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STRENGTHENING INSTITUTIONS TO IMPROVE PUBLIC EXPENDITURE ACCOUNTABILITY

Cost-Effectiveness and Benefits-Cost Analysis of Some Water Interventions (the Case of Bauchi State, Nigeria)

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Abbreviations and Acronyms

ADB	African Development Bank
AU	Unit of Account
BAURUWASSA	Bauchi State Rural Water Supply and Sanitation Agency
BCA	Benefit-Cost Analysis
BWS	Borehole Water Supply
BWSB	Bauchi State Water Board
CEA	Cost-Effective Analysis
DALY	Disability Adjusted Life Year
FGN	Federal Government of Nigeria
FMWR	Federal Ministry of Water Resources
FMAWR	Federal Ministry of Agriculture and Water Resources
JICA	Japan International Cooperation Agency
LGA	Local Government Authority
MDGs	Millennium Development Goals
NAFDAC	National Agencies for Food and Drug Administration and Control
NWRI	National Water Resources Institute
OPEV	Operation Evaluation Department
PHCN	Power Holding Company of Nigeria
PWS	Pipeline Water Supply
R4D	Results for Development
RBDA	River Basin Development Authority
RWSN	Rural Water Supply Network
SIIPEA	Strengthening Institutions to Improve Public Expenditure Accountability
SSA	Senior Special Assistant
SWA	State Water Agency
UA	Unit of Account
UNDP	United Nations Development program
UNICEF	United Nations Children's Fund
UPVC	Unplasticized Polyvinyl Chloride
WHO	World Health Organization
WSSD	World Summit on Sustainable Development

ABSTRACT

This report presents a Cost-Effectiveness analysis of water interventions in Bauchi state, Nigeria, with particular emphasis on pipeline and borehole (Hand pump) water supply schemes. Using the measures adapted from Whittington *et al* (2008), this study estimates the cost and effectiveness measures such as time savings and health benefit aimed at reducing the incidence of and death from, diarrhea disease. First, it conducts a BASIC CEA which compares the cost per household per year of PWS with BWS program. Second, it performs a PROGRAM CEA to determine the relative effectiveness of the programs. The cost analysis shows that BWS is less expensive than PWS. Combining cost and effectiveness, the cost-effectiveness ratio shows the BWS is more cost-effective than the PWS program.

Nevertheless, CEA is not sufficient to determine the most attractive intervention, since it cannot quantify cost and effectiveness in the same unit. Hence, a benefit-cost analysis, which estimates the monetary value of benefits, is applied. The results of the BCA seem to support the evidence that emerged from the cost-effectiveness analysis.

A sensitivity analysis is then performed to determine the robustness of these findings. A one-way and multi-way sensitivity analyses (with worse and best case scenarios) performed on the results show that BWS is more cost-effective and attractive. The study then concludes with a recommendation that in areas where there are high cases of morbidity/mortality from diarrheal, access to portable water and improved health outcomes in densely populated areas can be achieved by diverting resources from BWS to PWS, that is by increasing pipeline water supply. The converse is true for sparsely populated areas with low cases of morbidity/mortality from diarrheal. However, in mildly populated areas with moderate cases of morbidity/mortality, PWS and BWS can be implemented as complements.

1. INTRODUCTION

The type of access and quantum of water supply, as well as quality of sanitation facilities available to households or communities determine the quality of life of the people and the potential for poverty alleviation. In spite of its abundance, however, it is estimated that about 900million people do not have access to improved drinking water supply, with 84% living in the rural areas. More so, about 330 million of the 900 million people reside in sub-Saharan Africa (WHO/UNICEF 2010). Additional estimates show that 1.8 million people die every year as a result of diseases caused by unclean water and poor sanitation (WHO 2005). This problem is even more serious in developing countries where a large number of women and children in rural areas spend hours each day walking kilometers to collect water from unprotected sources such as open wells, muddy dugouts and streams. For example, in Nigeria a large population still does not have access to good quality water in adequate quantity. Based on population and water supply coverage, it is estimated that only about 65% of the urban and 30% of the rural population had access to improved drinking water sources[1]. Several reasons are responsible for this, and include amongst others, poor planning, inadequate funding, insufficient relevant manpower, haphazard implementation and wrong policy/program interventions. Attempt to curb these challenges and other related economic problems led to the World Summit in 2000, where 180 countries including Nigeria agreed to a set of development goals and target to be achieved in 2015. In 2002, at the Johannesburg World Summit on Sustainable Development (WSSD), the set of objectives was also reinforced, among which is the commitment to reduce by half the number of people in the world living without access to safe drinking water and

[1]Vision, 2020 ... please say the name of the report from where you extracted the information

improved sanitation[2]. In Nigeria, several water and sanitation programs are being, or have been implemented by the federal and state governments and in many cases are supported by development partners and the donor community.

However, given the competing demand for available financial resources and the need to achieve the water MDG and wider objectives of sustainable development, there is a need to pursue programs/interventions that will reduce costs, increase access to portable water and have long-lasting impact on the communities. It is in this instance that the cost-effectiveness tool is applied to identify interventions with optimal impacts[3]. Cost-effectiveness analysis is a method for assessing benefits and costs of programs/interventions with similar goals. It helps in identifying ways to redirect resources to achieve expected outcomes, and also in identifying neglected opportunities. It does so by highlighting interventions that are relatively inexpensive, yet have the potential to achieve optimum outcomes. In sum, it demonstrates not only the utility of allocating resources from ineffective to effective interventions, but also the utility of allocating resources from less to more cost-effective interventions[4]. The application requires researchers to identify two or more policy alternatives with similar goals, estimate the cost and effectiveness of each alternative, and then compare the cost-effectiveness ratio of the alternatives. However, CEA does not quantify benefits in monetary unit since cost and

[2]Available at http://www.nwri.gov.ng/userfiles/file/NWRI_Cost_Effective_Borehole_Drilling.pdf

[3] The concept of Cost Effectiveness Analysis (CEA) is the third analytical component of the project; "Strengthening Institutions to Improve Public Expenditure Accountability (SIIPEA)" a five year project launched by the Global Development Network (GDN), in coalition with Results for Development (R4D). This project is geared towards supporting 15 research and policy institutions in developing economy to produce analysis to achieving expected outcomes including; to produce an internationally comparable and evidence-based analysis that aims at improving the institutions capacity to make appropriate policy/program choice for the education sector in the developing countries.

effectiveness are frequently in different units. Accurate measurement of effectiveness is another challenge that cannot be neglected. In this case, a technique that addresses these concerns will certainly do a better job in determining the attractiveness of the programs, or at least, complement the CEA. Such technique can be the benefit-cost analysis.

1.1 Scope of the Study

This study focuses on two alternative programs, namely; Borehole Water Supply and Pipeline Water Supply Program. Given the enormity of conducting an extensive cost-effectiveness analysis in terms of resource, time and data requirements, it will be impossible to examine interventions extending to several parts of the country. With this limitation in mind, this study makes use of data from the Bauchi State Water Supply Project (and Bauchi State Water Board (BSWB).

