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THE NEXUS OF WATER, ENVIRONMENT AND WATER RESOURCE MANAGEMENT DILEMMA IN THE KANO: IN SEARCH OF A NEW GAME THEORY APPROACH

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ABSTRACT
The demands for water is astronomically increasing due to population growth and diminishing opportunities to economically develop water supplies in Kano. In spite of the various plans to supply adequate potable water to the Kano Region, yet water is increasingly becoming difficult to get. The rapid increase in population coupled with uncertain climate may perhaps be the cause of the setbacks. The use of water, both surface and ground which is not easily renewable has adverse effect on the environment. The water crises in Kano is intensifying with no solution in sight. The critical options must actually resort to either due to scarce water resources, failure of governments to inadequate plan for safe water delivery system. Kano in terms of water resource crises is in like the *prisoner's dilemma* as water, a common good for all, is no longer obtainable on sustainable basis. This paper attempt to look at the scenario as a dilemma for all nexus (environment, water, people and sustainability) of which a new approach needs to be encapsulated in solving the problem. Such approach is the Game theory.

Key*words:* Game Theory, Water Resource, Water Management, Water Crisis, Governance

INTRODUCTION

Many decisions made on water policy in Kano are centered on demand and supply for raw water for human use rather than for the environmental sustainability issues. This may be the reason for 'gaps and overlaps (Hadejia, 2015) in decision of governing the affairs of water in the region. Decision making under competing demand is crucial and requires careful study that affect the outcome of a situation for all other than individual involvement. No other resource have competing users like water. And subsequently, its abstraction is so much related to environment. In the past, it was my view and still is my view that,

> 'To address the issues of sustainable water resource development, proven and sound management strategies must be developed. And must integrate the environment with a sound management systems that checks and guards environmental degradation through good policy that guarantees supply of water (Abdulhamid, A. in Tanko and Momale 2014)'.

On that take, I proposed the three tier management strategies, which start with local level to state and regional (**figure 1)**. The whole process is certainly lost in the crises of water that does not consider any form of ordering in the state in particular and in the region at large. This requires a new approach to handling water and water development issues.

Geography has gone deep into policy formulation theories. Harvey (2016) warned that no subject is so much important than geography. He opined that 'Geography is too important to be left to geographer alone' and at the same time, it is far too important to be left to generals, politicians, and cooperate chiefs. In this regard, policy issues are central to geography, not only to the economists and other social scientists. Game theory contains theories and models that can solve geographical problems such as: Prisoner's Dilemma, Zero Game Theory Matrix, Bayesian Equilibrium, Investment Game, Battle of the Sexes to name but a few.

Study Area

The area is the urban Kano stretching some 25 – 30 kilometers wide across. The settlements roll across the vast terrain of 420 – 500 meters above sea levels. The area is under the influence of Hadejia-Jama'are basin. This area has been described as having characterized with concentration of high population supported by high agricultural production (Olofin, 1987). The population is projected at 4,175,389 in 2018.The main rivers in the area which mainly supply water from rainfall are river Gari, river Tomas, river Jakara, river Chalawa-Kano-Hadejia, river Gaya and river Katagum. All these rivers developed within the region, except for the Katagum system which developed in Bauchi state. Since 1973 serious efforts were made to supply portable water to the citizenry of this region. The major development on the main Hadejia-basin was the construction of 22 earth dams, 13 regional water schemes and several borehole based water schemes. It was noted however that the first water treatment plant was constructed in between 1928-1932 with a full capacity of 20 million liters per day (Kano State, 2005).

Presently, Greater Kano is served with water from five main sources: Joda, Watari, Panshekara, Tamburawa and Wudil water works. Some of these water schemes partially reach core parts of Kano. Pipe-borne are intercepted by other water users for irrigation, fisheries and sometimes by competing domestic users and commercial vendors. Pipe-borne water are therefore intercepted from all directions into the city, to such an extent that little amount or none reach users in the core parts of the city.

