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Preference for water boreholes to odor stream harnessing at Amaopkara

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The paper focuses on provision of sustainable portable water to Amaokpara community in Orumba Local Government Area of Anambra State, using "Decision Tree Analysis" which involves two options of water boreholes and odor stream harnessing. This is to achieve one of the key targets of millennium development goals by 2015, which is aimed at the proportion of people without sustainable access to safe drinking water and to ascertain the majority of premature deaths which is accounted by water related disease, in many cases could be alleviated by the provision of an adequate supply of water for both drinking and washing with full participation of the community.

Key words: Decision-tree, water supply, boreholes, stream, construction, production, maintenance, sustainability.

INTRODUCTION

Water is a source of life and fresh water resources are not unlimited, therefore communities need to use the scarce resources with care so that future generation will be able to benefit from good quality water (Kalulu and Hoko, 2010). Also, correct utilization of water means taking care of waste water in order to avoid pollution and alleviate the spread of dangerous diseases.

The (JMP) report from 2012, stated that provision of safe water supply in the rural areas is a means of defeating water borne disease and promotion of other health benefits and greatly reduce burden of water collection for women and children, especially during the dry season.

The provision of adequate supply of safe drinking water, sanitation and hygiene education is stimulating a reduction in the incidence of diseases in developing nations even without medical intervention. UNICEF and WHO (2012) report on progress on drinking water and sanitation emphasizes that the provision of water and sanitation is greatly influencing a reduction in the transmission of many diseases and also enhances efficiency of other non-healthy living condition.

In some cases women have more time to do other rewarding activities more often (WHO, 2011) in places where water supply and sanitation coverage are in most of African countries, resulting to an extra burden placed on women to provide the facilities and service. It then becomes difficult for women to engage in rewarding activities like trading, unskilled labour and child care will be affected.

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Bhagwan et al. (2009) observed that provision of portable water for communities is at the discretion of the government without involvement of the beneficiary communities, reason is more political than socio-economical and the anomaly is leading many communities to be without access to the essential commodity.

The access to water by rural dwellers focuses on their primary source of drinking water which was recently published in Guardian Newspaper (2016), showing that about 85% of rural household rely directly on water from streams and local vendors. Observation reveals how poor rural dwellers rely on a diverse range of water source of differing quality and price for different uses, drinking, cooking and washing. Also, few of these dwellers have access to shallow boreholes and surface water for some of their needs (Mwanza, 2005).

Ndokosho et al. (2007) observes that, water is increasingly seen as one of the most critically stressed resources and yet, it plays a major role in poverty alleviation in developing countries. Moreover, Schwartz (2008) clearly explains that efficient allocation of water is a key international concern, and it demands the attention of policy makers, resource managers and government. An access to, and reliability of water sources have such large influence on promoting sustainable livelihood, and where environmental impact associated with inadequate resources management are significant as ever.

UNICEF and WHO (2011), report emphasizes on the need to consider water supply and sanitation as human right and they are basic priorities in making comparison between the two options of safe stream water supply and boreholes construction for Amaokpara community. Therefore, to achieve a proper good improved quality of life, there should be provision of education and training programme for the beneficiary community.

Sudhakar and Mamallia (2004), provided an overview that where alternate water is better quality, cheaper to develop, easier to obtain or less risk, it should be given priority. Along with checking the sequence of priorities, the planner must also consider the alternative source of water and must be compared with water harvesting in cost and risk involved (Cullivan et al., 1988). The comparison with "Decision Tree Analysis" must take into account the water quality required, operation and maintenance considered as well as the initial cost (Taha, 2011). A clear example is the two options, odor stream and water boreholes for domestic uses at Amaokpara. The water harvesting scheme will only be sustainable if it fits into the socio-economic context of the community and also fulfills a number technical criteria (UNICEF and WHO, 2012).

The establishment of Rural Water Supply and Sanitation Programme (RWSS) is one strategy to improve the living standard of rural communities, which are out of the mainstream of development. Rural water supply and sanitation programme creates and improves the prevailing socio-economic conditions through livelihood development in the rural communities (FMWR, 2010). The programme adopts a novel and innovative approach by placing the beneficiary communities in the centre of the process and provides opportunities for them in decision making at all stages of project implementation, such as planning, design and management of the facilities created.

