**A TERM PAPER ON**

**MODELLING AND SIMULATION: ISSUES AND SPECIAL APPROACHES FOR HANDLING WATER SUPPLY IN ABIA STATE**

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SUBMITTED TO

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ABSTRACT

This paper offers an introductory overview of discrete simulation, with emphasis on the simulation modelling process rather than on any specific simulation package. Examples are used to demonstrate the application of the methodology at each step of the process. An extensive list of additional readings is given for the reader who wishes to deepen his/her knowledge in a specific area.

# INTRODUCTION

Water, as a social service is not only important for the proper functioning of the human system

but for overall economic development process. Pure water has no substitute being perhaps the

most versatile servant of man. Water has a very high status in the domestic and economic life

of both rural and urban dweller. It remains one of the key social amenities without which life

will be at a standstill in any environment, settlement or society (Tebbut, 1993).

In spite of its extreme importance, potable water supply in Nigeria is facing serious challenges.

Water supply in Abia State is problematic, particularly potable water. The general picture

about potable water supply in Abia State is one of either total absence or gross inadequacy of

the existing system. Successive governments have been pursuing with vigour aggressive water

supply programme. Despite these efforts in water related infrastructure, the public are still

disenchanted because access to potable water and the quality of services in this sector remains

poor.

The responsibility of providing potable water in Abia State rests solely on the shoulders of the

State Water Board. But all it has to show for this is an array of abandoned projects and obsolete

equipments that have become monuments, a situation which has resulted in one of either total

absence or gross inadequacy of potable water supply. This state of affair in which most existing

water supply projects are abandoned is very disturbing and unacceptable because water

security is not only for human consumption but provides a take-off ladder for the economic

development of any region.

It is an established fact that the demand for water is perfectly inelastic. Therefore, there is no

substitute for water. Water can be put into its best use when the water is of very good quality.

The development of adequate water supply is a function of availability of water sources;

method and efficiency of exploiting the source; and the effectiveness of the distribution system

(Chima, 1994). Hence, the availability of water sources without proper method of exploiting

them and subsequent distribution to the final consumers may result in potable water supply

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It is an established fact that the demand for water is perfectly inelastic. Therefore, there is no substitute for water. Water can be put into its best use when the water is of very good quality. The development of adequate water supply is a function of availability of water sources; method and efficiency of exploiting the source; and the effectiveness of the distribution system (Chima, 1998). Hence, the availability of water sources without proper method of exploiting them and subsequent distribution to the final consumers may result in potable water supply shortages in relation to demand.

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Population growth, increased food production, and industrial growth in conjunction with improved living standards lead to increased water demand, while climate change and environmental pollution affects the availability of water resources to meet this growing demand (Domene & Sauri, 2006) . Scarcity of traditional water sources, such as surface and groundwater, coupled with low water use efficiency are increasingly threatening the security of urban, agricultural, and environmental water needs. (Becker, 2013) explains the problem of ground water depletion and overdraft of river water, giving examples from different continents. Sustainable use of these water resources is increasingly important as their mismanagement leads to severe financial, environmental, and social issues. This context highlights the need for introducing alternative water sources and demand management, and importantly to consider the sustainability of all these water sources.

With the advancements in technology and increased need of alternative water supplies, a range of water sources such as desalinated water, reclaimed water, storm water, rainwater, and grey water have been introduced and are used in many parts of the world. Depending on the purpose, water is treated using an appropriate technology and supplied to meet different water needs such as drinking, other residential end-uses, farming, industry, commercial, institutional, and recreational. Sustainability of water sources in meeting these diverse water demands must be studied and understood in detail.

The term “sustainability” originated around 1980s as an approach to growing the economies without destroying the environment or sacrificing the well-being of future generations (Andrew & Weber, 2013) . Another definition for sustainability is a desire to create a society that is safe, stable, prosperous, and ecologically minded (Caradonna, 2014). Nearly all definitions for sustainability in recent years emphasise the notion that human society and economy are intimately connected to the natural environment (Caradonna, 2014). Following this concept, environmental, economic, and social sustainability have become integral parts of development projects where numerous evaluation criteria are used to assess them.

The path towards achieving sustainability differs between countries and jurisdiction. (Rygaard, et al., 2014) discuss how water infrastructure decisions have been influenced historically around the world. They use examples from the Middle East, India and Europe which have been influenced by needs such as agriculture and hygiene.

