Economic efficiency of the water monitoring system in Nigeria

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Abstract. Currently, many areas in Nigeria face strong water stress, and to reduce the pressure exerted on water, making water a reusable ecosystem service is essential. Economic efficiency of a water monitoring system can involve having a program to influence and manage water resources and the environment based on the utilization of modern information technologies and techniques. This article aims at demonstrating the importance of Economic efficiency of a water monitoring system, cases and deaths from water-related diseases by decade. A significant factor of managing water safety is understanding water availability, demand, utilization, how it acts in response to change, climate and pressures. Comprehensive understanding of a water system correctly and deeply depends on professionalism, monitoring, documentation and reporting of water system parameters. Human health risk assessment model was applied to estimate cases and deaths from water-related diseases.

1 Introduction

Natural systems including human economic and social activities are influenced by water in the perspective of a river basin. Water systems are designed by physical basins, climate systems, human use, and environmental changes [1]. Economic efficiency takes place when the cost of producing a given output is as low as possible [2]. Economic efficiency of monitoring system allows for a proactive response, data security, information gathering and the overall good health of people. It prevents unpleasant incidents and when these incidents occur, they are identified faster, which saves lives, time and money. Ecologists, Environmentalists and Economists supporting values on Eco-system service such as water have a different opinion to whether price and fares should be introduced for water protection and who is to pay for the cost of the protection. These various opinions are a result of consideration of the triple bottom line, which differs from traditional reporting frameworks and includes ecological, economic and social aspects that are often difficult to measure.

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2 Methods

The U.S. Environmental Protection Agency (EPA) health risk assessment methodology was followed for this study. This method focuses on assessing the risk of certain behaviours and exposures of a specific population by categorizing uncertainties, monitoring exposure to a specific infection, and evaluating the characteristics of infection. The evaluation consists of three steps: hazard identification, exposure assessment, and risk characterization, in this case, all based on pre-existing literature. We then carried out the calculation on Death-to-Case Ratios for a target population, estimating years of potential life lost and the number, percentage, and ranking of deaths from water-related causes of death.

2.1 Data Collection

Most of the data used in the assessment were collected by document review. Data related to water infection identification and documents from authorities such as the World Health Organization.

2.2 Data Analysis

Two main data analysis methods were used in this study: risk characterization and risk comparison. Risk comparison refers to the evaluation of the risk of exposure to each identified infection as well as collectively estimating and comparing the health risk. Risk characterization refers to the analysis and summarizing of data collected in each step of the risk assessment.

3. Results

3.1 Hazard Identification

In this step, toxicokinetic and toxicodynamic data were collected for water-related infections identified.

3.1.1 Toxicokinetics

Most of the identified infections are typically absorbed during water metabolism from the digestive tract. All identified infections can travel to different parts of the body once absorbed. There isn’t limited information about how the infection is distributed in the human body. Some water infections are life-threatening while some do not pose a significant health-threatening risk. Most infection usually accumulates instead of going through any specific metabolic processes in the human body. Most identified infections can’t be excreted by the renal system.

3.1.2 Toxicodynamics

All identified water infections may contribute to different types of adverse excretory outcomes. Diarrhoea has been identified as having a significant impact on the digestive and excretory system.

3.2 Exposure Assessment

In this study, the number of deaths from estimated water-related causes of death, all ages in Nigeria, 2017 was 226,484. The data considered in the assessment are based on studies that were reviewed by the World Health Organization.

Based on studies, out of the infections identified cholera, typhoid and dysentery were found to have more than 87% of deaths from estimated water-related causes of death. The infection levels observed were considered to pose a significant risk to populations within the ages of 5 to 14 and 25 to 34. On the other hand, the government's incompetency makes the infection rate more complicated as little or nothing is done to provide clean water to communities deprived of access to clean water.

3.3 Risk Characterization

Based on all findings above, all infection identified calls for concerns. The infection levels are higher than the yearly projections of deaths from water-related death. Water-related infection is linked to major types of adverse health concerns such as cancer, digestive diseases and excretory diseases. Assuming a daily consumption of contaminated water, all identified chemicals' maximum exposure levels (arsenic, asbestos, radon, agricultural chemicals, and hazardous waste) would exceed the guideline levels.

4 Economic Value and limitations in Water Protection Nigeria

4.1 Current state and scenarios

In general, the economic value of water ranges from socio-economic value to environmental value such as providing habitable space for biodiversity. Limitations regarding a fully developed water monitoring system include government intervention, price instability, and steady changes in the climate. In many regions, the price of water varies from year to year due to the cost of production, which is mainly based on the price of fuel. Water degradation has cost effects in Nigeria and on Nigerians, this goes a long way affecting the gross national product (GNP). In general, the degradation of water and water services contributes to a reduction in GNP, regional crisis and increases the infant mortality rate. Priority factors estimated in the evaluation of water as ecosystem service includes health risk, environmental water risk and economic impact assessment (Table 1).

