99	4.86	5.16	5.16
Chemicals		0	2.79	3.40	3.62	2.62
Other O & M		0	3.59	4.38	4.65	4.65
Total O & M		**0**	**12.42**	**15.19**	**16.21**	**16.65**

Source: Niger State Water Board (2008)

Table 4.14 Project Benefits (₦ millions, 2008 prices)

	2008	2009	2010	2011	2018 2028
Tariff Revenues	-	128.71	170.02	215.19	300.15
Resource Cost Savings	31.70	45.31	50.25	60.10	65.27
Health and Env. Benefit	60.33	63.19	72.81	85.91	96.21
Time Saving Benefit	25.52	28.37	30.33	40.25	50.71
Amenity Benefit	2.79	2.91	3.05	3.55	4.01
Employment Benefit	3.51	4.00	3.15	2.99	2.52
Other Benefit	1.02	1.89	1.92	1.95	1.95
Total Benefits	**124.57**	**252.38**	**331.53**	**409.94**	**520.84**

Source: Author's Field Survey (2008)

Table 4.15 Cost-Benefit Analysis of Proposed Minna Water Supply Project (₦ millions, 2008 prices)

Year	Capital cost (1)	Operation& Maint. Cost (2)	Total Cost (3)	Tariff Revenue (4)	Resource Cot Savings (5)	Health& Env. Benefit (6)	Time Saving Benefits (7)	Amenity Benefits (8)	Employment Benefits (9)	Other Benefits (10)	Total Benefits (11)	Net Benefits (12)	PV @ 10% (13)
2008	169.01	-	169.01	-	31.70	60.33	25.52	2.79	3.51	1.02	124.57	(44.44)	+-
2009	230.66	12.42	243.08	128.71	45.31	63.19	28.37	2.91	4.00	1.89	252.38	9.30	7.68
2010	87.19	15.19	102.38	170.02	50.25	72.81	30.33	3.05	3.15	1.92	331.53	229.15	172.16
2011	30.32	16.21	46.53	215.19	60.10	85.91	40.25	3.55	2.99	1.95	409.94	363.41	248.20
2018 2028	-	16.65	16.65	300.15	65.27	96.21	50.71	4.01	2.52	1.95	520.84	504.17	313.04

Source: Author's Field Survey (2008)

NOTES: (i) The cost column in (1) shows estimated capital of the water supply system of N517M spread between 2008-2018. The total cost column (3) is made up by adding (1) and (2). Columns (4) – (10) show the estimated annual benefits accruable to the project. Column (11) indicates total benefits. Column (12)is made up by subtracting (3) from(11). Column (13) is the present value at 10% of net benefits.

(ii)The discount rate is 10%.

4.2 Summary (₦ millions, 2008 prices)

Total Estimated Investment Cost			525.25
Annual Operation and Maintenance Cost			15.11
Total Estimated Investment Cost			540.36
Present Value of Estimated Benefits			1061.59
Net Present Value at 10%			700.68
Benefit Cost Ratio	1061.59/540.36	=	1.96

4.3 Sensitivity Analysis (assuming 25% variance) ₦ millions

Estimated investment cost (by 25% higher): 540.36 x1.25=675.45

Estimated benefits (by 25% lower):1061.59x0.75=796.19

Benefit cost ratio: 796.19/675.45=1.17

CHAPTER FIVE

5.0 DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Discussion

This chapter is concerned with the discussion of the results of the reconnaissance/socioeconomic survey, the estimates obtained and presented in Chapter Four, estimated population, and total required capacity of the project, the cost-benefit analysis, the evaluation criteria and some recommendations among others.

5.1.1 Socioeconomic Status of Respondents

Table 4.1 shows that households consisting of between 6 to 10 persons were higher in number from the survey carried out. This is an indicator of the quantity of water demanded.

Tables 4.2 and 4.3 show the occupational status and average incomes of respondents respectively. Most of those interviewed were civil servants whose average monthly income was more than ₦20000 per month. This was a good indicator of their willingness to pay for improved services with the proposed project.

Table 4.4 shows the main sources of water for households that were not connected to the water supply system. Most of the respondents get their water from open wells (35.6%). However, there is an increasing reliance on supply from water vendors.

