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Msc in Computer Systems Management

Final Year Dissertation

Project Title:

Explore and Design an Artificial Intelligent and Data Analytic Software model to address domestic water usage billing crisis in Botswana Urban areas

Author:	Motlhatlhedi Gaboalapswe	**Supervisor**:	Dr Srinath Doss, PhD
E-mail:	motlhatlhedi.gaboalapswe@bothouniversity.ac.bw.com	**E-mail**:	srinath.doss@bothouniversity.ac.bw
Phone:	+267-71633489/73734600	**Phone**:	+267-3919999/ +267-77784263
Student Number:	1817861	**Submission Date**:	4 November 2019

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Abstract

The rapid development of Information and Communication Technology (ICT) in water sector has greatly enhanced the management of water energy resources, water usages projections and integrates water information asserts into one dashboards screen for reporting decision making purpose. Information Technology intelligent tools like Artificial Intelligence and Big Data Analytics (BDA) are the cornerstone of assisting water utilities corporation Botswana on water billing crises, problems and provide relevant and reliable information for household water meter reading data collections. The research has explored and studied AI and data analytics as a solution to address high domestic water billing crisis in Botswana cities and towns by WUC. Artificial Intelligence has big impacts on numerous areas of expert system commonly used now days to resolve complex problems like in water sectors engineering, business, medicine, etc. The Artificial Intelligence technology is applied to improve the quality and efficiency of the services (Pannu, 2015). The integrations of AI and data analytics has been identified by these study as a technological tool as a remedy for WUC Botswana to manage water management issues appropriately as per these research study. BDA receives, process and transform data into knowledge that water utilities corporation (WUC) Botswana may utilize to manage water usages and consumption from domestic house hold facilities in an efficient manner (Ghernaout et al, 2018). Accurate data collections from smart meter reading through Artificial intelligence devices, analytics and decision framework through data analytics applications may enable water utilities corporations to manner water resources effectively in Botswana. The study utilize RPC communication protocol and SOA as web service architecture as the backbone of the proposed Enterprise integration systems for WUC. The network architecture of the solutions employ internet of things (IoT) of smart meters across the cities and towns through telecommunication authorities. The study has performs data collections and results analysis based on Household meter readings collections, ICT implementations factor, AI and Data Analytic Design operational Factors and Benefits of AI and Data analytics software model to WUC. 87% of the study feedback are agreed and proved to requirements of proposed study solution.

Keywords: Artificial Intelligence, Big data Analytics, Digital smart meter networks, Service Oriented Architecture (SOA), domestic Household, Water Utilities Corporations (WUC)

1. Introduction

Computing development advances has greatly enhanced the humanitarian intelligence with development of Artificial Intelligence technology which seeks to study and perform what human being brain senses, learns and acts (Stone et al, 2016). The demand and necessity of water resources in human and other natural things demands technological tools which could be used to monitor water usages at both domestic households, agricultural sectors, sewerages, construction industries and manufacturing firms. However, these study seeks to explore and design an AI and data analytics software model which addresses high water billings of domestic water usages which is currently the major crises in Botswana urban areas. The country is experiencing extremely high demand of domestic water usages due to alarming growth of populations in cities and towns. It is therefore the need for advanced technological systems model designed to manage cost of water transitions, distributions, water treatment plants and high billings of water consumptions at domestic level (Suresh et al, 2017). Water utilities Corporation (WUC) is a Botswana government owned authority which is mandated to provide water and waste water services across the country. However, it is currently an outcry of high and unrealistic billings for domestic water consumptions hence this study to design an AI and data analytics model that addresses such problem in Botswana cities and towns. According to these research work, WUC receives high volumes of complaints from its customers regarding unrealistic meter readings leading to high billings. The study has also noted that some households keep dangerous dogs which stops WUC employees from entering their homes for water meter readings hence estimation are used based on the patterns of how water has been used previously. Due to the fore mentioned problem of WUC, these study aims to explore and design an AI and data analytics software model that could address WUC Botswana problems. The research also defines benefits that is derived from the research project and how effective and efficient the AI and data analytics application model integration helps WUC to address its main challenges of domestic water management. Statistical data collection has been carried out by these study to quantify and qualify reasons for the problems from public domains and WUC employees themselves. These research work answers some of the following questions; How AI and big data analytic addresses water billing situations in Botswana urban areas? What benefits is derived from these research project and how effective and efficient the proposed AI system model is? How will