Bauchi State is one of the six (6) North Eastern states in Nigeria created in 1976, and has a population of 4,936,438 people (617,054 households) as at 2008 and 20 Local Government Areas. Bauchi State occupies a total land area of 49,119km^2 , representing about 5.3% of Nigeria's total land mass, and is located between 9^{0}3' and 12^{o}3' north of the equator. Longitudinally, the State lies between 8^{o}50' and 11^o east of the Greenwich meridian. Bauchi State spans two distinctive vegetation zones namely, the Sudan savannah and the Sahel savannah. In addition to its vegetation, Bauchi State is watered by a number of rivers and dams for irrigation and other uses. They include the Gongola and Jama'are rivers, Gubi and Tilde Fulani dams respectively. The Bauchi State Water Board (BSWB) is in charge of regulation and coordination of water supply activities and other related in the state. The Bauchi State Government launched a Pipeline Water Supply Scheme in 1992 and recently launched State water supply Scheme (2007) by investing heavily in water supply project throughout the state. The massive investment is aimed at meeting the fast growing demand for safe water and to also improve the socio-economic development of its populace, especially those dwelling in the rural areas.

1.2 Research Objectives

The broad objective of this study is to carry out a detailed cost-effectiveness analysis as well as a benefit cost analysis of some water programs; Borehole (hand pump) water supply and Pipeline water supply projects. Specifically, the report intends to provide answers to the following questions:

- Which of these programs/interventions in the water sector, namely: borehole water supply (BWS) and pipeline water supply (PWS) program is more cost effective in terms of beneficiaries covered?
- What is the relative efficiency of the BWS and PWS Programs in terms of improved portable water accessibility and prevention of water borne related diseases?
- In monetary terms, which of these interventions is more beneficial and sustainable with respect to costs?

The remainder of this report proceeds as follows: Section 2 summarizes the key studies in the water CEA and BCA literature. Section 3 looks at the structure of the water sector and sources of funding in Nigeria; section 4 presents the background of the programs, while sources of data and methodology, including description of the identified water programs are presented in section 5. Section 6 discusses the findings of water CEA and BCA. Section 7 concludes while policy recommendations, challenges to the work and limitations are presented in section 8, 9 and 10 respectively. Lastly, plans for dissemination of findings are presented in section 11.

2. THE NIGERIA WATER SECTOR

Prior to the creation of Regional Governments in the early 1950s, public water supply in Nigeria started at the lowest administrative level in a few towns, and beneficiaries of these facilities were Lagos, Calabar, Kano, Ibadan, Abeokuta, Ijebu Ode and Enugu. At this time, no operational subvention was received from government, while revenue generated from water supply (water rate) was used to maintain the water schemes. However, with the establishment of the regional governments, the financial and technical responsibilities for developing new water schemes as well as assigning supervisory high level manpower (Water Engineers and Superintendents) to the water supply undertakings were conducted by the regional governments.

However, the first independent body; Water Corporation, was formed in 1966 by the then Western region following the growing demand and increasing cost of water supply. The independent body was responsible for developing, operating and managing the water supply undertakings in the region. As Nigeria witnessed significant political transformation by moving from the regional governments to state governments, the independent water corporations were not left out of the transformation. Individual states created their own independent water corporations, and at present all the thirty-six (36) states of the federation and the Federal Capital territory have independent Water Corporations managing water supply undertakings, with the local governments providing complementary water supply services to small villages in their jurisdictions.

Historically, the first commitment of the federal government of Nigeria to water supply was made in 1976 when it created the Federal Ministry of Water Resources and the eleven (11) River Basin Development Authorities (RBDAs) to manage the water resources of the country and to provide bulk water for irrigation and water supply. In addition the Federal Government through its ministry of water resources undertakes basic hydrological data collection and storage for national planning purpose. Beyond this, other agencies – United Nation Children's Fund (UNICEF), United Nations Development Programme (UNDP), and a number of other bilateral, multilateral are involved in public water supply by providing aid and loans to federal and state governments. The National Water and Sanitation Policy Program divide the responsibility of water supply in Nigeria between the Federal, State and Local Governments (CSEA PBA, 2011), and water supply policy operators in the urban, semi-urban and rural areas are made up of Federal ministry of Water Resources, River basin Development Authorities, the State Water Agencies and the Local Government Authorities.

2.1 The Federal Ministry of Water Resources (FMWR)

FMWR is charged with the responsibilities of policy advice and formulation, data collection, monitoring and co-ordination of water resources development (of which water supply is a component) at the national level.

2.2 The River Basin Development Authorities (RBDAs)

The responsibilities of the RBDAs include development, management and operation of reservoirs for the supply of bulk water for water supply amongst other uses in their areas of jurisdiction.

2.3 The State Water Agencies (SWAs)

The SWAs are responsible mainly for urban, semi-urban and rural water supplies. In some states separate agencies exist for rural water supplies, urban and semi-urban water supplies.

2.4 The Local Government Authorities (LGAs)

The LGAs are basically responsible for the provision of portable water to rural communities in the areas of their jurisdiction. However, because of the lack of funds and the gross shortage of manpower this function has not been effectively carried out in some local government areas of the country.

However, it is worth noting that in Nigeria only purchasable portable drinking water is regulated by the National Agencies for Food and Drug Administration and Control (NAFDAC). It is only of recent that the FMWR commenced the Water Quality Laboratories and Monitoring Network project with two reference laboratories in Lagos and Kano states, and four regional laboratories in Akure, Enugu, Gombe and Minna. These laboratories are set up to monitor drinking water quality for both rural and urban areas, and to carry out training for the state water agencies. Currently, there is no functional standard body that supervises the quality of drinking water in the country. Drinking water is sourced from domestic piped taps, community taps, springs, wells and water suppliers. The poor often get drinking water from community taps, springs, rivers, and hand-dug wells and in most cases, buy from water suppliers/vendors (CSEA *PBA*, 2011).

2.5 Sources and Allocation of Funds

The Federal Capital Water Resources Agency is funded by the Federal Government through the Ministry of Federal Capital Territory, while the State Governments fund water supply schemes through budgetary allocation to State Water Agencies. The funds are for capital projects, operations and maintenance, though the boards generate revenues through its services but the revenue realized in most cases is not enough for its operations and maintenance. Other sources of funding of water supply include; commercial loans either from local sources or through international lending Agencies like the World Bank and the African Development Bank. Rural water supply is financed by the Local Governments and partly by the Federal Government, international donor agencies. Table 1, presents analysis of Government spending on water sector; it indicates that federal government expenditure to the sector has been declining since 2006.

Table 1: Federal Government Total Spending on Water Sector (millions of naira & 2006 prices)

	2006	2007	2008	2009	2010 (budgeted)
TOTAL	**78,156.41**	**46,040.74**	**39,476.97**	**15,467.32**	**45,322.19**
Recurrent	3,616.19	3,949.19	13,457.50	2,504.70	2,438.78
Capital	74,540.22	42,091.54	26,019.47	12,962.62	42,883.41

Source: Program Budgeting Analysis (CSEA, 2011)

According to Helen (2011), many of the River Basin Development Authorities established in the 1970s to develop a framework for the development of the nation's water resources have become moribund and many of the dams constructed at huge cost to harness water resources for domestic, agricultural and industrial purposes have been abandoned. It is against this backdrop and other related issues that the federal and state governments of Nigeria through various agencies lunched a series of programs/interventions aimed at overcoming some of these challenges. Similarly, donor agencies like UNICEF, UNDP, JICA, ADB, Water AID, supported the development of water supply and have committed huge sums of money to the provision of boreholes, pipes, hand pumps, chemical laboratory kits, plants, drilling rigs, damming rivers, etc. to ensure sustainability of the program.