The provision of water supply shall have a greater impact on health and wellbeing of Amaokpara community and the prevailing issues involved in poverty, as unavailability of basic services such as water supply which is the key indicator of poverty will be alleviated.

Amaopkara community uses her limited water supply for lucrative activities such as production of palm oil, etc., as well as domestic needs. The productive use of water by the community will really thrive when the required quantity of water is available and will often generate numerous benefits.

Moreover, the basic needs approach in provision of portable water in Amaokpara requires intervention of State Government and the provision of water by the State Government depends on the resource and economic policies of the government. In the sustainability of any government sponsored water project, there must be community participation and the new approach will surely facilitate sustainability of service in the water sector, (Kalulu and Hako, 2010).

It also aims at empowering the Amaokpara community to take responsibility of her own development with the aid of government. Meanwhile the support to be provided by government shall be limited to construction phase with the assistance to training planning, technical and managerial advice, monitoring and evaluation (Mwanza, 2005). The new proposal approach will satisfy the fundamental drinking water need of Amaokpara community with demand-driven approach (WEDC, 2004).

In the year 2000, about 191 United Nation members adopted the United Nation millennium declaration of eight international development goals for the year 2015 tagged “millennium Development Goals which Nigeria is a member. One of the eight targeted goals is sustainable access to safe drinking water and basic sanitation.

Consequently, this paper focuses on provision of sustainable potable water to Amaokpala community in Orumber North Local Government Area, of Anambra State using Decision Tree Analysis which involves two project options of “water boreholes and Odor stream harnessing.

The study is to achieve a sustainable potable water supply and maintenance of good sanitation as one of the key targets of millennium development goals by 2015 but has been shifted to 2025.

The state government deemed it very important to integrate in the rural development programme, water supply and sanitation to alleviate the problem of rural dweller. Amaokpala is one of the beneficiaries of the

Figure 1. Google map image of Amaokpara and environs.

programme, because water is an essential commodity that must be given to the people for the dividend of democracy.

The purpose of the study is to select the optimum decision criterion for the benefit of Amaokpala as a community using Decision Tree method of operation research. The criterion is based on economy, quality and quantity.

The decision theory is an analytical and systematic approach of comparing decision alternatives in terms of expected out comes, examples, water boreholes and stream harnessing. The decision theory provides a frame work and methodology for rational decision-making when the outcomes are uncertain.

Aim and objective

The aim of the paper is to identify the more promising and viable choice among the two options of safe stream water supply and water borehole construction.

The objective of the study is to assess the main factors influencing economic sustainability of water supply management in the rural areas, like Amaokpara and it is expected to:

(1) Provide safe water for the community
(2) Increase coverage of safe water supply to the entire community.
(3) Develop a sustainable service for provision of water supplies.
(4) Improve public health and sanitation
(5) Promote community participation
(6) Develop private sector to actively support water supply and sanitation
(7) Develop and strengthen institutional structure for sustainable effective village level operation and maintenance of water points.
(8) Facilitate the sustained application of decision tree technology options, in making choice between water boreholes and odor stream harnessing.
(9) Give the community a voice to make choice from options, and demand accountability from service providers.

Study area

Amaokpala town is one of the communities in Orumba North Local Government Area of Anambra State of Nigeria. It is geographically located between latitude 6° 3 - 6°2’ 30 of North and South equator and longitude of 7°6’00 -7° 5’25 East and West of Greenwich Meridian. The people are mostly farmers and the town is partly surrounded by Odor stream a non-perennial which is badly destroyed by commercial sand dredging activity. Amaokpala is found in Ameki formation which is predominantly argillaceous rock and shell. The climate is hot equitoria with average maximum and minimum at 31 and 19°C, respectively and has an average temperature of 25°C. Because of the conducive atmosphere, the herdsmen and their cattle found the town habitable, eventually contaminated the water at the upstream (Figures 1 and 2).