For connected households, Table 4.5 shows the regularity of supply. Most of the respondents only get water twice weekly (45%). A substantial number (20%) seldom get water.

Table 4.6 indicates the occurrence of water related diseases. Typhoid has the highest incidence. A significant number of respondents also fall ill due to diarrhea and dysentery. The cost of treating these diseases or of work days lost as a result of illness is discussed later in this chapter.

5.1.2 Population and Coverage

A summary of the population data is presented in Table 4.8. The population of Minna was roughly 200,000 according to the latest census figures (NPC, 2006) which is expected to grow at 3% per annum. The project is aimed at a gradual increase in coverage from the present 45% of population to 70% in 2012 and 80% in 2018. The population served with the project increases by almost 120,000 consumers, up from 90,000 in 2008, to 209,000 by 2018.

5.1.3 Present Water Consumption

Non-Connected Households

The details of the present consumption of non-connected households are presented in Table 4.7. An average household consists of 6 persons and the estimated monthly demand per household was $14m^3$. This gives a per capita consumption of (14 x 1000)/ (6 x 30) =78 lcd.

Connected Households

The average piped water consumption for a connected household is 85 lcd. Since this is not sufficient to satisfy demand, an additional 15 lcd is collected from secondary sources, mainly from open wells.

5.1.4 Present Supply Cost of Water

Non-Connected Households

Column 1 of Table 4.7 shows the various sources of water from non-connected households. The average collecting time per household is 36 minutes and the average consumption per household is (75 x6) = 450 litres per day. It thus takes a household about (36/0.450) = 80minutes to collect 1m^3 of water.

The cash expenditures for water obtained from neighbors and vendors constitute a major part of the supply cost (Smith, 2005).

Connected Households

The supply costs involved are comparable to those for non-connected households. The financial demand price of water has therefore been assumed to be ₦1000/m^3.

5.1.5 New Consumers/Beneficiaries of the Project

Table 4.9 of the results shows the new consumers that will benefit from the scheme. The beneficiaries will increase steadily from year one of the project i.e. 2008 to about 118,000 persons by 2018. (Note that the year 2018 is the year that the maximum net benefit is expected to be realized).

5.1.6 Total Demand/Required Capacity

Table 4.10 shows the total demand and required capacity. The total piped water demand was multiplied by a peak factor of 1.15 that takes into account losses in the distribution system. Thus the required capacity was found to be about $3.2Mm^3$ in 2008 rising to about $9.2Mm^3$ in 2018.

5.1.7 Project Costs

Table 4.11 shows the breakdown of the costs of the project. The financial cost has been apportioned into traded, unskilled labour and other non-traded components in order to arrive at the economic cost. The total economic cost was determined to be ₦525.25 million.

Further, Table 4.12 shows the investment and disbursement profile over a four-year period from 2008-2011. In the first two years of the project, there will be huge investments in source development and distribution system (40%). However, by the end of 2011, the costs would have petered out to near zero levels. The other physical costs of the project include water treatment, ground and elevated storage, pumps, etc. Non physical costs include consultancy, institutional support and investigations.

Table 4.13 gives the operation and maintenance costs. This is broken down into labour, electricity, chemicals for water treatment and others. From the table it can be seen that there is a general gradual decrease in investment costs in the project as 2011 is reached. Between 2018 and 2028, no further physical investment is required except in the operation and maintenance costs. In fact, maintenance costs show a steady increase from 2009 due to costs of replacing worn equipment as time goes on. It is pertinent to note that operating and maintenance costs increase with time. Total investment in the first year (2008) is ₦169.01 million, rising to ₦230.66 million in 2009, before steeply declining to ₦87.19 million in 2010.

5.1.8 Project Benefits

Table 4.14 shows the benefits broken down into the various estimates over the project period. The project will have benefits ranging from ₦124.57 million in 2008 to ₦520.84 million in 2018. In the first year, i.e. 2008, no tariffs are imposed, but from the second year the tariff revenues accruing to the government will increase steadily from ₦128.71 million to ₦215.19 million. The resource savings to consumers will also climb steadily as will all other benefits envisaged in the water supply scheme. A maximum net benefit of ₦540.84 million is expected to accrue by 2018.