3. BACKGROUND ON PWS AND BWS PROGRAMS

This section provides a brief discussion on Bauchi State and background of the PWS and BWS programs. The two programs were implemented in the same part of the country, Bauchi State, though at different periods. These programs are the two most important (also common) water supply schemes in Bauchi State and Nigeria at large and they are introduced to achieve the basic objective of improving quality and accessibility of portable water supply. The background information on the two programs is presented below;

3.1 Bauchi Township Pipeline Water Supply Project

Prior to the establishment of this project, Gubi dam and ground water sources were the available drinking water sources in Bauchi Town. In 1987, only about 7,300m^3/day or roughly less than 35 litres per capita per day drinking water was available for an estimated population of 210,000. In order to supplement the existing supply, increase the per capita per day supply of minimum population needs, meet the needs arising from the projected population growth and enhance the reliability and adequacy of the supply to the newly established industrial zone in Bauchi, the PWS project was conceived. The goal of PWS is in line with the sector's goal of promoting good health and economic development in Bauchi through the provision of adequate water supply.

The project is aimed at raising the demand level from about 35 litres/capita/day in 1987 to 106 litres/capita/day for an estimated population of about 400,000 by the year 2000, in line with Federal Government's long term goal of providing 115 litres/capita/day in all urban areas. The scope of the project comprises the construction of a new 45,500m^3/day treatment plant, a 600V/2,100KVA stand-by power station, a high lift pumping station, about 79km of pumping main transmission and distribution pipelines and provision of logistics. The estimated total cost of the project is UA 50.67 million (NGN1.39billion)[5] and an ADB loan of UA 44.95 million (NGN1.24billion) was to be extended to the FGN for on lending to Bauchi State Government in October 1989 for the implementation. The balance of NGN0.15billion was to be raised by the Federal Government. The final project cost was UA 49.30 million (NGN1.35billion) and was to be completed in October 1992 instead of the stated completion date of December 1991[6].

3.2 Bauchi Borehole Water Supply Project

Before the new government administration came on board in 2007, out of the 45 million gallons of water required by Bauchi metropolis daily, only 2.5 million gallons were available. Water supply from the Gubi dam as at that time was in the region of 25 percent to 30 percent installed capacity. The capacity under-utilization is usually attributed to epileptic power supply. To meet the water supply MDG which will at least provide 1 borehole for 230-500 people living within 500m radius of the water point, the Bauchi State Government through the Millennium Development Goals (MDGs) office and Bauchi State Rural Water Supply and Sanitation Agency (BAURUWASSA) moved to boost water supply through the provision of solar powered boreholes, motorized boreholes and hand pumps. Under this scheme, boreholes were constructed in communities, villages, secondary schools, higher institutions, hospitals, as well as in organizations with acute water shortage. The project was expected to deliver 231 motorized boreholes, 100 solar boreholes and 200 hand pump boreholes. According to Bauchi State Commissioner of Water Resources, Bayero Bukar in 2009, 275 solar powered and motorized borehole projects have been completed and inaugurated. He also added that 200

[5] 1992 exchange rate (1UA = NGN27.48)

[6] African Development Bank (June, 2000) ‘‘*Project Performance Evaluation Report on Bauchi Township Water Supply Project*’’. Operation Evaluation Department (OPEV).

hand pump boreholes have been constructed and commissioned. According to Hajiya Hajara Wanka, Senior Special Assistant 2007-2011 (SSA) to the Governor on MDGs, about N4billion was expended in providing motorized, solar, and hand pump boreholes, using the 2007 and 2008 grant. The Bauchi State Government has spent over N1.2billion on the execution of water supply project in the state. N1billion of the amount was part of the Conditional Grant Scheme from the Federal Government under the Millennium Development Goals (MDGs) on water used for provision of solar boreholes and additional N200million was counter-part fund released by the State Government for the drilling of 200 hand pump operated boreholes across the state. The State Government also set up committee on maintenance of boreholes drilled in the state to ensure adequate maintenance of all the water schemes. Given these facts, this study will attempt to provide governments and donor agencies with adequate information on the cost-effectiveness of these alternative water supply programs implemented in Bauchi State.

4. LITERATURE REVIEW OF WATER CEA

Studies of cost-effectiveness and benefit-cost analysis have multiplied since 1950s, and the techniques have become more widely implemented. These analyses have been estimated and carried out on water supply programs, with different effectiveness and benefit measures such as health and non-health benefits, prevention of waterborne diseases, water quality, sanitation, and others.

For example, Clasen *et al.* (2007) using effectiveness data from recent systematic review and cost from program implementers and World Health Organization (WHO), conducted a cost effectiveness analysis of water quality interventions for preventing diarrhea disease in developing countries. The study compared non-piped water source (dug well, borehole and communal stand post) and four types of household based interventions (chlorination, filtration, solar disinfection and flocculation/disinfection) to improve the microbial quality of water for preventing diarrhea disease using methodology based on generalized CEA, an approach developed by WHO. The scope of the study was on two WHO epidemiological sub-regions: sub-Saharan African countries with very high adult and child mortality and Southeast Asian countries with high adult and child mortality. The outcome of the findings measured against international benchmarks showed that water source and household-based interventions were generally highly cost effective while household-based chlorination was the most cost-effective where resources are limited and household filtration also yields additional health gains at higher budget levels. Flocculation/disinfection was strongly dominated by all other interventions; solar disinfection was weakly dominated by chlorination.

Haller *et al.* (2007) also estimated the costs and health benefits of water and sanitation improvements at the global level. The study focused on interventions aimed at increasing access to improved water supply and sanitation facilities, increasing access to in-house piped water and sewage connection, and providing household water treatment, in ten World Health Organization (WHO) sub-regions. It relied on the acute health effects of diarrhea as the effectiveness measure. The cost-effectiveness of each intervention was assessed in terms of US dollars per disability adjusted life year (DALY) averted. The study found that almost all interventions were cost effective in most sub-regions, especially in developing countries with high mortality rates. This is even more so for access to piped water supply and sewage connections on plot - as it had the largest health impact across all sub regions. Overall, household water treatment was found to be the most cost-effective intervention. The study concluded that using improved water and sanitation facilities such as dug wells, plot piped-water, and ventilated improved latrine would bring a major improvement in health.

Geriani *et al.* (1998) performed a cost-effectiveness analysis to determine the adequacy of further investments in water supply system in Libya. The study identified minimum or least-cost combinations of investments in Libya's Great Man-made River Project (GMRP) components which is the world's largest irrigation project, together with desalination capacity required to meet specified water demand targets at various demand sites in the country. No other sources of water were considered, nor benefit analysis performed. In the study, over 250 separate scenarios or model solutions were examined as well as a number of sensitivity analyses were performed to estimate the increase in annual total costs, interest rates, operating costs and other costs. The result of the study based on availability of data and assumptions made showed that GMRP will be more cost-effective than by adding desalination capacity in meeting increasing water demand.

Rosen and Vincent (1999) reviewed and analyzed the results of studies on household water use in rural areas of Sub-Saharan Africa. The focus of the study was on the connections between household water supply and the quantity and quality of labour available in rural areas of sub-Sahara Africa. The study presented the human health and rural water supplies, costs of collecting water, cost and cost-effectiveness of improving water supplies and sanitation improvements as alternative means of reducing the burden of water-related diseases such as diarrhea, dysentery and others.

Jeuland *et al.* (2009) presented a cost-benefit comparison of improved water supply investments and cholera vaccination programs. Using parameters such as disease incidence, the effectiveness of vaccine and water supply interventions against diarrhea diseases, and the value of statistical life, the study conducted a cost-benefit evaluation of water interventions namely; deep wells with public hand pumps and biosand filters, and two cholera immunization programs (school-based and community-based programs). Also, a probabilistic sensitivity analysis was performed to estimate a frequency distribution for benefit-cost ratio for interventions and the result of the study showed that the two improved water supply interventions and targeted (school-based) cholera vaccination program were more likely to yield attractive cost-benefit outcome than a community- based vaccination program.