In Australia, the development and management of the urban water sector has undergone four phases: protecting public health, securing urban water supplies, microeconomic reform, and every drop counts (Byrnes, 2013) . These decisions can attract heavy criticism due to their political nature and lack of scientific evidence and evaluation. For instance, sustainability and choice and scale of water supply augmentation projects adopted during the Millennium Drought (e.g., Wonthaggi desalination plant, North-South pipeline) which had serious infrastructure and economic impacts on urban water supplies in Australia remain a question mark in terms of the sustainability performance. Approaches to assess sustainability, however, vary widely across the water sector which highlights the need to rely on an objective framework to evaluate water supply policy initiatives using criteria that includes: health and hygiene, supply reliability, sustainability of governing institutions, efficiency of supply, and environmental sustainability. Further, speedy decisions made during the Millennium Drought and their accelerated delivery time played a key role in leaving other important criteria overlooked (Anon., 2007). To date, the two major water supply augmentation projects in Victoria, Australia, implemented during drought are not in use due to the abundance of water and political reasons (Edwards, 2012). Had there been a comprehensive policy support framework with already available information to support those policy decisions, outcomes could be more sustainable and politically less vulnerable.

(Rygaard, et al., 2014) also highlights that the decisions on urban water infrastructure are often influenced by political aspects and physical constraints, although these decisions affect future inhabitants, economic and environmental systems, and other social aspects such as public acceptance. These examples emphasise the need for a comprehensive water policy assessment framework for long-term planning which is also a proactive approach compared to a reactive emergency type response (Bichai, et al., 2015).

# LITERATURE REVIEW

Water systems have been a common problem since the beginning of civilization. The increase in population, the improvements in economic conditions and industrial developments have increased the use of water. These have necessitated the water supply systems to be built in technical disciplines. Generally, water supply systems consist of four major components: Retention, supply, treatment and distribution systems. In the supply systems, pumps, pipes, reservoirs and valves play important role in the fluid process dynamic behaviour.

The word simulation means different things depending on the domain in which it is being applied. In this tutorial, simulation should be understood as the process of designing a model of a real system and conducting experiments with this model for the purpose of understanding the behaviour of the system or of evaluating various strategies for the operation of the system (Shannon, 1975). In other words, simulation modelling is an experimental technique and applied methodology which seeks:

* to describe the behaviour of systems,
* to construct theories or hypotheses that account for the observed behaviour, and
* to use these theories to predict future behaviour or the effect produced by changes in the operational input set.

## SOME TERMINOLOGY

Every simulation model represents a system of some form. The system may be a manufacturing cell, an assembly line, a computer network, a service facility, or a health care facility, just to name a few. Although these systems seem to be completely different, they are not really that different if we expressed them in terms of their components. In general, the components of a system are dynamic entity(ies) and resource(s). Dynamic entities are the objects moving through the system that request one of the services provided by the system resources. Entities have attributes which describe a characteristic of it. Entities may experience events which is an instantaneous occurrence that (may) change(s) the state of the system. An endogenous event is an event that occurs within the system, whereas an exogenous event is an event that occurs outside the system. Resources are the static entities that provide a service to an entity. Resources are further classified based on the type of service they provide; e.g. servers (machines or persons), free path transporters, guided transporters, conveyors, and so forth. Resources engage in activities which is a time period of specified length. The state of the system is a collection of variables needed to describe the system's performance. Simulation will model the random behaviour of a system, over time, by utilizing an internal simulation clock and by sampling from a stream of random numbers. A random number generator is a computational algorithm that enables the creation of a new number every time the function is invoked. The sequence of these numbers is known as a random number stream. A true random number cannot be generated by a computer. Computers can only generate pseudo-random numbers. However, these numbers are statistically random; thus, their usage in simulation modelling is valid.

## ADVANTAGES AND DISADVANTAGES OF SIMULATION

Simulation modelling is a highly flexible technique because its models do not require the many simplifying assumptions needed by most analytical techniques. Furthermore, simulation tends to be easier to apply (once the programming side is overcome) than analytic methods. In addition, simulation data is usually less costly than data collected using a real system. However, despite its flexibility, simulation modelling is not the magic wand that solves all the problems. Constructing simulation models may be costly, particularly because they need to be thoroughly verified and validated. Additionally, the cost of the experiment may increase as the computational time increases. The statistical nature of simulation requires that many runs of the same model be done to achieve reliable and accurate results. Despite its disadvantages, simulation remains a valuable tool to address a variety of engineering problems, at the design, planning, and operations levels. In each of this areas, simulation can be used to provide intonation for decision making, or it may actually provide a solution (Pritsker, 1992).