Table 1. Estimated number of cases and deaths from water-related diseases by decade — Nigeria, 1940–2019.

Decade	Number of new cases	Number of deaths	Death-to-case ratio (× 100)
1940-1949	1,956,000	1,034,659	52.90
1950-1959	2,120,001	1,182,794	55.79
1960-1969	3,509,535	1,942,134	55.34
1970-1979	2,744,213	1,320,600	48.12
1980-1989	2,265,120	1,131,999	49.98
1990-1999	2,031,117	985,910	48.54
2000-2009	1,919,742	910,711	47.43
2010-2019	1,801,924	800,875	44.45

In Nigeria in 2018, a total estimate of 598,543 deaths occurred. The estimated population was 196,752,840 [8]. The crude mortality rate in 2018 was, therefore, (598,543÷196,752,840) × 100,000 with a total of 304.21 deaths per 100,000 population.

In 2018 a total estimate of 198,329 deaths was attributed to water-related diseases, yielding a cause-specific mortality rate of 100.80 per 100,000 population. In addition, an estimated total of 130,000 deaths happened among persons aged 4–7 years, and the age-specific mortality rate was 419.35 per 100,000 4–7-year old (Table 2).

Table 2. Estimated deaths attributed to cholera or typhoid by age Group in Nigeria, 2017.

Age group (years)	**Population (× 1,000)**	**Number of cholera deaths**	**Number of typhoid deaths**
0-4	11,861	1510	1821
5-14	31,523	1001	2353
15-24	29,251	723	1332
25-34	33,203	822	1221
35-44	30,117	731	1012
45-54	15,248	812	942
55-64	20,022	903	750
65+	20,611	810	782
Total	191,836	7312	10213

Table 3. Estimated deaths and years of potential life lost attributed to typhoid by age group in Nigeria, 2017.

Age group (years)	Deaths	Age midpoint	Years to 65	YPLL
0-4	1821	2.5	62.5	113,813
5-14	2353	10	55	129,415
15-24	1332	20	45	59,940
25-34	1221	30	35	42,735
35-44	1012	40	25	25,300
45-54	942	50	15	14,130
55-64	750	60	5	3,750
65+	782	-------	--------	--------
Total	10213			389,083

The calculation of years of potential life lost (YPLL) and YPLL rates.

The data in Tables 2 and 3 were used to calculate the Typhoid-related mortality rate for all ages, the mortality rate for persons under age 65 years, YPLL, and YPLL rate.

1. ***Typhoid related mortality rate, all ages*** = (10213÷191,836,000) × 100,000 = 5.3 typhoid deaths per 100,000 population
2. ***Typhoid related mortality rate for persons under age 65 years***

$$\left[\frac{1821+2353+1332+1221+1012+942}{(11861+31523+29251+33203+30117+15248+20022)} \times 10^5\right]$$

$$= \left[\frac{8681}{171225}\right] \times 10^5$$

= 5,069.9 Typhoid deaths per 100,000 persons under age 65 years. (1)

3. Typhoid related YPLL

a) Calculating the midpoint of each age interval. The midpoint of the age group 0–4 years is (0 + 4 + 1) ÷2, or 5 ÷2, or 2.5 years. The same is repeated for all age groups.

b) Subtracting the midpoint from the endpoint will determine the years of potential life lost for a particular age group. For the age group 0–4 years, each death represents 65–2.5= 62.5 years of potential life lost. The same is repeated for all age groups.

c) To calculate age-specific years of potential life lost, the number of deaths in a given age group is multiplied by its years of potential life lost. For the age group 0–4 years: 1821 deaths x 62.5 =113,813

d) The total years of potential life lost attributed to typhoid in Nigeria in 2017 were 389,083.

4. Typhoid related years of potential life lost rate:

= years of potential life lost at age 65 rate in Nigeria;

= years of potential life lost divided by population to age 65.

$$= \left[\frac{389083}{171225} \right] \times 10^3$$

$$= 2{,}272.3 \text{ YPLL per 1,000 population under age 65} \qquad (2)$$

Annual freshwater withdrawals in Nigeria total 12.470 m³ bn in Dec 2010. This records an increase from the previous number of 11.570 m³ bn for Dec 2005. Nigeria's annual freshwater withdrawals data is updated yearly, averaging 10.940 m³ bn from Dec 1987 to 2010, with 4 observations (Fig.1, 2)

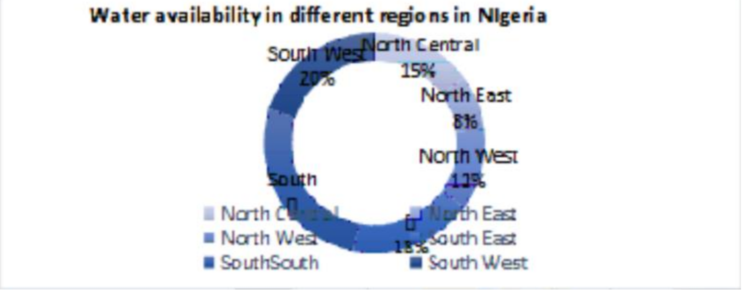

Fig. 1. Water availability in different regions in Nigeria.