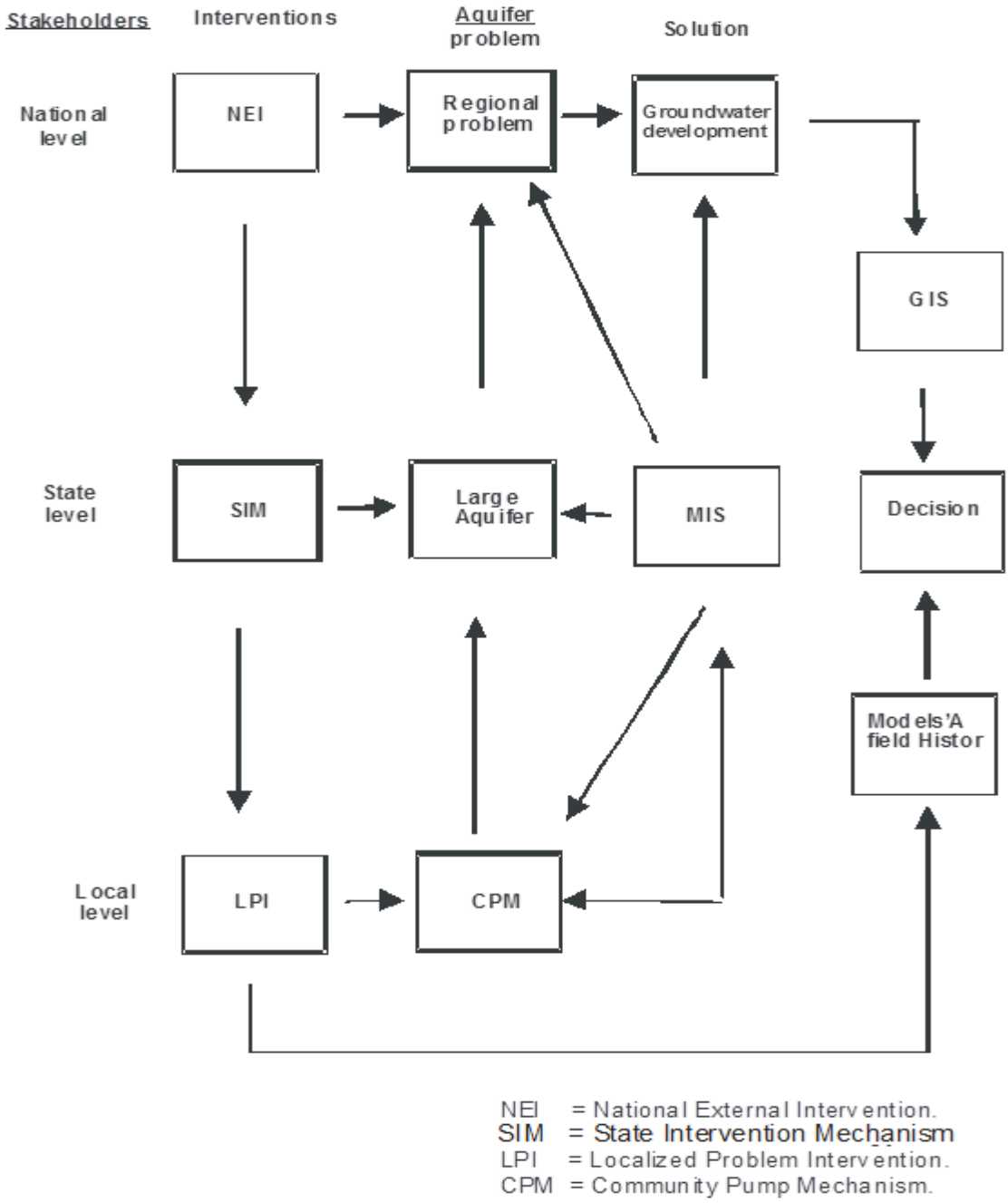

Fig. 1: Three Tier Management Strategies for Regional, State and Local Levels

Drainage Systems

The Hadejia river system constitutes the main drainage which contributes about 80% of the historic flow of the river system. The mean annual flow at Wudil was calculated at 1.890 m^3 x 10^6 (WRECA, 1986, Schultz, 1976) which comes from three