## TYPES OF SIMULATION

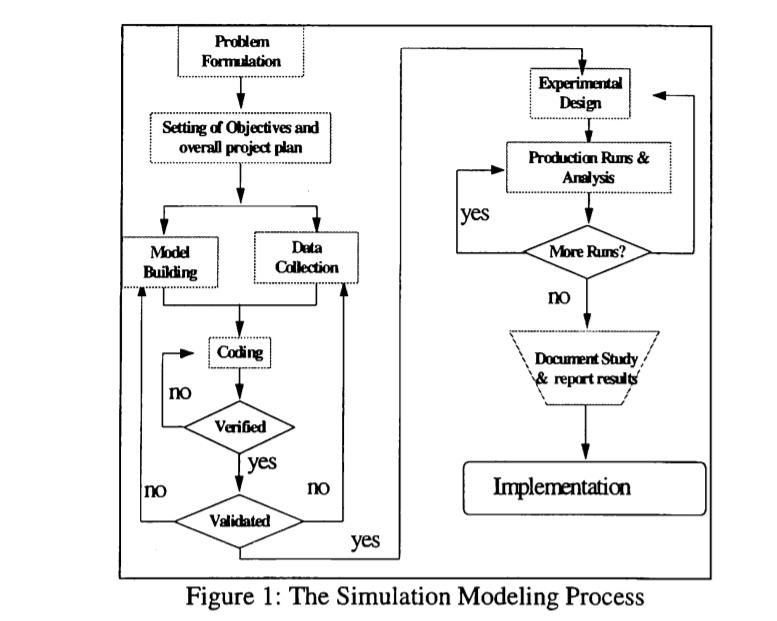
Simulation is classified based on the type of system under study. Thus, simulation can be either continuous or discrete. Our emphasis in this tutorial will be on discrete simulation. There are two approaches for discrete simulation: event-driven and process driven.

Under event driven discrete simulation, the modeller has to think in terms of the events that may change the status of the system to describe the model. The status of 15 the systems is defined by the set of variables (measures of performance) being observed (e.g. number in queue, status of server, number of servers).

On the other hand, under the process driven approach, the modeller thinks in terms of the processes that the dynamic entity will experience as it moves through the system.

# METHODOLOGY

The simulation modelling methodology has many stages including: definition of the project and its goals, abstraction of a model, digital representation of the model, experimenting with the model, and producing complete documentation of the project. It tends to be an iterative process in which a model is designed, a scenario defined, the experiment run, results analysed, another scenario chosen, another experiment was run, and so forth. However, advances in computer hardware, software engineering, artificial intelligence (AI), and databases are exerting a major influence on the simulation modelling process (SMP) and the development philosophy of support tools. If we look at the SMP (Figure 1), it is clear that simulation modelling is a knowledge and data intensive process. Notice that the flow through the SMP is not a sequential one; rather, it is a highly iterative one as discussed in the following paragraphs.



A study of a system starts when there is a problem with an existing system, or when it is not possible to experiment with the real system, or when the system is under design, Le. the system does not exist yet. After clearly understanding and assessing management needs and expectations, the modeller must determine whether or not simulation is indeed an adequate tool for the analysis of the system under scrutiny. In some instance, an analytical technique may suffice to obtain adequate solutions. Analytical tools should be preferred over simulation whenever possible. The modeller must establish a set of assumptions under which a technique, or a combination of techniques, is applicable, feasible and sufficient. If simulation modelling is the technique, or it is part of a combination of techniques, the modeller proceeds to gather data and performs proper statistical analysis to support models of the system. The needed data may be available in many different places and/or in different formats. For example, data may reside on paper, or it may reside within a database of a computerized information system. In either case, statistical tests must be performed without altering or destroying the original raw data. When there is no data available, the modeller must define the inputs to the model about the system using rules of thumb and/or personal experience. A conceptual model of a system must be devised and converted into a digital model. The modeller resorts to tools that will make the transition less difficult and less time consuming such as model generator front ends, simulation packages and so on. However, converting a conceptual model into a digital one is by itself meaningless, unless such a digital model is thoroughly verified and validated. The reliability of the digital model is directly affected by the quality of the verification and validation processes. Verification entails assuring that the digital code of the model perfonns as expected and intended, and validation seeks to show that the model behaviour represents that of the real-world system being modelled. With a reliable and accurate digital model, the modeller proceeds to the experimentation phase. Statistical experiments are designed to meet the objectives of the study. Observing a model under one set of experimental conditions usually provides little or incomplete intonation. Thus, a set of experimental conditions must be analysed within the framework of multiple experimental conditions. The capstone of the SMP is the preparation of a set of recommendations into a final management report. This report includes implementation and operations guidelines.

## CODING THE MODEL

This the stage that, at first, seems to be the most time consuming. However, without proper planning and proper analysis, the effort at this stage is useless. It does not matter how Beautiful" the model looks like (animation), or how fancy (full of details) the model is. If it does not address the original problem, it is useless. The modeler must be knowledgeable about programming and/or a simulation package. Although simulation models can be built using general purpose languages such as C/C++ and FORTRAN, nowadays there are a significant number of packages that have proven themselves as versatile and robust. Some of these packages are domain specific, while other are more general purpose. These packages include GPSS/WM, GPSSlWorld™, SIMAN/ARENA®, SLAMSYSTEM@, WITNESS, SIMFACTORY, ProModel, AutoMod, AIM, and Taylor (Banks, 1995).