AI and data analytic framework works to collect meter readings across household in the cities and towns of Botswana? How does the AI and BDA topological and logic design model looks like?

The high volume of data from different AI sources in the era of 21th century leads to the implementations Artificial Intelligence systems to work in collaborations with big data analytic applications (Adamala, 2017). Numerous data volume emerging from the machine learning however requires such intelligent application systems like big data analytics that would be able to handle such unformatted data from different source of artificial intelligence devices. The AI systems has been studied, tested and proven to be a solutions to applied across many industries like auto self-driving cars, robotics, auto piloting, health care diagnostics, etc (Stone et al, 2016). According to Stone et al (2016), AI and machine learning will be applied in areas of agriculture, food processing and will attract much of usages by young members of the global communities. However, this study focuses on how AI and data analytics can be utilized to assist domestic water consumptions to address the outcry of high water billings for individual household in Botswana. The report design an AI model or software architecture that reads smart water meters from every household through AI devices to provide monthly meter readings as well as any anomalies water flow experience at individual house hold.

2. Problem Statement

Water utilities Corporation (WUC) is a Botswana government owned authority which is tasked to provide water and waste water services across the country. It provides services of waste water and water services to individual household, companies and industries and issue a monthly water consumptions for individual household. However, it is currently an outcry of High and unrealistic billings for domestic water consumptions hence this study aims to design an AI and data analytics system model that would address such crisis in urban areas of Botswana where it appears to be major challenges since WUC also complaints of households keeping dangerous dogs which stops WUC employees from entering their homes for water meter readings. With technology

advancements, these seeks to study and design an Artificial intelligence and data analytic model that would close that gap.

3. Aim of the study

These study aims to research and design an AI and data analytics application software model to address WUC high billing crisis for individual household in Botswana urban areas.

3.1. Research Objectives:

The main objective of these study is;

- To carryout research on the artificial intelligence and data analytics technology to be used as a software model for water billing system in Botswana
- To design an AI and data analytic software model for WUC Botswana for individual household in Botswana urban areas meter reading

3.2. Research resolution questions:

The following questions are to be resolved by these study;

- How AI and data analytic Technology could be used to address water billing situations in Botswana urban areas?
- What benefits would derived from these research project and how effective and efficient the proposed AI system model is?
- How would the AI model work to collect meter readings across household in the cities and towns of Botswana?
- How does the AI and BDA architectural design model will look like?

4. Background and previous work

Some previous related research work of technologies which the study employs to design the AI and data analytics software models are perused and analyzed for improvement and its capabilities to address the water billing challenges in Botswana urban areas.

What is artificial intelligence technology? Due to the high volumes of data from different sources has leads to a technology that can replace a human being called artificial intelligence systems (Ghernaout et al, 2018). AI is the current art of studies performed by numerous researchers and determining how it can benefit and improve humanitarian lives and daily works. According to Nilsson (2018), there is no exact and specific definitions of artificial intelligence but can be described as “a set of integrated technologies and techniques used to complement traditional

approaches, human intelligence and analytics." AI is an emerging technology which is still immature and predicted to work across multiple sectors to address different and dynamic challenges of human life. According to researchers, AI is predicted to be the most impactful technology disruption which we may live with (Ward, 2018). AI is one of the powerful information technology tool that transforms many areas of human lives like health sector, education, agriculture and many other industries like in cars, auto piloting, etc. Ward (2018) stipulated that AI services can be easily transformed to country's local citizens. Numerous surveys and researches has been conducted and proved to be trusting and confidence that AI can vastly improve government institutions services like WUC Botswana. AI brings effectiveness and efficiency by performing repetitive, tedious and time-consuming work at less cost (Ward, 2018). It is therefore these study aims to utilize the capability of AI to address the current high water billings challenges experienced by Batswana specifically urban areas. Furthermore, the AI sensors would send some alerts to abnormal water usages in individual household which violates predicted water consumption threshold for ordinary water consumptions of household.