More extensively, Whittington *et al.* (2008) conducted a cost-benefit analysis of investments in four (4) alternative water and sanitation intervention; including pipeline water supply and Hand-pump borehole water supply project. The study adopted a Monte Carlo simulations approach, using recent data applicable to developing country locations for parameters and the effectiveness of portable water supply against diarrhea disease. Thereafter a probability sensitivity analysis was adopted to estimate a frequency distribution of the benefit-cost ratios for all four interventions, given a wide variety of possible parameter combinations. The outcome of the study showed potential conditions in developing countries under which these interventions can be effective. That is the success of each intervention depends on the specific context in which it is implemented. However, with the reasons stated under the methodology section and coupled with the initial challenges faced by CSEA in finding an appropriate effectiveness measure for the Water CEA, this study will be drawing on the work of Whittington *et al.* (2008) particularly, the estimated effectiveness measure.

5. METHODOLOGY

This section sets out the assumptions, sources and methods of data collection, and technique used in the study.

5.1 Assumptions

The following assumptions were made:

- It is assumed that the initial capital cost of the programs does not include the operations and maintenance cost, and management cost.
- Operations and maintenance, and management costs are constant throughout the lifespan of the projects[7].
- With the provision of alternative power supply (generator) we assume that the PWS will now run for 24hrs.
- The estimated average lifespan of PWS and BWS projects are 20 years and 10 years, respectively, with a 24hrs water supply to households from both interventions
- As a result of time savings from the new water interventions, this study assumes increase in water consumption by households for other domestic purposes.
- It is assumed that the 106 litres/capita/day targeted by the program could be achieved.
- Average number of beneficiaries per borehole is 365 individuals.
- The PWS and BWS programs will deliver high-quality services and positive health outcomes.

[7] The Borehole water supply project is expected to have average lifespan of 10yrs. See for example Whittington *et al* (2008) and Adekile and Olabode (2009)

- Total health benefits are reduction in morbidity and mortality, since both benefits are health related.

5.2 Data Sources

The sources of data for this report are; Bauchi State Water Board, Bauchi State Rural Water Supply and Sanitation Agency, Federal Ministry of Water Resources, Africa Development Bank. Pipeline Water supply program data are from the Operation Evaluation Department of the African Development Bank. Given the challenges of getting the actual information on the programs and their cost components, some data were derived through several computations, adaption from relevant and previous literature, interactions and interview with some government officials/individuals, and program managers. Units of measurement will be litre, hour, and expenditure /Household as beneficiaries. In addition, the costs of all projects were expressed in Naira (local currency), same base year and deflated to a single reference year.

5.3 Cost Analysis

This subsection presents the techniques adopted in conducting the BASIC and the PROGRAM CEA.

5.4 BASIC Cost Effectiveness Analysis

In this analysis, the Basic CEA measures the cost effectiveness of PWS and BWS by comparing the unit cost of both programs per household per year.

5.4.1 Effectiveness Measure for the BASIC CEA

The effectiveness measure adopted for the BASIC CEA is defined in terms of the beneficiaries covered by each of the two programs. Therefore, the PWS and BWS program effectiveness is measured in terms of households covered, that is, the number of households benefitting from the two programs.

5.5 PROGRAM Cost Effectiveness Analysis

The Program CEA for this study is basically an extension of the Basic CEA. It tries to evaluate the relative effectiveness of the PWS and the BWS programs by examining the achievement and impact of the programs on the targeted population, in this case the households.

5.5.1 Effectiveness Measure for PROGRAM CEA

The PWS and BWS programs implemented by the state government at the various local governments, town and villages of Bauchi state are certainly not new but there are little or no data to capture the effectiveness of the two programs. In most cases the government has not really seen the importance of conducting impact evaluations alongside the execution of the programs and this is neither peculiar to the water programs nor to Bauchi state government. It is only in few instances, in particular, donor-assisted projects that reports on project execution are presented, and usually focus on the accountability of funds allocated for the programs[8]. As stated earlier, three different types of BWS program (Solar, Motorized and hand pump boreholes) were implemented in Bauchi state, however, this study focused mainly on the most common borehole technology in Nigeria-hand pump BWS. Also, given the lack data to calculate the effectiveness measure, this study therefore adopts the two effectiveness measures reported in Whittington *et al*. (2008), Whittington and Jeuland (2009) and others; namely; time savings that result from the installation of new water source and health benefit (reduction in morbidity and mortality). Basically, the estimates were based on Monte Carlo simulations, and for each of these measures, plausible range of values are specified based on professional judgment, and reference to related literature. Thereafter, specific probability distribution that

[8]For example there is a report on the Bauchi state Pipeline Water project by African Development Banks, given that the institution extends a loan to the Bauchi state government for the project. So the report focuses more on the project execution and accountability of funds.

determines the likelihood that a specific value within the specific range will occur is assumed. The studies were on developing countries, especially Africa and focused on five alternate water supply and sanitation projects. The PWS and BWS programs implemented by Bauchi State Government are similar to the programs identified in Whittington *et al*. (2008), and Whittington and Jeuland (2009). This similarity therefore provides a good basis for adopting the same methodology.

5.6 Benefit-Cost Analysis

This subsection explains the technique of the Benefit–Cost Analysis. For the BCA, the cost of the programs – BWS and PWS are the same as the cost previously estimated for the Basic CEA. In terms of the benefits, the estimation considers two sources of benefits (direct and indirect). Direct benefits are associated with value of time savings with BWS and PWS rather than fetching water from the traditional source (this is estimated based on average wage of unskilled labour and the value of time savings as a percentage of market wages of unskilled labour (see Table 2 in the Appendix for details). The other benefit, indirect (total value of Health Benefits), is the value of avoided morbidity/mortality (this is estimated based on cost of illness of diarrheal and value of statistical life); this benefit is distributed over the lifespan of the interventions. After computing the costs and benefit of alternative programs, the Net Present Value (NPV) and Benefit-Cost ratio are then calculated to evaluate the usefulness (attractiveness) of the programs, and to further decide on the program to recommend for implementation. The benefit-cost analysis is based on the following assumptions:

Assumptions for Benefit-Cost Analysis

- With the provisions of maintenance and operating cost, both BWS and PWS are assumed to run effectively during their stated life span.
- The value of statistical life (VSL) is assumed to be the same for all the targeted beneficiaries of the intervention.
- Cost of illness (COI) from diarrheal is derived from recent survey, and it is assumed to be a true representation and the same for all the targeted beneficiaries of the intervention.
- Since most water interventions are targeted at the poor, this study adopts the unskilled wage as a proxy for the average income of the poor.

The estimates of the COI and VSL were derived from IAHHM Project (2010) and ICF International (2009), respectively. Although, there are various studies with estimated values of COI and VSL, the selected studies tried to provide an extensive review of the existing estimates of the parameters along side with a survey, before arriving at the current estimates. While both studies were coordinated by World Bank, the former focused on Nigeria and the later on Sub-Saharan Africa.

Sensitivity Analysis

In order to analyze the impact of uncertainty and to also determine the robustness of the estimates and the underlying assumptions made in the analysis, a one-way (including worse and best case scenarios) and multi-way (with worse and best case scenarios) sensitivity analyses are undertaken. This highlights the impact on the results of varying key parameters which are either uncertain or may change overtime. The essence of the analysis is to determine the extent to which one can rely on the initial results (confidence level) given that some assumptions and global view of some parameters were adopted which include the lifespan of each intervention, the discount rate, the effectiveness of each intervention and the percentage of annualized capital costs used to estimate operation and maintenance costs.. These scenarios arise due to lack of data and may have ramifications for the relative effectiveness of the interventions.