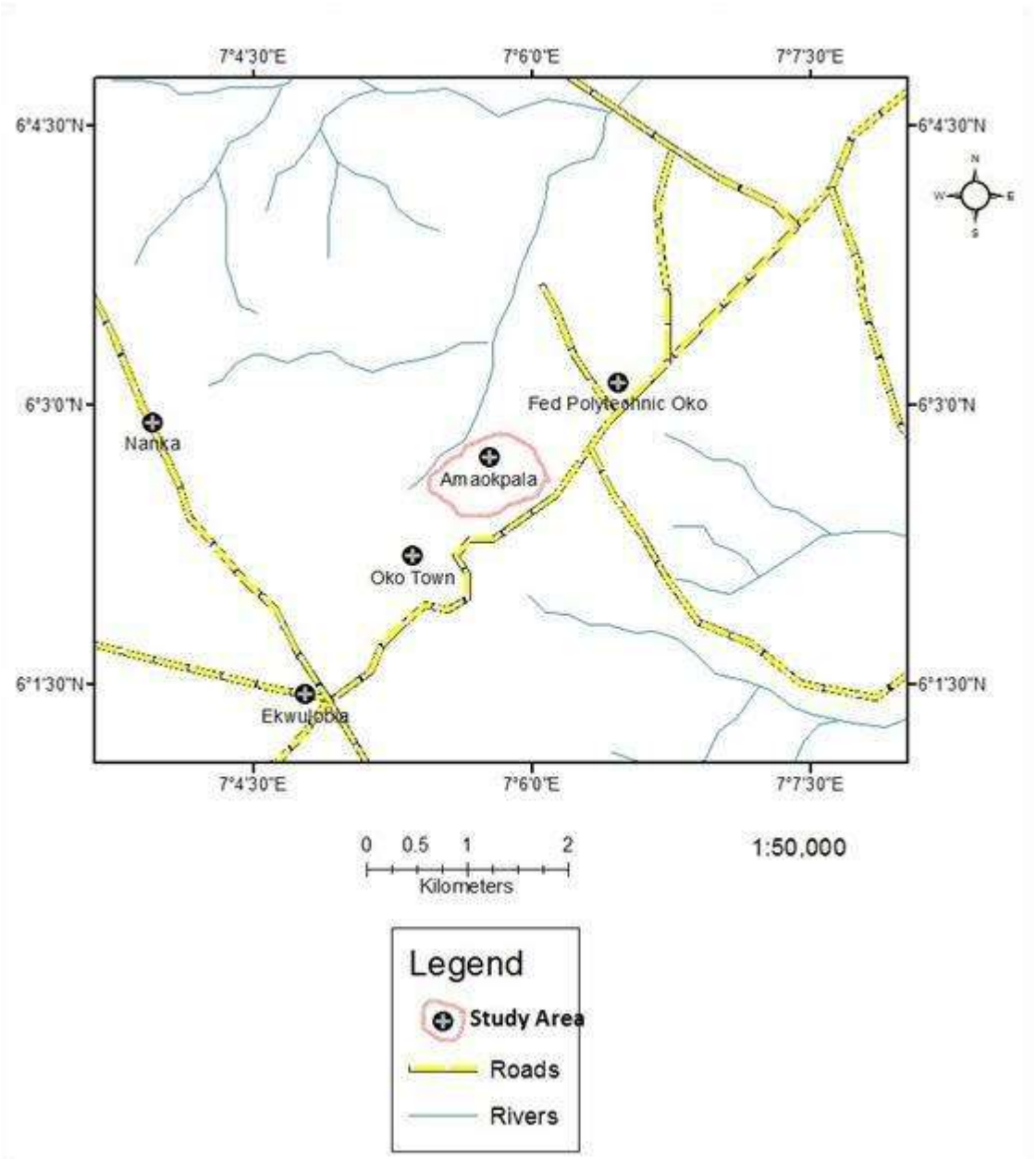

Figure 2. Amaokpara community and the surrounding rivers.