5.1.9 Comparative Cost –Benefit Analysis

The cost-benefit analysis is presented in Table 4.15. The cost column in (1) shows the estimated cost of the water project of N517 million spread between 2008 and 2018. The total cost column (3) is made up by adding (1) and (2). Column (4)-(10) shows the estimated annual benefits accruable to the project. Column (11) indicates total benefits.

Column (12) is made up by subtracting (3) from (11). Column (13) is the present value at 10% of net benefits. The chosen discount rate is 10%.

The number of new consumers is obtained by deducting the existing population served from the target population to be served.

5.1.10 Demand with the Project

Existing Consumers

Since the financial demand price of water from other sources including open wells is above the price of piped water and since supplies are no longer constrained, the project is expected to replace all water previously obtained from other sources. The total piped water demand is projected to reach 3.4Mm^3 by 2018.

New Consumers

The number of persons to be served is a result of the set targets. The number of new connections is determined by the average household size of 6 persons. The project is expected to fully displace water obtained from alternative sources. The new consumers will develop a similar consumption pattern as that of old consumers. The total piped water demand is projected to reach 4.55Mm^3 by 2018.

Data are presented in Table 4.9. The per capita demand forecast, which is assumed equal for existing and new consumers is built around a price elasticity of 0.35 (author's survey data) and an income elasticity of 0.50 (World Bank Report for Developing Countries, 2004). The forecast considers that:

(i) the tariff should be increased to meet the financial targets set in financial agreement for the project. An annual increase of 2 percent (in real terms) is proposed. As a result, the existing tariff of ₦1000/m^3 will increase to ₦1450/m^3 by the year 2017. This is expected to cause a 0.7 percent demand decrease (0.02 x -0.35).

(ii) macro-economic forecasts for the country (World Bank, 2007) estimate a 2.5 percent real capital income increase. This is expected to cause a 1.25 percent annual demand increase (0.025 x 0.5).

The net effect is a 0.55 percent annual increase in per capita demand.

5.1.11 Demand without the Project

Existing Consumers

Relevant data are presented in Table 4.9. The water supply system is maintained and operated at a level that is required to continue to provide the existing level of service to 90,000 consumers through 15,000 existing connections. Without the project, no further service extension will occur.

The total per capita demand of water of 100 lcd in 2008 grows by 0.5 percent annually to 105 lcd in 2018. Since the existing water supply system operates at its maximum capacity, 15 to 20 lcd would have to be obtained from other sources. The total piped water consumption would be 2.79 Mm^3 per year. Water obtained from other sources would increase from 493,000m^3 to 657,000m^3 by 2018.

5.1.12 Consumers of Water from Other Sources

The data are presented in Table 4.9. In the 'without-project' scenario, the focus would be on the 'without-project' demand for water obtained from other sources for the portion of the population which will be connected with and as a result of the project. It is the consumption of water from other sources that will be displaced as a result of the project. Ultimately, 118,700 additional people are expected to benefit from the project. Their existing 2008 water demand from other sources of 78 lcd is expected to grow at 0.5 percent annually to reach 82 lcd by 2018 and to peak at $3.54Mm^3$.

5.1.13 Total Demand and Required Capacity

The total piped water demand with the project will reach $8Mm^3$ annually by the year 2018 (see Table 4.10). The total required supply capacity is calculated on the basis of a peak factor of 1.15 and increases from $3.2Mm^3$ to $9.2Mm^3$ by 2017.

5.1.14 Estimated Benefits of the Proposed Minna Water Supply Project

Table 4.14 captures some of the expected benefits of the proposed project which include:

(i) tariff revenues to government

(ii) resource cost savings consumers

(iii) health and environment benefit

(iv) time cost saving and productivity benefits

(v) amenity benefits

(vi) employment benefits

(vii) other unquantified benefits

5.1.14.1 Tariff Revenues to Government

The proposed project is expected to gradually increase the number of house connections to the piped water supply system. This implies that, with adequate metering and pricing measures, the total revenues from the incremental water as a result of additionality of supply will increase.

From Table 4.10, the demand of consumers expected to benefit from the project in the first year (2009) is 555,000m^3 rising to 4,550,000m^3 by the year 2018. This gives a revenue of (555,000 x 1000) = ₦555 million in the first year. This will rise to (4,550,000 x 1000) = ₦4.55 billion by 2018.