6. RESULTS AND DISCUSSION

This section presents summary costs of programs, results and discussions of findings on the BASIC CEA, PROGRAM CEA and BCA.

6.1 Summary of Cost

Computing the cost of the programs posed a major challenge in this study as data regarding the component/ingredient cost for both programs were not available. In most cases only the total cost and expected number of beneficiaries of the programs were made available. Given this challenge, this study makes use of the annualized aggregate cost (i.e. capital and operations and maintenance cost)[9] to present the cost on per household per year basis (see Table 2 for detail).

6.1.1 Summary Cost of Pipeline Water Supply Program

For capital cost of PWS, we adopt the figure in the African Development Bank (2000) performance evaluation report on Bauchi State Township Water supply project. Using a 3% discount rate, a 0.06721 capital recovery factor for the entire life span of project is derived. This means that the annualized capital cost of PWS is N91, 061,410.59. The operations and maintenance cost is derived using an average of 37.5% of annualized capital cost, therefore, the total cost per household per year is estimated at N2, 504.19 (see Table 2).

[9] Capital cost includes; storage, transmission to treatment plant, treatment of drinking water, standard distribution of water to household (including house connections), generator, labour and other program cost.

Table 2: Computation of PWS/Hand pump BWS; Unit cost per household per year

Cost Description	Equation	Values (PWS in 1992 prices)	Values (BWS in 2008 prices)
Capital recovery factor	$CR = \left(\frac{[r \cdot (1+r)^d]}{[(1+r)^d - 1]}\right)$	0.06721	0.1172
Capital (NGN Per year)[a]	$C^{Capital} = CR \cdot C^{PWS}$	91,061,410.59	135,486.40
Operation & Maintenance Costs (NGN Per year)	$PWS: C^{o\&m} = \left(P^{O\&M} \cdot C^{Capital}\right)$; $BWS: C^{o\&m} = C^{O} + C^{M}$	34,148,028.97	71,140.14
Total (Annualized)cost(NGN Per year)	$C^{Total/Year} = C^{Capital} + C^{o\&m}$	125,209,439.57	206,626.5
Total cost per household per year(NGN Per year)[b]	$\frac{\boldsymbol{C^{Total/Year}}}{\boldsymbol{n}}$	**2,504.19**	**4528.8**
Comparison of the CE Ratio for PWS and BWS Programs			
Cost Description		**PWS (2008 Prices)**	**BWS**
Total Cost per household/year (in naira)		**53,005.36**	**4528.8**

Note: [a] Capital cost for PWS includes the cost of alternative power supply (generator).
[b] The household coverage (*n*) is used to determine the unit cost per household. It is not used as an effectiveness measure.
See Table 2 in Appendix for the detailed definition of variables.

6.1.2 Summary Cost of Borehole Water Supply Program

There are also challenges to the proper costing of the BWS program due to non-availability of data on cost component among others. However, similar method adopted in costing of PWS is employed for BWS. Although the total cost of the program and the number of planned boreholes are available, data on the other cost components are not available. According to a study conducted by Adekile and Olabode (2009) on public and private borehole drilling in Nigeria, and sponsored by UNICEF and RWSN, the average economic cost of hand pump borehole in Nigeria is made up of five (5) components. It is possible that the cost of these components may vary in different regions of Nigeria following differences in topography that will likely affect the depth of the borehole. According to the findings by Adekile and Olabode, the average depth of hand pump borehole in the northern part of Nigeria is 50m deep, and based on this, the estimated average cost of hand-pump borehole was $9,750 (see Table 1 in

Appendix). This study therefore adopts the Hand pump cost estimates in Adekile and Olabode (2009). Using the 2008 exchange rate of NGN118.5669/US$, an average cost of producing a hand pump borehole is estimated at NGN1, 156,027.26. With this, the total cost of the 200 hand-pump boreholes is N231, 205,455. Given the 3% discount rate and the average life span of 10years of BWS, the capital recovery factor equals 0.1172. This implies an annualized capital cost of N135, 486.40 for BWS. The operations and maintenance, and management cost is derived using an average of $600/N71,140.14 as presented in Whittington *et al* (2008)[10], therefore, the total cost per household per year is N4, 528.8 (see Table 2).

6.2 CE Ratio for BASIC CEA

The cost effectiveness ratio is derived by dividing the annualized total cost of each program by the number of household beneficiaries (see Table 2 for details). This represents the cost per household per year for the provision of the interventions and it is expected that the program with the lowest CE ratio is more cost-effective.

The results of the Basic CEA presented in Table 2 show that the total economic cost per household/year for PWS program is N53, 005.36 while that of BWS is N4, 528.8 per household/year. It means that on average, it will cost about N4, 528.80 to supply a household with a Hand pump water supply in a year while it cost about N53, 005.36 to supply the same household with Pipeline water supply in a year. This implies that the BWS program is more cost-effective than the PWS program and would be recommended for uptake, if basic CEA is the only choice criterion. This is also true if one was to base the decision on capital investment per household/year.

[10] Whittington et al (2008) presents the global annual operation and maintenance, and management cost as $250 to $950 per year.

6.3 PROGRAM CEA

The program CEA extends the analysis of the Basic CEA by simultaneously examining the unit cost of the program and the estimated program impact.

- **Effectiveness and Benefit Measures**

As stated earlier, two different effectiveness measures are adopted for the Program CEA. Table 3 shows the equations from which the effectiveness measures of PWS and BWS are derived.

Table 3: Equations for the Computation of Effectiveness Measure of PWS and BWS programs

Effectiveness Measures	Equations	Values (PWS)	Values (BWS)
Time Savings(hours) experienced in period *1* collecting 35 liters/day /individual	$\Delta T_1^w = T_0^w - T_1^w$	$1hr\ 10min$	$35min$
Total Time Savings: Water (hrs per household-year)	$TTS = \Delta T_1^w \cdot S \cdot 365$	$3407hrs$	$1703hrs$
Avoided Morbidity (per household-year)	$V^{morbidity} = I \cdot E \cdot S$	8.18	2.73
Avoided Mortality (per household-year)	$V^{mortality} = I \cdot E \cdot S \cdot CFR$	0.0069	0.0023
health Benefits (per household per-year)	$V^{HB} = V^{morbidity} + V^{mortality}$	8.19	2.73

See Table 2 in Appendix for the detailed definition of variables.

Table 4, summarizes increase in program achievements which shows the estimated absolute value of reduction in initial time spent and health benefits: morbidity and mortality, that is, the estimated values for effectiveness measures.