METHODOLOGY

WHO (2012) clearly defined that in order to carry out the assessment of two options, odor stream harnessing or water boreholes, for the implementation of the water scheme, Decision Tree Analysis is to be used to evaluate the cost-effectiveness, water quality and quantity. Sharma (2010) explains the reason; overall decision is based on construction, production and maintenance programme against prior probability and posterior probability being expensive or non-expensive in Table 1 and Figure 3.

Stream water harnessing is building a dam across the stream to capture and store water which would otherwise drain away during period of heavy rainfall (JMP, 2012). The dam, a concrete barrier that stretches across the stream, allows water to pool behind it while excess spills over the top and continues downstream. Pipes installed in the pool behind the weir tap, the water and carry it underground to storage tanks. The idea is to tap the little water that flows through the stream course, but also prepare to harness bigger volume from the season flood (WEDC, 2004).

Meanwhile, boreholes construction is time taken to undertake the activities, affecting the basic drilling cost as follows:

(1) The basic drilling cost, as mobilization drilling installation and well development.
(2) Additional cost; includes value added tax, overhead and risk involvement.
(3) Siting and supervision cost bore by state government.

Table 1. Data for both options and condition of projects.

Project	Prior probability	Condition	Proposal	Posterior probability
			₦95M	0.3
	0.6	Expensive	₦70M	0.4
			₦30M	0.3
A				
			₦65M	0.3
	0.4	Non Expensive	₦35M	0.4
			₦15M	0.3
			₦75M	0.3
	0.6	Expensive	₦45M	0.4
			₦20M	0.3
B				
			₦35M	0.3
	0.4	Non Expensive	₦20M	0.4
			₦10M	0.3

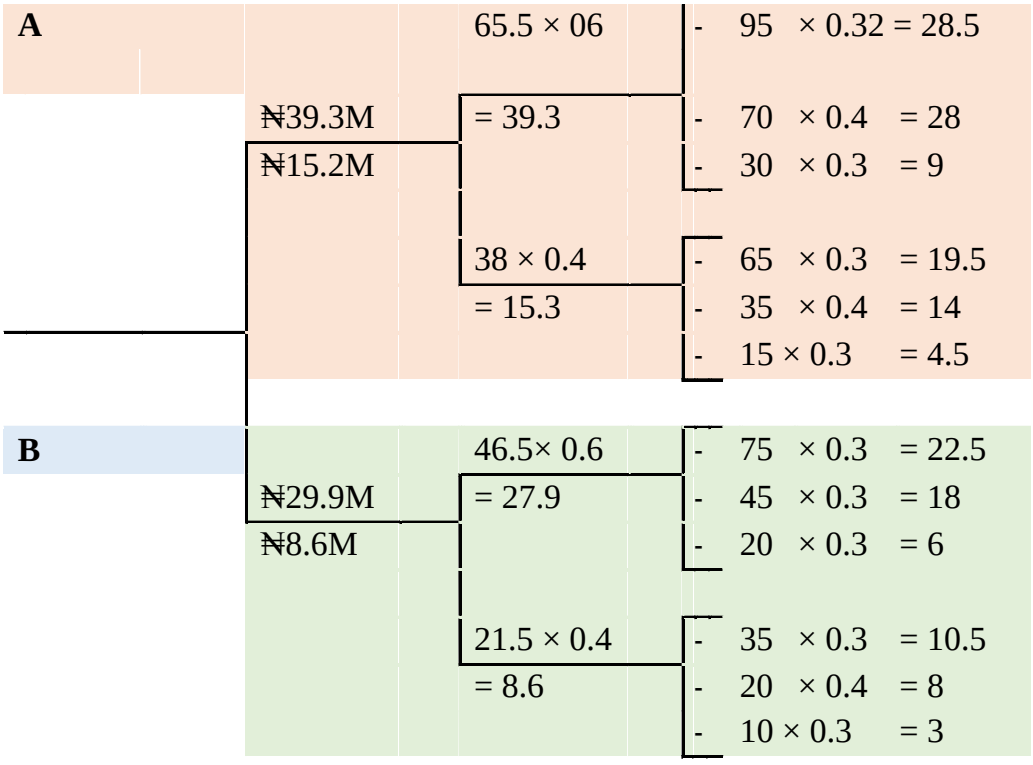

Figure 3. Decision tree for both options.