main tributaries: Kano River, Chalawa River and Wateri River. The remaining 20% of the River discharge come through Jakaradi and Jakara River system which disappear in to sand in the chad formation as disappearing streams forming groundwater potentials of the Jigawa state.

Water Management and Governance

Water management and governance is the precondition for achieving UN-SGDs goal number 6 of the 17 goals to be achieved by 2030 (i.e. Clean Water and Sanitation). Water management option was for long been advocated for the area (IUCN, 1999). This viewed water as an integral part of the environment. Water governance refers to rules and practices for decision making about water sourcing and management. It consists of a range of political, institutional and administrative processes through which stakeholders express their interests, and their concerns are considered whereby decisions are made and implemented (Hadejia, 2015). And decision makers are held accountable for the development and management of water resources and delivery of water services (Aziza, 2009). It was discovered that today water crisis is not independent of governance crises. Therefore, viable solution to the crisis is very crucial for its development.

Water Demand and Supply

Water supply and demand scenario is such that community has to sort for water in their own ways. The current supply of water in Kano does not exceed 1.58×10^5 cubic meters, as against the demand of 8.40×10^5 cubic meters (Kano Water Board, 2018). Supply is fivefold lower than the demand. Because of that groundwater production is geometrically increasing with population increase to such an extent that private sourcing of water grew to 54% with 46% public supply. Still more water is need to the public. The production of private supply is mainly from boreholes and shallow wells while the public supply mainly by government is from surface water. It is estimated by World Bank that the basement complex of Nigeria depend on precipitation to recharge rivers and aquifers, and with more and more growing population. Kano in particular is facing excessive decline in water resources per capita. In the last 50 years there was decline of 3687 LPCD, this will account to over 60% reduction per capita which is a serious problem and also "the poor pays more than the rich" (UNDP, 2017).

It is pertinent to note that pipe-boned water is more palatable than groundwater, palatability may not necessary indicate quality, hence groundwater is much safer and free from bacteria. But consumers prefer to buy water from vendors for drinking than to drink borehole water. It was identified that 20% of the users prefer sachet water as against other type of water. Although, usage of sachet water depends on the affordability of individuals which is regarded as pure. Sachet water has its consequence in terms of littering the environment. The city is highly littered with polythene materials generated from sachet water, and polythene is non-biodegradable material. Because of the preference of pure water (sachet) over other table water by consumers, pure water processing factory is on the increase at every corner of the urban area, which compound the decision of government on the control of waste in the city.

The more deepening problems of Water Crisis and Environmental Degradation in Kano

The number of boreholes in urban Kano grew astronomically. The survey in 1997 revealed a total number of 83 in Tudun Wada – Bachirawa exist across nine quarters only (Sulaiman and Abdulhamid, 1997). Yakudima (2009) counted 406 boreholes in Dala Local Government area (LGA) alone, of which estimates showed a total of 2, 743 in the whole 8 LGAs of metropolitan Kano. This number commensurate with the rising population to 4,048 boreholes in 2018 (table 1). In recent year's serious decline of surface and subsurface waterhas been identified from long trend-surface analysis in Kano state generally (Kano NEWMAP, 2018). Groundwater conditions in the area is becoming worst due to geological formation and high rates of abstractions. The impediments caused by the hydro-geology made the region dual, in terms of harnessing water resource. Development of surface water was made on basement complex, through the construction of dams, while Chad Formation with sedimentary geology, its water was only harnessed from the aquifer, through boreholes and wells. Currently demands for groundwater usage have been increasing due to population growth and rural-urban gradient which complicated the problem as well as diminishing opportunities to economically develop surface water supplies (Abdulhamd and Barau, 2016).