4.1. Classifications and significance of AI

Artificial intelligence is a general term for all computing automation technologies for decision marking, machine learning and deep learning techniques (Suomaa, 2018). AI defines a high-level term for a combined sets of advanced analytics solutions (Suomaa, 2018). AI classifications includes;

Machine learning (ML): - ML is a computing technology discipline enabling computers to learn certain behavioral patterns or repeated activities, observe actions and analysis of the patterns to baseline any anomalies of drastic changes (Sapp, 2017). ML plays a pivotal role in the study of AI and data analytics software integration model to deal with the issue of complex raw meter readings and develop some thresholds of daily and monthly collections limit based on the pattern of domestic water usages and routine meter flows (Suomaa, 2018). The study utilize the capability of machine learning to determine the behavior water continuous movement at the smart meter readings and able alerts the household of any anomaly patterns of water flows. The ML sub module has ability to analyze and develop internal sets of algorithms that would representation and predict the behavior and patterns of water usages and sets some threshold for individual household's daily domestic usages (Pannu, 2015).

The rapid growth of artificial intelligence technology has a significant solutions to many problems experienced by African countries including Botswana in core sectors like health care, agriculture, finance and water sector environment (Zakaria and Times, 2017). These study seek design AI application framework model that could enhance the capability of new smart meter reading devices to add an efficient and effective means of water consumption billings and water management for the country. The revolutions of neural networks has led to the birth of advanced technologies of AI, which excites most researchers in the fields of data science, as a way of solving challenges experienced by human labor intensive involvements (Derrington, 2017). The literature also revealed that AI-based technologies are beneficiaries to health applications that are employed on handheld and networked devices such as smart phones (Derrington, 2017). The water sector likewise could utilize the advantages of these emerging technologies of AI and BDA as tools to monitor water usage consumptions and data collection mechanism on individual household.

AI technology areas of applications are benefited in Expert Systems, Natural Language and other areas of human intelligence systems like Neural Computing (Pannu, 2015). Therefore the study would also tap into the capabilities of AI as has been proved beneficial in other areas of sector to design a software framework that will address current water billing problems in Botswana.

4.2. Big Data analytics (BDA)

Big Data Analytics (BDA) is a business strategic tool to analyses large volumes of data, or big data. The trending growth of Information Technology has developed some smart data analytical tools called Big Data analytical platforms through some business applications called Business intelligence (BI) systems (Romero et al, 2017). The research utilizes the BDA analysis the help the WUC to uncover water usage patterns and connections that may be invisible and can give valuable insights about the domestic household usage of water. Such huge volume of data may be gathered from a wide variety of sources, including real-time monitoring sensors, digital images, sensors, transactional records, etc. as it integrates with AI to deliver numerous data collections from water smart meters of various households. Numerous research has been conducted with regards to how BDA can be used in water corporations industry to assist in

strategic way of generating smart graphical and textual reports from complex and various amount of large data (Romero et al, 2017).