(4) Cost of social infrastructure, mobilizing and training community members.
(5) Construction quality and post construction failure increase actual borehole cost significantly.

In confirmation, ReVelle et al. (2004) justified the application of Bayesian decision tree theory in the paper. They used the example of a contractor who was faced with the decision of whether or not to bid on one of two construction project, dam and highway. The contractor was limited to choosing, at most, only man power and equipment available to time and the highest expected profit.

Most decision made on large civil engineering and environmental projects involve element of risk and uncertainty. Risk is defined as the situation where objective data exist upon which to estimate the

probability event. The probabilities would be based upon the result of experimental test and historical data.

The study has “Alternatives of “A” or “B” projects stream harnessing or water boreholes. Each alternative has finite number probability which may depend on the previous decision made and on what happened sequent to previous decision.

Each project has some “states of nature” under the condition the condition of being expensive on non-expensive (market price “inflation” Natural disaster “erosion” Borehole - failure “lost in circulation, weather condition, political development “Defection” “Youth restiveness” nature of the soil for foundation.

States of nature are not-determined by neither contractor (individual) nor consultant (decision maker).

Payoff is the numerical values (out comes) resulting from each possible combination of alternatives and states of nature. Pay off values are large conditional values because of its unknown states of nature.

With the states of nature which are conditional, inserting the probabilities depending upon expensive or non-expensive, this leads to winning or losing by some percentages.

Project Cost

A = stream water harnessing
B = water boreholes construction

A - Expensive

(i)	Cost of construction	= ₦95M
(ii)	Cost of Production	= ₦70M
(iii)	Cost maintenance	= ₦30M

A - Non Expensive

(i)	Cost of construction	= ₦65M
(ii)	Cost of production	= ₦35M
(iii)	Cost maintenance	= ₦15M

B - Expensive

(i)	Cost of construction	= ₦75M
(ii)	Cost of production	= ₦45M
(iii)	Cost maintenance	= ₦20M

B - Non Expensive

(i)	Cost of construction	= ₦35M
(ii)	Cost of production	= ₦20M
(iii)	Cost maintenance	= ₦10M

A – Expensive

$$\left.\begin{array}{l}(i)\ \ 95\times 0.3 = 28.5\\ (ii)\ \ 70\times 0.4 = 28\\ (iii)\ \ 30\times 0.3 = \dfrac{9}{65.5}\end{array}\right\} 65.5\times 0.6 = \mathrm{N}39.3M$$

A – Non Expensive

$$\left.\begin{array}{l}(i)\ \ 65\times 0.3 = 19.5\\ (ii)\ \ 35\times 0.4 = 14\\ (iii)\ \ 15\times 0.3 = \dfrac{4.5}{38}\end{array}\right\} 38\times 0.4 = \mathrm{N}15.3M$$

B – Expensive

$$\left.\begin{array}{l}(i)\ \ 75\times 0.3 = 22.5\\ (ii)\ \ 45\times 0.4 = 18\\ (iii)\ \ 20\times 0.3 = \dfrac{6}{46.5}\end{array}\right\} 46.5\times 0.6 = \mathrm{N}27.9M$$

B – Non Expensive

$$\left.\begin{array}{l}(i)\ \ 35\times 0.3 = 10.5\\ (ii)\ \ 20\times 0.4 = 8\\ (iii)\ \ 10\times 0.3 = \dfrac{3}{21.5}\end{array}\right\} 21.5\times 0.4 = \mathrm{N}8.6M$$

RESULTS AND DISCUSSION

Surely before selecting a specific technology between stream harnessing and water boreholes, due consideration must be given to the social and cultural aspects of Amaokpara as it is paramount and will affect the success or failure of the technique to be implemented. Most of the rural water projects fail because the community’s priorities are not normally taken into cognisance. Therefore, decision theory analysis as system engineering, mathematical model assisted in the choice making between the two aforementioned options. The prescriptive model gave the best strategy in choice making, considering cost effectiveness of the projects.

In the course of selection, due consideration must be taken, regarding the following issue, that may arise in the community involved.