Table 1: Projected Population with Estimated Boreholes in the Eight Local Government Areas of Urban Kano

SN	LGA	1991 Population	ICGR for LGA*	Population as of May, 1997	Population as of March, 2006**	Population as of May 2018	Estimated Number of Boreholes 2006***	Estimated Number of Boreholes 2018
a)	Dala	316,137	1.96	352152.39	418,777	618,113	406	599
b)	Fagge	156,342	1.68	171449.78	198,828	293,469	193	285
c)	Gwale	177,437	4.98	233290.11	362,059	534,398	351	518
d)	Kano Mun	270,764	2.09	303808.50	365,525	539,514	354	523
e)	Kumbotso	166,558	4.01	207672.54	295,979	436,864	287	424
f)	Nassarawa	355,729	3.61	433819.07	596,669	880,681	578	854
g)	Tarauni	135,846	3.41	163840.48	221,367	326,737	215	317
h)	Ungogo	168,373	5.49	227679.34	369,657	545,612	358	529
Total for Kano Metropolis		**1,747,186**		**2,093,712**	**2,828,861**	**4,175,389**	**2,743**	**4,048**

NB:

Sources: NPC (1991, 2006)

Projection formula (exponential growth model): Pt+n = Pter.n

*ICGR = Inter-Census Growth Rate

** Both the 1991 and 2006 populations are actual census results, while the rest are projected values

*** The 2006 value for Dala is from a survey, while the rest are estimated

Theoretical Premise

The Nexus between Water, Environment and Water Resource Management Dilemma is becoming a puzzle of rational choice on which planners have to sacrifice environment for water or water for environment. The problem in Kano resembles that of Prisoner's Dilemma discussed in the literature on rational action (table 2). In an argument from analogy one agues from known similarities to further similarities (Perry, et al, 2007).

Table 2: The analogy of Prisoner's dilemma with water crisis and environment

Prisoner's Dilemma	Water crisis dilemma
Two men suspected of committing a crime together are arrested and placed in separate cells. They are not permitted to communicate with one another. Each of them is told the following:	The decision of getting raw water for domestic, industrial and agricultural uses has resulted into decision crisis for sacrificing environment for water or safeguarding the environment in the following dimensions:
• You may either confess to the crime or refuse to confess. • If one of you confesses but the other does not, then, the one who confesses will go free and the other one will go to jail for *four* years. • If both of you confess, then, you will both go to jail for *three* years. • If neither of you confesses, then, you will both go to jail for *one* year. • The other of you is being told these same things.	• Surface water quantity demand overstretched the environmental supply. • Groundwater quantity demand had reached the environmental threshold. • Water demand does not match with supply. • Water resource cannot be sourced from elsewhere.

Prisoner's Dilemma

Recall that prisoner's dilemma scenario which can be depicted in figure **2** (shaded) that:*If both of you confess, then, you will both go to jail for* **three** *years* **as the best choice**. The dilemma in water demand and supply is enormous and produced worst case scenario (figure 3, shaded). Biswas (1991) had already identified four contentious tight spots that are directly linked to the global water general trend. He outlined them as follows:

i. The amount of fresh water available to any country on a long term basis is limited;
ii. The world population is increasing steadily while water requirements increases without one-to-one relationship between water and population;
iii. Human activities increase, while more and more waste products are contaminating available sources of water; and
iv. The increasing delays that is likely to be witnessed, in the coming decades, to implement new water strategy.

Kano has worst case scenario when the global scene is downscaled to local level, where the dilemma is both for public and private decisions in getting raw water for daily uses as follows:

- Allow private operation of Groundwater (GW), more damage to the environment;
- Allow private enterprise on surface water (SW), expensive to access;
- Supply surface water (SW), more damage to the environment;
- Control private operation by government, no water to public;
- Supply more surface water by public, expensive for government to bear;
- Contaminated water must be recycled at whatever cost.