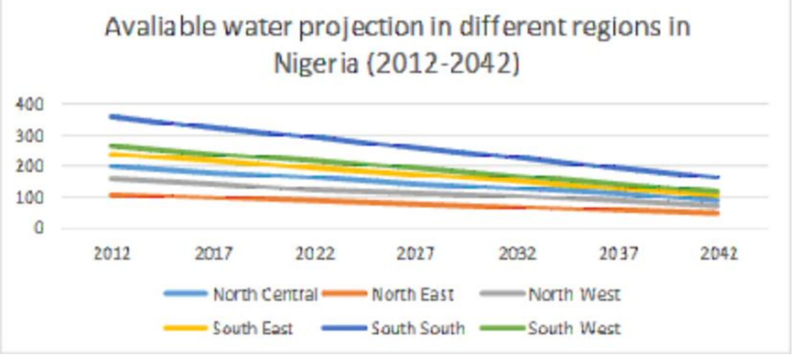

Fig. 2. Available water projection in different regions in Nigeria (2012-2042).

Several regions in Nigeria are facing a severe water crisis. Data reveals that the crisis is getting worse by the day. The per capita water availability in the country has fallen by 73% in 55 years from 1962 to 2017 (Fig.3)

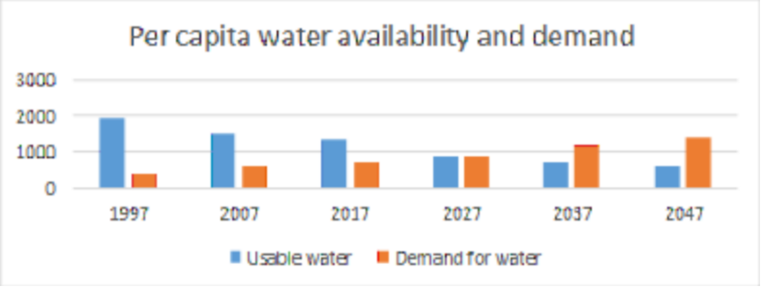

Fig. 3. Per capita water availability and demand.

The demand for water for various uses in Nigeria is estimated to be about 700 BCM, 1200 BCM, and 1400 BCM by the year 2017, 2037 and 2047 correspondingly. According to an ongoing temperature analysis conducted by scientists at NASA's Goddard Institute for Space Studies (GISS), the average global temperature on Earth has increased by about 0.8° Celsius (1.4° Fahrenheit) since 1880. Two-thirds of the warming has occurred since 1975, at a rate of roughly 0.15-0.20°C per decade [3].

4.2 Economic Limitations in Water Protection Nigeria

Limitations regarding a fully developed water monitoring system include government intervention, price instability, and steady changes in the climate. In general, the fundamentals of water supply are based on expectations, and if the outcome of the expectations is wrong, the excessive supply or scarcity cannot be revised. In many regions, the price of water varies from year to year due to the cost of production, which is mainly based on the price of fuel. Providing prices cover operating costs and cost of water distribution, it benefits water supply companies to carry on with production and supply if prices for water drop to a very low level.

The instability of portable water prices is accompanied by the instability of public income. Most times local and state government workers are not paid for several months making it impossible for them to buy clean water. Systems and infrastructures constructed to support and improve availability and predictability of water demand and supply help decrease vulnerability of water in times of droughts and shortages. Most rural communities incline in improvement and development of water infrastructure as alternatives for the sustenance of economic, social and environmental activities.

Within the perspective of climate change, the frequent occurrences of floods and droughts are increasingly changing, causing insecurity in realization and application of more modern water resources infrastructure. Some results of a changing climate are expected to include more frequent spring flooding, shifts in the growing season, and changes in the hydrological cycle. These changes in climate conditions influence social, ecological, economic and physical structures in a way that makes a more active approach to be needed for water management to ensure that demands for water in different regions in Nigeria are reached.

5 Conclusion

Economic efficiency of water monitoring system is greatly influenced by the water management system. Despairingly, the Nigerian government fails to live up to its policies and promises. Civil servants, poor people and forgotten rural communities majorly don't have access to good quality water. Professionals, policymakers, stakeholders and planners need to create a platform for decisions about activities concerning water usage and distribution, waste disposal, use of fertilizers, pesticides and insecticides in the farm as well as to decide on the allocation of ecosystem service such as water resources to different regions. Decisions and balance on water usage have to be made considering the three-bottom line that is social, environmental and economic to recognize and categorize tolerable tradeoffs.

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