(1) Social and cultural
(2) Politics of winners take all
(3) Soil texture
(4) Prices of materials.

All these are paramount and affect the success or failure of the technique being implemented. The success or failure of the study also depends on giving priorities to community’s views and needs. Moreover, the technique of Decision Tree Analysis is totally a programme based on:

(1) Construction
(2) Production
(3) Maintenance

All against prior-probability and posterior-probability being expensive and non-expensive to arrive at optimum decision.

The prior-probability is the probability made before any experimentation taking place while the posterior-probability is the probability estimated or calculated after having seen an experimental result.

Through the institution in control of bidding in the state, the prior probability is prominently considered. The probability of not being selected will be 60% or 0.6 in expensive condition and 40% or 0.4 to non-expensive for project A (Harnessing Odor stream).

Similarly, the probability not being selected will be 60% or 0.6 in expensive condition and 40% or 0.4 for non-expensive, for project B (water boreholes). Obviously, one of the projects will be identified as the best alternative through optimum decision with regard to cost-effectiveness of boreholes construction.

Consequently, the decision-making process of safe water supply project compares two different options namely water boreholes and stream supply using Decision Tree Analysis, based on construction, production and maintenance programme against prior

probability and posterior probability being expensive or non-expensive could solve the problem of water scarcity in the community.

Based on the result formed by cost-effectiveness of Decision Tree, the analysis shows that the economic sustainability of water schemes management is reviewed through a comparison of the two schemes, through cost construction, production and maintenance.

Taha (2011) research proves to be effective in the methodology adopted and relevant for the findings achieved which highlights issues seriously affecting the sustainability of water schemes and their functionality, so ultimately affecting people ability to access water service. Therefore, emerging response to need for rapid and effective provision of safe and water supply in Amaokpara community is informed by the decision makers and the prioritization of intervention need to be made within limited time and resource available.

Conclusion

The study provides strength for the proposed index prescription of an "Answer to water Scarcity" to Amaokpara community (UNICEF and WHO, 2011). Moreso, shows economic sustainability of water scheme management which is reviewed through a comparison of the two proposal, with cost of construction, production and maintenance.

Consequently, in the past the community suffered some setbacks because of inappropriate technology of choice, supply-driven approach to project design and failure to involve Amaokpara community in decision making processes at project preparation stage, retard her growth in water supply coverage.

In comparing and contrasting of the two options regarding the cost-effectiveness, water boreholes scheme is more sustainable than odor stream harnessing in Amaokpara community, mainly boreholes management is more economical and easier to maintain than that of odor stream harnessing.

Investigation shows that odor stream harnessing is non-perennial and faces seasonal changes in quantity and quality and could result in water pollution which is considered as a side effect of economic growth of the community development and environmental pollution problems.

Finally, based on the result found by cost-effectiveness of "Decision Tree Analysis" (Taha, 2011; Sharma, 2010), odor stream harnessing (₦39.3M/ ₦15.2) and water boreholes (₦27.9M/ ₦8.6) both in expensive and non-expensive criteria, water boreholes is more economically sustainable than odor stream harnessing. Therefore, the water boreholes are preferred to odor stream harnessing.

RECOMMENDATIONS

Water as a key resource for sustainable development and its economic-good value hence requires proper management (WEDC, 2004). However, efficient management of water remains a challenge in the developing nations leading to unsustainability of institutions that are mandated to provide water services.

Therefore, in recommendations, the planner project must prepare and introduce materials as well as supply innovative and important methods aimed at sustainability in all phases and activity, policies and guidelines, organisational structure consisting a stake holder project cycle including targets, training and outcomes, available technical options, terms of reference for community base organisation (CBO), awareness and technical options for water supply and maintenance system for pipe borne-water supply.

Consequently, there must be provision for safe water and liable water supply and sanitation facilities for the entire community, confirmed by WHO (2011) in evaluating household water treatment option. Moreover, it is an important goal to make a particular strong commitment to improve water and sanitation in the plan for accelerating and sustainable development to poverty alleviation which targets an increase in access to sufficient water of acceptable quality to satisfy basic human needs (Dach, 2007).

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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