Table 4: Estimates of Increase in Effectiveness of PWS and BWS Interventions in Bauchi States

Effectiveness Measure	Before borehole water supply intervention	After borehole water supply intervention	X^n. Estimated Increase in Achievement	Before pipeline water supply intervention	after pipeline water supply intervention	X^n. Estimated Increase in Achievement
Time spent collecting initial quantity of water (hrs per household-year)	3407	1703	**1703**	3407	0	**3407**
reduction in morbidity (nonfatal cases of diarrhea per household -year)	10.91	8.18	**2.73**	10.91	2.73	**8.18**
Risk of death from all diarrhea (reduction in mortality) per household-year	0.0092	0.0069	**0.0023**	0.0092	0.0023	**0.0069**

Source: Computed by CSEA staff

- **Time savings**

Prior to the installation of the PWS and the BWS interventions, an average individual in Bauchi state collects water from the traditional and other sources distant from home. According to ADB report (2000), an average individual uses 35litres/capita/day which is 280litres/capita/day for a household (that is, 35 multiplied by 8 - the number of individuals in a household) and since the amount of water an individual uses is a function of time, Whittington *et al.* (2008) estimated that the average time it will take an individual to fetch water from the traditional sources in the developing countries as 1hour/20litres. Similarly, Rosen and Vincent (1999) study of household water resources and rural productivity in Sub-Sahara African countries found that the average time spent per carrier per day ranges from 17 to 103 minutes, with some carriers spending as little as 7 minutes or as much as 264 minutes per day. Based on 40 minutes/20 litres, we estimate that it will take an individual roughly 70 minutes to fetch 35 litres of water per day from existing sources. This means that a household spends about 9.3hrs a day to fetch water (i.e. 3407hours/year). The results that emerge from Whittington *et al.* (2008) show that with the installation of BWS and PWS, it will, on average, take 20minuties/20litres to fetch water from boreholes and zero (0) time from piped-water, respectively[11]. Following the finding from Whittington *et al*., it means that a household will now save a total of 3407hours/year with the installation of PWS while with the BWS intervention, a household will now spend 280 minutes/day (i.e. 1703hours/year) to fetch the same amount of water, saving approximately 1703hrs/year.

- **Health Benefits**

[11] We take half the time (upper limit) spent on collecting water from the existing sources as the new time for collecting water from the BWS.

The health related benefits considered for the improved water supply are reduction in morbidity and mortality due to reduction of cases of diarrheal disease in a household.

- ***Reduction in Morbidity***

The results of water interventions on diarrheal incidence vary widely along various water supply projects and across regions. It is expected that the improved water supply from PWS and BWS interventions in the developing countries on the average has the capacity to reduce the diarrheal incidence rate within the range of 60-90% and 10-40%, respectively (Whittington *et al.,*2008 and Whittington and Jeuland, 2009). Drawing on WHO (2002), the estimated baseline diarrheal incidence for Nigeria is 1.36 cases/individual/year[12]. Therefore, taking the average of the range of possible reduction in diarrheal incidence in developing countries, the PWS and BWS have the capacity to reduce diarrheal incidence by 75% and 25%, respectively (see Table 2 in the Appendix). With installation of improved water sources, the estimations show that PWS will reduce diarrheal incidence by 8.18 cases/household/year while the BWS will reduce diarrheal incidence by 2.73 cases/ household /year. This implies that PWS is more effective in the reduction of incidence of diarrhea.

- ***Reduction in Mortality***

The reduction in deaths due to diarrheal is another important health benefit of improved water supply. Therefore, if improved water supply program reduces cases of diarrheal incidence then there will be reduction in deaths related to diarrheal disease. Using data from WHO (2002, 2008) report, the diarrheal case fatality rate (live lost/case) which is estimated at 0.00084 is used to calculate the effectiveness measure (reduction in deaths) for PWS and BWS. The

[12] WHO (2002) reported annual incidence/case of diarrheal in Africa as 838,857,000; death per total case as 707,657 and specifically, it reports annual death per total case for Nigeria as 173,900. Using this information, this report was able to derive diarrheal incidence/case for Nigeria.

analysis shows that the reduction in mortality from diarrhea disease per household per year as a result of PWS and BWS are 0.0069 and 0.0023, respectively.

- **Cost Effectiveness Ratios**

The ratio of estimated unit cost of the programs and the probable impacts (i.e. time savings and Health benefits) gives the estimated value of the potential cost-effectiveness of the programs. In theory as well as in practice, the program with the lowest cost-effectiveness ratio is expected to be the program with the least cost and a reasonable impact on beneficiaries. Overall, the cost-effectiveness result suggests that the BWS program is more successful and efficient than the PWS program.

Table 5: Estimates of Cost-Effectiveness Ratios of PWS and BWS Interventions

Intervention/Program	Z. Estimated Cost of intervention /beneficiary	Cost Effectiveness (Time Saving) Z/X^1	Cost Effectiveness (reduction in diarrhea) Z/X^2	Cost Effectiveness (Reduction in mortality) Z/X^3	Cost Effectiveness (Health Benefits)
Borehole water supply intervention	**4,528.80**	**2.66**	**1,661.02**	**1,968,973.28**	**1,970,634.30**
Pipeline water supply intervention	**53,005.35**	**15.56**	**6,480.22**	**7,681,660.90**	**7,688,141.12**

Source: Computed by CSEA staff

Clearly, on all the two (2) effectiveness measures adopted in this analysis, the results indicate that BWS program is more cost-effective than the PWS program. Table 5, summarizes the estimated cost effectiveness ratios. The results show that the potential cost-effectiveness ratios for BWS and PWS are (1.27 and 10.37) and (1,970,634.30 and 7,688,141.12) based on time savings and health benefits, respectively. All cost-effectiveness outcomes indicate a lower CE ratio for the BWS than for the PWS. This implies that the BWS intervention, with smaller unit cost has more impact on the beneficiaries than PWS intervention. In sum, this suggests that the BWS intervention is more cost-effective than the PWS.

6.4 Benefits-Cost Ratio

The ratio of estimated unit cost of the programs and the monetary value of probable impacts (i.e. time savings and Health benefits) gives the estimated value of the potential benefit-cost ratio of the interventions. Overall, the CBA shows that the BWS program is more sustainable and beneficial than the PWS program. Table 6 presents the equations for the computation of the monetary benefits of PWS/BWS programs while Table 7 presents the estimates and comparison of the Net Present Value (NPV) and BCA ratio for both programs, respectively.

Table 6: Equations for the computation of monetary benefits of PWS and BWS programs

Effectiveness Measures	Equations	Values (PWS)	Values (BWS)
Time Savings(hours) experienced in period *1* collecting 35 liters/day /individual	$\Delta T_1^w = T_0^w - T_1^w$	**1hr 10min**	**35min**
Value total Time Savings: Water (hrs per household-year)	$V^{ts} = \Delta T_1^w \cdot S \cdot 365 \cdot v \cdot \frac{w}{8}$	**87,094**	**60,965**
Value avoided Morbidity (per household-year)	$V^{morbidity} = I \cdot E \cdot S \cdot COI$	**5,819**	**1,940**
Value avoided Mortality (per household-year)	$V^{mortality} = I \cdot E \cdot S \cdot CFR \cdot VSL$	**24,544**	**8,181**
Total Benefits (household per-year)	$V^{TB} = V^{morb.} + V^{mort.} + V^{ts}$	**117,457**	**71,087**

See Table 2 in Appendix for the detailed definition of variables.

Table 7: Estimates of Benefits-Cost Ratios of PWS and BWS Interventions

Intervention/Program	Total Cost (Per household)	Total Benefits (per household)	Net Present Value	Benefit-Cost Ratio
Borehole water supply intervention (BWS)	**4,528.80**	**71,086.55**	**66,557.75**	**15.70**
Pipeline water supply intervention (PWS)	**53,005.36**	**117,456.72**	**64,451.37**	**2.22**

Source: Computed by CSEA staff

Similar to the CEA, the CBA results indicate that BWS program is more cost beneficial than the PWS program. The results show that the potential Net present value and benefit-cost ratios for BWS and PWS are (N66, 557.75 and N64, 451.37) and (15.70 and 2.22) based on total benefits (time savings and health benefits), respectively. The benefit-cost outcomes indicate a higher BCA ratio for the BWS compared to PWS project although PWS appears to have higher benefits.