5.1.14.2 Resource Cost Savings to Consumers

Without the project, households spend resources on buying water from vendor and storage vessels. Because the average cost of obtaining 1m^3 of water from vendor is ₦1000, it follows that a household of 6 persons spends approximately ₦350 per day if the consumption per capita is fixed at 75 litres. In a year, this amounts to (45x365) = ₦164, 250 per household. In Minna, there is flat rate for tariff per household connection ₦500 per month, it is clear that households save more in resource costs.

5.1.14.3 Health and Environment Benefits (Public and Private)

Water supply projects have been justified on the basis of expected public and private health benefits, which are likely to occur with the project due to the overall improvement in the quality of water. Such benefits are likely to occur provided the adverse health impacts of increased volume of wastewater can be eliminated or minimized.

Using unsafe water can cause disease such as diarrhea, skin infections, dysentery, cholera, typhoid etc.

Consumers in Minna affected by these diseases have to purchase medicines, consult a doctor or lose a day's wage. Accordingly health benefit due to the provision of safe water has two dimensions: avoided private/public health expenditures and economic value of days of sickness saved. However it is often difficult to estimate health benefits in monetary terms. The reasons include:

(i) Improved health due to safe water and sanitation alone is difficult to arrive at

(ii) The supply of safe water alone may not improve health

(iii) The ultimate effect of health benefit is the increased labour productivity due to "healthy life days"

In Minna, the available medical statistics for the period 2001- 2005 from the Ministry of Health several that on the average, there are the following cases of disease per year:

Table 5.1 Average reported cases of disease for the period 2001-2005

Disease	**Number of cases**	**%**
Typhoid	200,000	**56.8**
Dysentery	55,200	**15.7**
Diarrhea	40,000	**11.3**
Cholera	32,000	**9.1**
Other	25,000	**7.1**
Total	**352,000**	**100%**

Sources: Authors Survey (2008); Niger State Ministry of Health (2006)

Typhoid has the highest incidence (56.8%) while cholera has the highest cause of death. On the basis of the above figure 70,400 cases of disease are reported on the average per year (352,000/5 years). At an average cost of treatment of ₦500 per person, the total cost of treatment may be estimated at ₦(70,400 x 500) = ₦35.2 million per year.

The loss of income from work days lost due to illness assuming about 10% (35,200 persons) are of working age may be estimated at ₦28.16 million (35,200 x 800) loss of earnings for 15 days totaling ₦63.36 million per year.

Table 5.2 Annual Health Cost Summary

Cost	**₦(millions)**
Treatment cost	**35.20**
Loss of income during illness	**28.16**
Estimated total	**63.36**

Source: Author's Survey (2008)

5.1.14.4 Amenity/Recreational Benefits

The proposed project is expected to increase amenities like gardens and swimming pools in households due to the increased availability of water. The average willingness-to-pay value to visit a garden or a swimming pool for 1 hour has been estimated at ₦200. If 25% of all households in Minna will have amenities, then it means that by 2018 there will be about 35,000 connections and the value of the amenity/recreational benefit is estimated at (0.25x200x35,000) = ₦1.75 million.

(Note: Amenity and recreational benefits are difficult to quantify)

5.1.14.5 Employment benefits

The project is expected to create employment to the population of the service area (Minna). However, a large percentage of the employment to be created will be during the construction phase of the source, distribution, storage and pump facilities.

5.1.14.6 Other Benefits

The other benefits include all other benefits that may result from the project but extremely difficult to identify and quantify.

5.2 Conclusions

This study has shown that there is a strong economic case for investing in improved water supply and sanitation services in Minna, when the expected costs per capita of different combinations of water supply are compared with the expected economic benefits per capita. Under base case assumptions, the cost-benefit ratio is almost ₦2 in economic benefit per ₦1 invested, and even under pessimistic data assumptions, the benefits per naira invested remained above the threshold. When potential benefits that were omitted from the analysis are included, the economic case for investment in the water supply interventions becomes stronger, depending on the context.

While these findings make a strong case for investment in water supply improvement, it should be recognised that many of the benefits included in this analysis may not give actual financial benefits. For the time gains calculated or the number of saved lives, these do not necessarily lead to more income-generation activities.