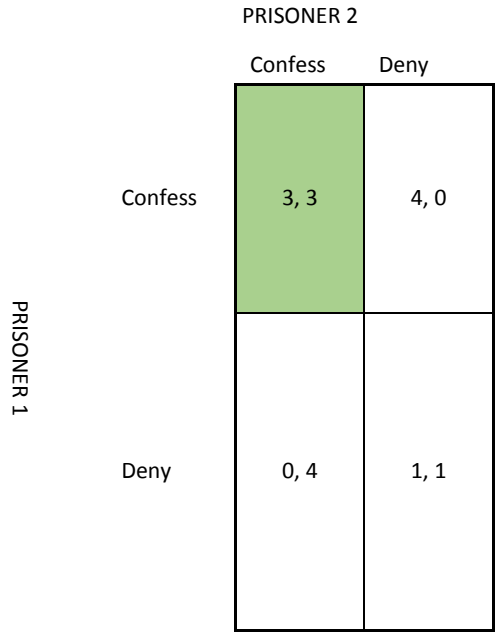

Figure 2: Prisoner's Dilemma and the Best Option Scenario

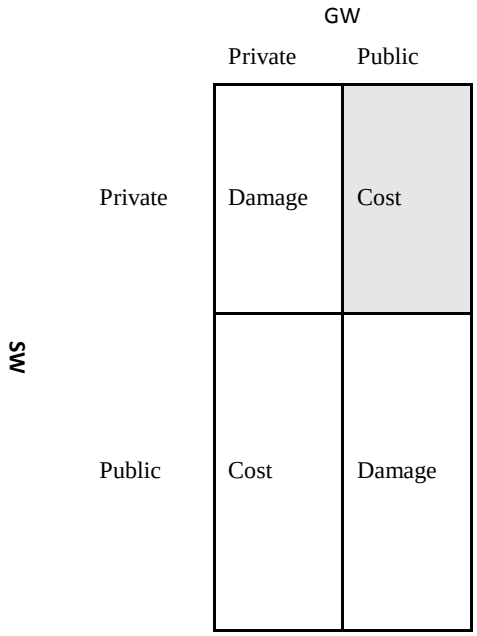

Figure 3: Worst scenario case of decision on water in Kano but best Responses

Although from the game, the players choose their strategies simultaneously, this does not imply that the parties necessarily act simultaneously. It suffices that each choose his or her action without knowledge of the other's choices, as would be the case for Kano, for instance, if the prisoners reached decisions at arbitrary times while in separate cell. In another scenario one can vividly see that in terms of supply of water to public either by government or by individuals.

Nash Equilibrium and Rational Decision

Nash equilibrium deals with problem by identifying certain subsets of outcomes, called solution concepts. It considers the game at individual agent point of view, rather than from the

advantage point view of the outside observer. If for example an agent (like private investor) knew how the government (public investor) were going to play, his strategic problem would become simple. Specifically, he would be left with single agent problem of choosing a utility-maximization action. Nash equilibrium is a stable strategy profile; no agent would want to change his strategy constitutes a unique best response to the other agent's strategies (Kockesen and Ok, 2007).

In view of the Nash Equilibrium the dilemma of water in Kano as a game has no dominant strategies in the sense that either government or private suppliers has stronger solution. The damage to the environment is much more negative than the cost of water to the general public. Cost should still be the best option than damage to the environment. The cost best be shared between public and private to alleviate the burden on the public alone. Here the Nash Equilibrium is based on cost rather than the environmental damage for both Surface water, Groundwater recycled, from public, private partners vested interest as the best choice as seen in figure 3 above.

CONCLUSION

Humankind cannot survive without water. Ironically, it is difficult to source without serious environmental import which is overstressed in Kano. While the population of Kano is rising, water demand is becoming extremely scarce with declining sources and increasing cost. This has set a crisis with different magnitude: crisis of demand and supply, managerial crisis and environmental sustainability crisis.