6.5 Sensitivity analysis

This section evaluates in economic terms, the extent to which the variations in parameters estimates/assumptions for each interventions could affect their relative benefits and their overall desirability. A one way and multi-way sensitivity analyses are presented and each focuses on two scenarios - the worse (lower limit of the parameters) and best case scenarios (upper limit of the parameters) for BWS and PWS interventions. This exercise re-estimates the total cost per household per year, Net present value and benefit-cost ratio of the BWS and PWS interventions by adopting a lower and an upper limit for few parameters (see Table 8 for details). The one way sensitivity analysis varies only the discount rate (see the yellow portion of Table 8), while the multi way sensitivity examines: (variations in discount rate and effectiveness), (variations in discount rate, effectiveness and lifespan of interventions) and (variations in discount rate, effectiveness, life span and percentage [absolute value] of operation and maintenance cost), see the green portion of Table 8.

Table 8: One-way and Multi-way Sensitivity Analysis on Basic CEA and Benefit-cost ratio

	PWS			BWS		
	Sensitivity on Discount Rate					
	Base case		Upper limit	Base case		Upper limit
Discount rate	**3%**	**5%**	**10%**	**3%**	**5%**	**10%**
Total Cost	**53,005.36**	**63,086.84**	**92,627.26**	**4,528.80**	**4,840.45**	**5,682.67**
Value of time savings	87,093.56	87,093.56	87,093.56	60,965.49	60,965.49	60,965.49
Value of Avoided Morbidity	5,818.94	5,818.94	5,818.94	1,939.65	1,939.65	1,939.65
Value of Avoided Mortality	24,544.22	24,544.22	24,544.22	8,181.41	8,181.41	8,181.41
Total Benefits	**117,456.72**	**117,456.72**	**117,456.72**	**71,086.55**	**71,086.55**	**71,086.55**
Net Present Value	**64,451.37**	**54,369.88**	**24,829.46**	**66,557.75**	**66,246.09**	**65,403.87**
Cost- Benefits Ratio	**2.22**	**1.86**	**1.27**	**15.70**	**14.69**	**12.51**
	Sensitivity on Effectiveness & discount rate					
	Base case	lower limit	upper limit	Base case	lower limit	upper limit

Effectiveness of Intervention	**75%**	**60%**	**90%**	**25%**	**10%**	**40%**
Total Cost	**53,005.36**	**63,086.84**	**92,627.26**	**4,528.80**	**4,840.45**	**5,682.67**
Value of time savings	87,093.56	87,093.56	87,093.56	60,965.49	60,965.49	60,965.49
Value of Avoided Morbidity	5,818.94	4,655.15	6,982.72	1,939.65	775.86	3,103.43
Value of Avoided Mortality	24,544.22	19,635.38	29,453.07	8,181.41	3,272.56	13,090.25
Total Benefits	**117,456.72**	**111,384.09**	**123,529.35**	**71,086.55**	**65,013.91**	**77,159.18**
Net Present Value	**64,451.37**	**48,297.25**	**30,902.10**	**66,557.75**	**60,173.46**	**71,476.50**
Cost- Benefits Ratio	**2.22**	**1.77**	**1.33**	**15.70**	**13.43**	**13.58**
	Sensitivity of Interventions Life-span, discount rate & effectiveness					
	Base case	**lower limit**	**upper limit**	**Base case**	**lower limit**	**upper limit**
lifespan of Intervention	**20yrs**	**15yrs**	**25yrs**	**10yrs**	**5yrs**	**15yrs**
Total Cost	**53,005.36**	**75,974.14**	**86,876.95**	**4,528.80**	**7,411.58**	**4,890.46**
Value of time savings	87,093.56	87,093.56	87,093.56	60,965.49	60,965.49	60,965.49
Value of Avoided Morbidity	5,818.94	4,655.15	6,982.72	1,939.65	775.86	3,103.43
Value of Avoided Mortality	24,544.22	19,635.38	29,453.07	8,181.41	3,272.56	13,090.25
Total Benefits	**117,456.72**	**111,384.09**	**123,529.35**	**71,086.55**	**65,013.91**	**77,159.18**
Net Present Value	**64,451.37**	**35,409.95**	**36,652.41**	**66,557.75**	**57,602.34**	**72,268.71**
Cost- Benefits Ratio	**2.22**	**1.47**	**1.42**	**15.70**	**8.77**	**15.78**
	Sensitivity on Percentage of O&M, discount rate, lifespan & effectiveness					
	Base case	**lower limit**	**upper limit**	**base case**	**lower limit**	**upper limit**
Percentage of O&M	**37.50%**	**25%**	**50%**	**$600**	**$250**	**$950**
Total Cost	**53,005.36**	**69,067.40**	**94,774.85**	**4,528.80**	**7,315.43**	**4,996.84**
Value of time savings	87,093.56	87,093.56	87,093.56	60,965.49	60,965.49	60,965.49
Value of Avoided Morbidity	5,818.94	4,655.15	6,982.72	1,939.65	775.86	3,103.43
Value of Avoided Mortality	24,544.22	19,635.38	29,453.07	8,181.41	3,272.56	13,090.25
Total Benefits	**117,456.72**	**111,384.09**	**123,529.35**	**71,086.55**	**65,013.91**	**77,159.18**
Net Present Value	**64,451.37**	**42,316.69**	**28,754.50**	**66,557.75**	**57,698.49**	**72,162.34**
Cost- Benefits Ratio	**2.22**	**1.61**	**1.30**	**15.70**	**8.89**	**15.44**

Source: Computed by CSEA staff

Overall, the findings re-affirm the initial results, which favoured the implementation of BWS. An increase in the discount rate from 3% to 5% and 10%, further increases the total cost per household per year to (63,086.84 and 92,627.26) and (4,538.80 and 5,682.67) for the PWS and BWS, respectively. This therefore reduces the Benefit-cost ratio to (1.86 and 1.27) and (14.69 and 12.51), respectively. Further analysis shows that with lower limits of 60% of effectiveness and 5% discount rate or upper limits of 90% of effectiveness and 10% discount rate for PWS intervention, the BWS intervention still has a more favourable BCR than PWS intervention. Also, reversing this scenario with lower limits of 10% of effectiveness and 5% discount rate or upper limits of 40% of effectiveness and 10% discount rate for the BWS intervention ceteris paribus provides a better BCR in favour of the BWS. Similarly, variations in the lifespan of the interventions to 5years /15years for BWS, 15years/25yeras for PWS, and both, with the previous variation in discount rate and effectiveness reduces the BCA substantially for both interventions. Finally, the sensitivity analysis of the percentage (or absolute value) of operations and maintenance, alongside with variations in discount rate, life span of interventions and effectiveness for either PWS and/or BWS, gives a result that is consistent with the previous analysis. It reduces the BCR to (1.61 and 1.3) and (8.89 and 15.47) for BWS and PWS, respectively.

7. CONCLUSIONS

Following the growing interest of government officials, policy makers and other stakeholders in improving the access to, and quality of water supply to the citizens, this study has empirically conducted the cost-effectiveness and benefit-cost analyses of two basic water interventions – BWS and PWS. The results of the cost analysis show that BWS program has a lower-cost per Household per year, while the PWS is more effective or has more benefits along the dimensions of time savings and total health benefits. However, the cost-effectiveness ratio and in particular, the NPV and the benefit-cost ratio suggest that the BWS is more efficient and beneficial (in monetary terms) than the PWS. This result is line with the findings by Whittington *et al.* (2008). In Sum, the findings provide answers to the first, second and third research questions stated in the earlier part of this report.