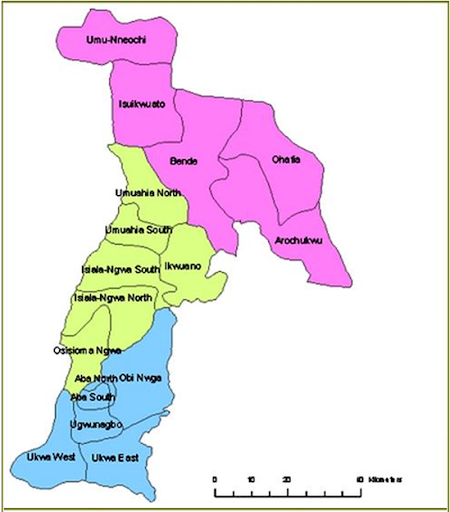


Figure ‑ Map of abia state

# DISCUSSION

All studies that are reviewed in this paper present important findings, although significant differences in terms of sustainability criteria, the categories that they have considered, and the level of detail in assessment, even within the same study area, are evident. Therefore, there is the need to combine a broad and diverse set of knowledge and skills to conduct a comprehensive study. (Baldwin & Uhlmann, 2010) acknowledge the challenges of undertaking a thorough and rigorous sustainability review of water supply options due to both the diverse skill sets needed and the limited data availability. Studies around the world provide a rich set of information necessary to build a policy support framework for assessing water supply and demand management options. Therefore, this review shows the importance of combining the considerations introduced by the different studies discussed in this paper and the need for a holistic, detailed, and generic framework to assess water supply and demand management options.

The majority of studies evaluate both centralized and decentralized water supply options due to the increased application of integrated urban water management principles to urban water management. However, many of them compare only a selected set of water supply options for an area. Further, few studies compare demand management options together with water supply options. As a result, studies which compare or evaluate a comprehensive list of water supply options (e.g., surface water, ground water, desalinated water, recycled water, rainwater, stormwater, greywater) conjunctively with demand management options which are essential for long-term planning and to avoid the evaluation of incomplete systems could not be found.

(Coombes, et al., 2015)Different scenarios were considered by different studies to assess water policy initiatives as a method of considering the uncertainty of the system due to its variable nature. (Coombes, et al., 2015)defined scenarios based on climate change, population/urban growth (i.e., Greenfield development), and economic change. (Hellström, et al., 2000)defined scenarios based on water or energy shortage, behavioural changes, and availability of economic resources. (Mukheibir & Mitchell, n.d.) characterise uncertainties in three broad categories. They are: trends; the gradual changes of the system (water demand), shocks, step changes of the system (bush fire, increase in energy price), and extreme variability of the system such as drought and flood. As such, different studies consider different sets of drivers from the system and the consideration of all these drivers in a single policy evaluation framework is essential. Further research is needed to include all drivers representing spatial and temporal factors affecting the water demand, supply, and other system components.

While these improvements are needed for a comprehensive policy evaluation framework for water supply and demand management options, collecting relevant information, data monitoring, and findings that are already available in the literature is recommended to support and inform this generic policy support framework. The areas suggested for further studies include identification of indicators and their plausible range of values, variability, and sources of uncertainty.

# CONCLUSION AND RECOMMENDATIONS

## CONCLUSION

This study examined the factors responsible for water supply inadequacies in Abia State. It found out demand-supply relationship and deficiency in potable water supply from the period of 2004 – 2012. It found out per-capita consumption of water and the factors which militate against the success of water supply by the Water Board Authorities. In all ramifications, Principal Component Analysis was used to uncover the latent structure of predictor variables in the responses. The use of PCA has thus made it possible to reduce our 30-predictor variables to ten major components or factors of potable water supply deficiencies in the area. These ten components enumerated above incorporate environmental, systemic and socio-economic factors responsible for potable water supply shortages in the area.

## RECOMMENDATIONS

1. The government should stop giving positions of authority to political party loyalists who lack the prerequisite knowledge to head the unit.
2. The government should aid and ensure prompt release of funds for the procurement of Equipments, spare parts and chemicals for purifying and treatment of water in the various stations.
3. Water agencies should be adequately funded to automate their network surveillance for rapid response to system failures. The geographic information system technologies will enhance the capability of the agencies to cope with these challenges and should be pursued with vigor.
4. The harmonious integrated operations of the power generating institutions (EEDC) and the water Board institution should be ensured so as to improve the services of both bodies. On the other hand, there should be a working standby generating plant as to supplement the power sector and inculcate constant maintenance culture of the Equipments

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