Also, for the averted costs of health care for diarrhoea cases, these savings to the health sector and the patient may not be realised as the greatest proportion of health care costs are usually fixed costs. On the other hand, it is clear that populations do appreciate time savings, such as the benefits of more time spent at school for children, less effort in water collection (especially women and children), less journey time for finding places to defecate, or more leisure time. In the recognition that these non-health and non-financial benefits are important to take into account in a study on social welfare, this analysis has shown that these benefits are potentially considerable and provide a strong argument for investment in improved water supply.

In line with the aim and specific objectives of the study as outlined in Chapter One, the current demand of water by households was determined. The economic costs and benefits were also determined and evaluated. Given the results of the analysis, the project is worth undertaking.

It is important to stress that the calculations underlying the CBA study should be regarded as order-of-magnitude. Economic estimates are heavily dependent on the quality of data and level of detail aimed at. Nevertheless, the analysis and the quantitative estimates presented demonstrate the principles, methods and assumptions underlying the application of the techniques of CBA to water supply strategies. Further and better data will serve to refine the results as they become available.

The capital cost used concerns the estimated investment for the construction of the proposed water supply infrastructure for the whole Minna area based on a combination of cost indicators and data provided from government sources. The operating and maintenance costs are capitalized and added to the capital cost to arrive at the total investment cost.

The estimated benefits over the period are expressed in terms of present values for comparison with the total capital cost.

The net present value (benefits minus costs) shows the value of the net 'wealth' created by the project available to society. It will be noted that the CBA study does not focus on the financial implication (funding and cash flows) of the proposed project from the point of view of the implementing agency but to the saving and quality of resources for future use by society.

Adopting the 10% discount rate used by the World Bank in Nigeria (which presumably reflects the social opportunity cost of capital), the estimated net present value is ₦700 million. On the basis of the quantified costs and benefits, the proposed water supply project is highly beneficial.

Also, because the project is gradually expected to replace all other sources of supply of water and to cover 80% of the population by 2018, it is of great value and it is worth undertaking.

The project has an approximate benefit cost ratio of 2 and because any project with a BCR greater than 1 has a positive NPV, it is worth undertaking too.

5.2.1 Evaluation of the CBA

The two criteria used in evaluating the CBA were;

i. The net present value

ii. The benefit cost ratio

The net present value of benefits is given by;

$$NPV = \sum_{t=1}^{n} \frac{(b-c)t}{(i+r)^t}$$

where b and c are benefit costs in each period t = 1, ... n and r is the selected discount rate.

The benefit cost ratio is given by

$$BCR = \sum_{t=1}^{n} \frac{C_t}{(i+i)^t}$$

where C represents capital costs and i is the rate of return.

Table 5.3 Summary of the CBA

Benefit/Cost	₦ (millions)
Total estimated investment cost	**525.25**
Annual operation and maintenance cost	
(Capitalized at 10% for 20 years)	**15.11**
Total capital cost	**540.36**
Present value of estimated benefits	**1061.59**
Net present value (at 10%)	**700.68**
Benefit cost ratio	***1.96***

Due to problems in measurement and valuation of some of the economic benefits arising from water supply interventions, the aim of this present study is not to include all the potential economic benefits that may arise from the interventions, but to capture the most tangible and measurable benefits. Some less tangible or less important benefits were left out for three main reasons: the lack of relevant economic data available globally (Hutton 2001); the difficulty of measuring and valuing in economic terms some types of economic benefit (Hanley & Spash 1993); and the context-specific nature of some economic benefits which would reduce their relevance for a cost-benefit analysis study.

For ease of comprehension and interpretation of findings, the benefits of the water supply improvements were classified into three main types: (1) direct economic benefits of avoiding diarrhoeal disease; (2) indirect economic benefits related to health improvement; and (3) non-health benefits related to water supply and sanitation improvement. As a general rule, these benefits were valued in monetary terms – in Nigerian Naira (₦) in the year 2008 – using conventional methods for economic valuation (Hanley & Spash 1993).