The situation has made decision making under competing demand very crucial, requiring careful study that affect the outcome of a situation for all other than individual involvement. In view of that, prisoner's dilemma attempted to create a scenario that be of rational decision making for the nexus between Water, Environment and Water Resource Management Dilemma which provides Nash Equilibrium for a quite rational solution.

REFERENCES

Abdulhamid, A (2014): Hydrology and Water Resource. Article in *Kano: Environment, Society and Development*, Edited by A.I. Tanko and S.B. Momale. Published by Adonis and Abbey publishers ltd, UK and Nig. Pp. 21-35.

Abdulhamid, A and Barau, S. A (2016): Water Crises in Urban-Rural Gradients of African Drylands: Insights into Opportunities and Constraints. In *Population Growth and Rapid Urbanization in the Developing World*. Edited by Benna, U.G. and Garba B. Published by IGI. Premier Reference Source. U.S.A.

Ahmed, A.S and Abdulhamid, A (1997): Water vendoring and water crisis in some Kano urban fringes. Paper presented at 40th annual national conference on land administration in Northern Nigeria, BUK.

Aziza, A.(2009): Governance of Water Policy: Issues for Discussion. Background paper presented at the Governance Regional conference 8-9 July, 2009. Tunis, Tunisia. Good gover+nance for development in Arab countries initiatives.

Biswas, A.K. (1991): Water for Sustainable Development in the 21st Century: A Global Perspective. Article in *Water International Journal*. Vol.16 No.4 Published by IWRA, USA.

Fudenberg, G. Trole, J. (1992): Game Theory. MIT Press, UK.

Gibbons, S. (1992): Game Theory for Applied Economists. Princeton University Press, UK.

Griffin C. (2012): Game Theory-Under a Creative Common Attribution. United States Licensed.

Hadejia, I. A. (2015): Functional Gaps and Overlaps in the Implementation of Integrated Water Resources Management in the Hadejia-Jama'are Komadugu Yobe Basin, Nigeria. (Unpublished) PhD thesis, BUK.

Harvey, D.(2016): The Ways of The World. Profile Book Limited. Great Britain. 3 Holford Yard. London

IUCN (1999): Water Management Option for the Hadejia-Jama'are-Yobe River Basin, Northern Nigeria. International Union of Conservation of Nature – Hadejia –Nguru Wetland Project.

Kano NEWMAP (2018): Monitoring & Evaluation of Baseline Survey in Nine Priority Gully control and water conservation Sites in Kano State, Kano Nigeria Erosion and Watershed Management Project, Part 2 (vol I).

Kano State, (2005): Tamburawa Water Works. A Publication of Research and Documentation Directorate. Edited by Ado-Kurawa, I.

Kano Water Board (2018): Greater Kano Water Production and Distribution; Abstracted Raw Waterand Treated Water Pumped months of January – June. Commercial Unit (unpublished).

Kockesen, L. and Ok E. A (2007): An Introduction to Game Theory. New York University Press.

Olofin E. A. (1987): Some Aspect of Physical Geography of Kano and Related Human Responses. Buk, Davis standard Press, Kano.

Perry, J. Michael B. and Fischer, J. M. (2007): Introduction to Philosophy: Classical and Contemporary Readings. Oxford University Press, Inc. U.K.

Schultz International Limited (1976): Hadejia River Basin Study. Volume E. *Water Resources*. Published by Can International Development Agency.

WRECA (1986): Groundwater Monitoring and Imbalance in Kano State. Water Resources Engineering and Construction Agency.

Yakudima, I. I. (2009): Spatial Distribution and implications of Groundwater Utilization in Dala Local Government Area. Paper in Techno Science Africana Journal, Kano University of Science and Technology, Wudil. vol. 3 no. 1, June, 2009.