8. POLICY RECOMMENDATIONS

Several important policy recommendations emerge from this cost-effectiveness and benefit-cost analyses of water programs in Bauchi State:

- In very dense towns, villages or areas where there is high level of mortality and morbidity arising from diarrheal, policy makers and government officials should consider increasing investment in PWS intervention.
- In sparsely populated villages or areas where access to portable water is very low or with a few cases of morbidity and mortality from diarrheal, there is a need to concentrate investment on BWS project.
- Where the objective of government officials and policy makers is to reduce the amount of time people spend collecting water, taking cost into account, investment should target the BWS project.
- Additionally, in communities with mild population and moderate cases of morbidity and mortality, government should take both the PWS and BWS as complements.
- Also, there is a need for the federal government, through Water Supply board in various states and other relevant agencies to encourage and support the states and local government to adopt the BWS or PWS interventions.
- Monitoring and Evaluation of programs should be introduced – households should be examined regularly for cases of diarrhoeal, cholera and other related diseases. This way, it will be easy to see whether programs are being adequately implemented and if there are improvements that can be associated with such interventions.

9. CHALLENGES TO CONDUCTING THIS WORK

The major challenges faced in conducting this study were lack of access to the required data and program documents. Officials and individual involved in the programs were not willing to release/disclose the program documents or answer certain questions. Some of the documents were termed ‘sensitive’ since some of the program costs are likely to have been manipulated and were not to be made public. Data on unit cost of water supply and exiting impact of the two programs were not available; therefore arriving at a good effectiveness measure was a major challenge. However, we attempted to generate some data through several computations, consultations and interview with some government officials/individuals and experts. We also used market estimates when possible. For the effectiveness and benefit measure, the values were generated from similar programs discussed in the literature.

10 LIMITATIONS

Borehole water supply intervention has several dimensions: – solar, motorized and hand pump. These dimensions also have their complications in terms of costing, measuring and isolating effectiveness and benefits. With this in mind, the analysis focused on hand pump borehole. This therefore limits the ability of this analysis to generalize. To address this shortcoming, this study suggests additional research on the cost-effectiveness and benefit-cost of solar/motorized borehole and the PWS. This can be addressed by future studies.

11 PLANS FOR DISSEMINATION

The findings of this study will be disseminated using various strategies including:

- Media: Press conferences, press releases, policy briefs as well as newspaper publications will be used to reach out to potential stakeholders and policy makers.

- Interactive communication: seminars, workshop and conferences will be conducted with various representatives of civil society organisation, non-governmental organisations, policy makers and stakeholders to share result of the findings.
- Collaboration and sharing research findings with Civil Society Groups, Community Based organizations, academicians, economists and researchers working on similar project.
- Website: the final report will be available on CSEA website as a source of information to interested parties, to create awareness and inform different audiences of findings and implications of projects.

Reference

Adekile, D. and O. Olabode (2009), "Study of public and private Borehole drilling in Nigeria" *UNICEF Nigeria*

African Development Bank Group (2000), "Nigeria Bauchi Township Water Supply Project; Project Performance Evaluation Report (PPER)" *Operation Evaluation Department*

El Geriani, A., O. Essamin, P.J.A Gijsgers and D.P. Loucks (1998), "Cost-Effectiveness Analyses of Libya's Water Supply System"

Helen, E. (2011), "Water for All, Not Much to Drink" http://www.tellng.com/index.php?option=com_k2&view=item&id=77:water-for-all-not-much-to-drink

Laurence, H., G. Hutton and J. Bartram (2007), "Estimating the costs and health benefits of water and sanitation improvement at global", *Journal of Water and Health*, Vol.5, pp. 467-478.

Rosen, S. and R. Jeffrey (1999), "Household Water Resources and Rural Productivity in Sub-Saharan Africa: A review of the Evidence"

Thomas, C., L. Haller, D. Walker, J. Bartram and S. Cairncross (2007), "Cost-Effectiveness of Water Quality Interventions for Preventing Diarrheal Disease in Developing Countries", *Journal of Water and Health*,Vol.5, pp. 599-608.

Uneze, E., V. Ushie and G. Nwadike (2010), "Strengthening Institutions to Improve Public Expenditure Accountability: Program Budgeting Analysis of Nigeria Key Social Sectors", *Centre for the study of economies of Africa (CSEA)*

UNICEF (2005), "Women, Water and Hygiene Are Key to Change in Africa UNICEF: *Services for women & girls must be priority for water and sanitation".*

Whittington, D. and M. Jeuland (2009), ''Cost-benefits comparisons of investments in improved water supply and cholera vaccination programs '', *Vaccine*, 27, pp. 3109-3120

Whittington, D., M. W. Hanemann, C. Sadoff and M. Jeuland (2008), ''The Challenge of Improving Water and Sanitation Services in Less Developed Countries'', *Foundation and Trends in Microeconomics*, Vol. 4, pp. 469-609.

WHO (2002, 2008) "Revised Global Burden of disease (GBD) Estimates"

www.who.int/whosis/mort/profiles/mort-afro-nga

APPENDIX

Table 1: Cost of a 110mm uPVC Lined Hand Pump Borehole 50m Deep

Description	Unit	Qty	Unit Rate (US$)	Amount (US$)
Mobilisations/Demobilisation	Ls	1	2,101	**2,101**
Drilling: Site clearing and preparation		1	35	35
Drilling (Fuel and lubricants cost $10 per h)[2]	m	50	46	2,254
Casing and Completion: 110 UPVC casing	m	40	22	878
110 UPVC screen	m	10	24	235
Supply sand pack river gravel	No	1	209	209
Backfill	Ls	1	70	70
Grouting (6 bags of cement)	No	6	23	139
Development and Pumping Borehole development (compressor running for 10hrs)	No	4	70	278
Pumping test (pump and generator for 24 hours)	No	3	208	624
Sub total				**6,823**
Other costs				2,927
Total Cost				**9,750**

Source: Computed by CSEA staff based on Adekile and Olabode (2009) estimates.

Table 2: Definition of Parameters Used in Cost- Effectiveness and Benefits-Cost Analysis

Symbols	Parameters Description	Average/Base(PWS)	Average/Base(BWS)
$C^{PWS/BWS}$	Total capital cost of Interventions	N1,354,764,000	N1, 156,027.26
$P^{O\&M}$	O&M expenditure, as percent of annualized capital (%)[2]	37.5	-
$C^{o\&m}$	Annualized O&M and Management cost	N34,148,028.97	$600/N71,414
d	Duration of Network (Yrs)[3]	20	10
r	Real (net of inflation) discount rate (%)[3]	3	3
S	Household size (person/Hh)[5]	8	8
k	Number of individual served by PWS/BWS	400,000	356
n	Number of household served by PWS/ Hand pump BWS	50,000	45.625
T_0^w	Collection time from traditional water source in period 0 (hrs/jerrican)[2]	0.67	0.67
T_1^w	Collection time from improved water supply in period 0 (hrs/jerrican)[2]	0	0.33
$\underline{Q}^w$	Water use when collection time is $T_1^w = 0$ (L /person – day)[4]	106	80
I	Diarrhea disease incidence (cases/household-yr)[5]	0.060905	0.060905
E	% reduction in diarrhea incidence due to water supply improvement[2]	75	25
w	Market wage for unskilled labour (N/per day)[3]	10,000	10,000
v	Value of time saving as a percentage of market wage for unskilled labour %[2]	30	15
COI	Cost of illness of diarrhea(N/case)	1305.5	1305.4
VSL	Value of statistical life (N/ life lost)	6,153,622.11	6,153,622.11
CFR	Diarrhea case fatality rate (Lives lost/case)[5]	0.0008436	0.0008436
CR	Capital recovery factor[2]	0.06721	0.1172