In interpreting the results of the CBA in this study, an important caveat needs to be noted. It relates to the fact that the study is a social and not a financial CBA. The measure of economic benefits is social welfare in the broadest sense, and focuses on a hypothetical, although real, set of benefits.

Furthermore, valuation of welfare effects in monetary terms brings with it problems and can lead to inappropriate interpretation of the results, due to lack of agreement on appropriate valuation methodologies and due to lack of evidence to support some variables.

A further aspect to consider in using the results of this study for policy decisions is the omission of some variables in the analysis.

5.2.2 Financing considerations

While cost-benefit analysis can be carried out to identify clearly all the beneficiaries and the (potential) financers of development projects, the analysis does not provide answers to the question of who should pay or where the funding will come from. This represents a particular challenge to economic evaluation when interventions have non-health sector costs and benefits, as the objective of the water agency – "to maximise water supply with a given budget" – may come into conflict with other societal objectives, including the maximisation of non-health related welfare. If all costs and benefits are included in a cost-benefit analysis, then a full analysis can be made of financing options.

One of the problems associated with identifying beneficiaries in order to identify those willing to pay for the costs is that the main beneficiaries (consumers, and the population more generally) do not always understand the full benefits until after the investment has taken place. For example, if a household does not understand fully the links between water quality and health or between water source and household time expenditure, then improvement in water access and quality are unlikely to be undertaken for health or economic reasons. This is where the technique of information sharing (Information, Education and Communication (IEC) or Behaviour Change Communication (BCC)) is crucial to influence the potential beneficiaries to be an agent for change, one aspect of which is to be willing to make a financial or an in-kind contribution (e.g. labour, materials). However, a constraint faced by households is that a large share of annual intervention costs are incurred in the first year of the intervention (investment cost), while economic benefits accrue over a longer time period. This raises the question about who is prepared to finance such an investment with benefits that are hard to know in advance and that are long-term in nature. Furthermore, credit, especially in rural settings, is not easily available to make up the temporary gap in finances.

These factors together lead to a type of 'market failure', where potential consumers of improved water and sanitation facilities are not fully informed about the benefits of such a product, and where financing sources for such an investment are in short supply. The end result of this market failure is that private consumers have extremely limited options for financing the initial investment requirements of water supply and sanitation improvements up-front.

There is one group of potential beneficiaries where the financing constraint is easier to overcome. Many households incur costs for their existing supply of water, for example those who purchase their water (e.g. bottled water or from a local water vendor or delivered by tanker truck) or those who treat their water by boiling or filtering it. In their case, when an alternative low-cost WS&S intervention is delivered, the cost saving from switching away from more expensive water options may lead to a net financial gain. In such cases, households need to be made aware of the opportunities for alternative low-cost WS&S interventions which will lead to a net welfare gain, including a potential financial saving.

In terms of whether the health sector would be interested in financing the interventions, in most regions and for most interventions the health sector is unlikely to be interested or capable to pay a significant contribution to the overall costs. This is because hardware interventions for WS&S are outside the core activity of a health ministry, but also because the real savings to the health sector are negligible in comparison to the annual intervention costs, as Hutton *et al.* (2001) showed in their analysis. Benefits of improving access to safe water and sanitation accrue mainly to households and individuals.

Compared to the potential cost savings reported in this study, it is unlikely that the health and environment sector will ever be able to recover these costs, as only a small proportion are marginal costs directly related to the treatment cost of the health episode. In fact, as most health care costs such as personnel and infrastructure are fixed costs which do not change with patient throughput in the short-term, the real cost saving is probably insignificant. On the other hand, when considered from the social welfare angle, the reduced burden to the health system due to less patients presenting with diarrhoea will free up capacity in the health system to treat other patients. Furthermore, the health system can play a role in leveraging resources and funds from other sectors or from financing agents, to fill financing gaps.

The implication of these arguments is that there should exist a variety of financing sources for meeting the costs of water supply and sanitation improvements, depending on the income and asset base of the target populations, the availability of credit, the economic benefits perceived by the various stakeholders, the budget freedom of government ministries, and the availability of non-governmental organisations to promote and finance water and sanitation improvements. However, it is clear that the meagre budget of the health sector is insufficient to finance water supply and sanitation improvements. On the other hand, it can play a key role in providing the 'software' (education for behaviour change) alongside 'hardware' interventions, involving the close technical cooperation of the health sector.

5.2.3 Sustainability and CBA

Natural resources contribute actively to fulfil the needs of human populations. Their conservation is therefore fundamental but sometimes in contradiction with the satisfaction of human needs. This reflects the difficulty of the concept of "sustainable development" implying simultaneously the conservation of the resource and the satisfaction of human needs.

Resource scarcity made people think about the new way of economic development – sustainable development which implies conservation of nature, the rational use of resources and implementation of new approaches in policy decision-making process.

While there remains a debate about what it means for development to be sustainable, there is now a coherent body of academic work that has sought to understand what a sustainable development path might look like, how this path can be achieved and how progress towards it might be measured. Much of this work considers the pursuit of sustainable development to be an aggregate or macroeconomic goal. Comparatively little attention has been paid to the implications of notions of sustainability for CBA. However, a handful of recommendations do exist with regards to how cost-benefit appraisals can be extended to take account of recent concerns about sustainable development.

According to one perspective there is an obvious role for appraising projects in the light of these concerns. This notion of strong sustainability starts from the assertion that certain natural assets are so important or critical (for future, and perhaps current, generations) so as to warrant protection at current or above some other target level. If individual preferences cannot be counted on to fully reflect this importance, there is a paternal role for decision-makers in providing this protection. With regards to the relevance of this approach to cost-benefit appraisals, a handful of contributions have suggested that sustainability is applicable to the management of a *portfolio* of projects. This has resulted in the idea of a shadow or compensating project. For example, this could be interpreted as meaning that projects that cause environmental damage are "covered off" by projects that result in environmental improvements. The overall consequence is that projects in the portfolio, on balance, maintain the environmental status quo.

There are further ways of viewing the problem of sustainable development. Whether these alternatives – usually characterised under the heading "weak sustainability" – are complementary or rivals has been a subject of debate. This debate would largely dissolve if it could be determined which assets were critical. As this latter issue is itself a considerable source of uncertainty, the debate continues. However, the so-called "weak" approach to sustainable development is useful for a number of reasons. While it has primarily be viewed as a guide to constructing green national accounts (*i.e.* better measures of income, saving and wealth), the focus on assets and asset management has a counterpart in thinking about project appraisal. For example, this might emphasise the need for an "asset check". That is, what the stocks of assets are before the project intervention and what they are likely to be after the intervention? It might also add another reason for the tradition in cost-benefit analysis of giving greater weight to projects which generate economic resources for saving and investment in economies where it is reckoned that too little net wealth (per capita) is being passed on to future generations.

5.3 Recommendations

1. The proposed water supply intervention is cost-beneficial and should be undertaken by the agency/department responsible for it.

2. Continued developments in environmental valuation methods are to be welcomed.

3. There remains more to do in terms of understanding why and how CBA is relied upon to actually inform some project decisions but not others.

4. A lot more research is required in the field of CBA in Nigeria in guiding decisions that have a direct impact on environmental sustainability/protection of ecosystems.

5. Sustainable utilization of scarce natural resources must be vigorously encouraged by all.

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APPENDIX

Consumers' Questionnaire

Please fill in the appropriate boxes and comment where necessary

How many persons live in your household?

(a)1-5 (b)6-10 (c)11-15 (d)16-20 (e)above 20

What is your occupation?

(a)trading (b)farming (c)civil servant (d)others

How much do you earn monthly on the average?

(a)below ₦5000 (b)₦5000 - ₦10000 (c)₦10000 - ₦15000 (d)₦15000 - ₦20000 e) above ₦20000

What is the source of your water supply (non-connected households)?

(a)neighbor (b)borehole (c)open well (d)vendor

How regular is piped water (connected households)?

(a)daily (b)weekly (c)twice weekly (d)fortnightly (e)seldom

Have you or your family members been afflicted by water related diseases?

Yes No

Which of the diseases?

(a)Typhoid (b)Dysentery (c)Diarrhea (d)Cholera (e)Others

Do you require a new piped connection?

Yes No

How much water do you use per day? ____________________

How long does it take you to collect the water? ______________

What is your reason for not having a piped connection? __________

How many additional hours per day of supply will be required to meet all your needs?