Water is an invaluable natural resources in which the economy of every country relies on its adequacy hence a needy for a good tool for its measurements of consumptions leading to accurate estimations on both customer billing information and overall country wide water consumptions (Ghernaout et al, 2018). These study has been derived from the current situations of high water billing complaints of water utilities Botswana for its unjustified high bills for water usages for individual household. The study seek to design an artificial intelligence and Big Data analytics (BDA) software model to provide realistic opportunities and efficient way of dealing with different data of water consumptions from different water meters of every house hold in Botswana. The data analytic application model receives, process and transform data into knowledge that water utilities corporation (WUC) Botswana may utilize to manage water usages and consumption from domestic house hold facilities in an efficient manner (Ghernaout et al, 2018). Accurate data collections from smart meter reading through Artificial intelligence devices, analytics and decision framework through data analytics applications may enable water utilities corporations to manner water resources effectively in Botswana. The artificial intelligence and machine learning is broader studies but in this research utilizes its previous studies capabilities design an integrated software model that would assist WUC Botswana to carry out its meter readings for every house hold customers and automate delivery and alerts for any high house hold usage triggering. BDA however shall sufficiently analysis any patterns, and produces an accurate predictions for water utilities management and enable better and informed decisions (Ghernaout, 2018). Data analytic application would further assists WUC with analytics and planning based on the received data collections from digital smart meters across their networks (Suresh et al, 2017).

4.3. Digital Smart meters

Digital smart meters is one of the critical device in the design of AI and BDA software model to automate water meter readings of individual household in Botswana. The global increase of technology adaptation to improve humanitarian life by minimizing repetitive tasks and activity patterns has leads to rigorous researches on digital smart metering (Suresh et al, 2017). Smart metering is not a new technology since has been tried on some other research works and even

in water sectors but has previously been researched based of developing mobile application development unlike in these research where smart meter technology is integrated with AI technology and data analytics application. The high increase of water demand in urban areas due to growing populations has forced high cost of water management hence a needy for these study of AI and data analytics software model to handle such ambiguous activities (Suresh et al, 2017). Intelligence technology tools AI and data analytic software models helps to mange complex water domestic usages and billing informations in smarter manner. Water billing is the revenue sources in most of water utilities authority through water consumptions in every company's premises and domestic households. The internet of things (IoT) for digital smart meters is the key area for these software design model to address issues of high water billings due to inaccurate meter readings collections for water household consumers. According to Suresh et al (2017), ICT usages like Customer Relations and Billing Management (CRBM) have been tried by water utilities in the past decades but live data collection from various household water meters being unveil. However, these research would propose a software model that would integrate digital smart meters through AI and data analytics application to receive the various source of water meter readings collection data and produce a household water billings. The interconnections of physical layout for smart meters through AI and Data analytic applications will be discussed in more detailed in the following chapters.

5. Study Software Design model

These research work aims at designing an AI and Data analytic software model that would be used as baseline to address water billing crisis in Botswana especially in urban areas. Software design model would include both physical IT architecture design and logical software design model in these study. A software model integrates numerous components of the software and collaborate them together to provide a usable architecture for these AI and data analytics applications (Edwin, 2014). Software frameworks are problem based design and follows solution patterns of the problems within a particular to address without involving technology implementations (Imran et al, 2016). The design covers both the static and dynamic functional structure which collaborates both software modules for reusability design. The AI and data analytic software model components are designed for static use of learning individual domestic water usage on every household and baseline the daily and monthly usages. Software design model systems are designed for reusability and extensibility hence more complex design and build the program. The design model architecture is the topological

structure of the software components which entails the physical connections in which the software runs (Imran et al, 2016). Both of these software design components are discussed below on how the study would utilize them to design AI and data analytic applications for water meter reading and customer billings.

5.1. ICT Topology architecture

The IT architectural design includes physical components of ICT devices which are connected together to form where the AI and big data analytic data would flow to reach destinations. These includes smatters, networking devices and telecommunications authority's towers. The interconnections of these smart meters would form internet of things (IoT) of household smart meters. The smart meters has an inbuilt AI device which contains some small software module to learn and uncover water flows of individual households. These smart meters are connect to WUC ICT core network through telecommunications towers which linked to high speed fiber optic cable connecting to the main hosting WUC system. The IT Network physical layout for these software model will answers questions of how the software looks like physically since software design model is transparent to ordinary persons. The physical layout out of the IT infrastructure to run proposed study solution are shown below on fig 1.0.

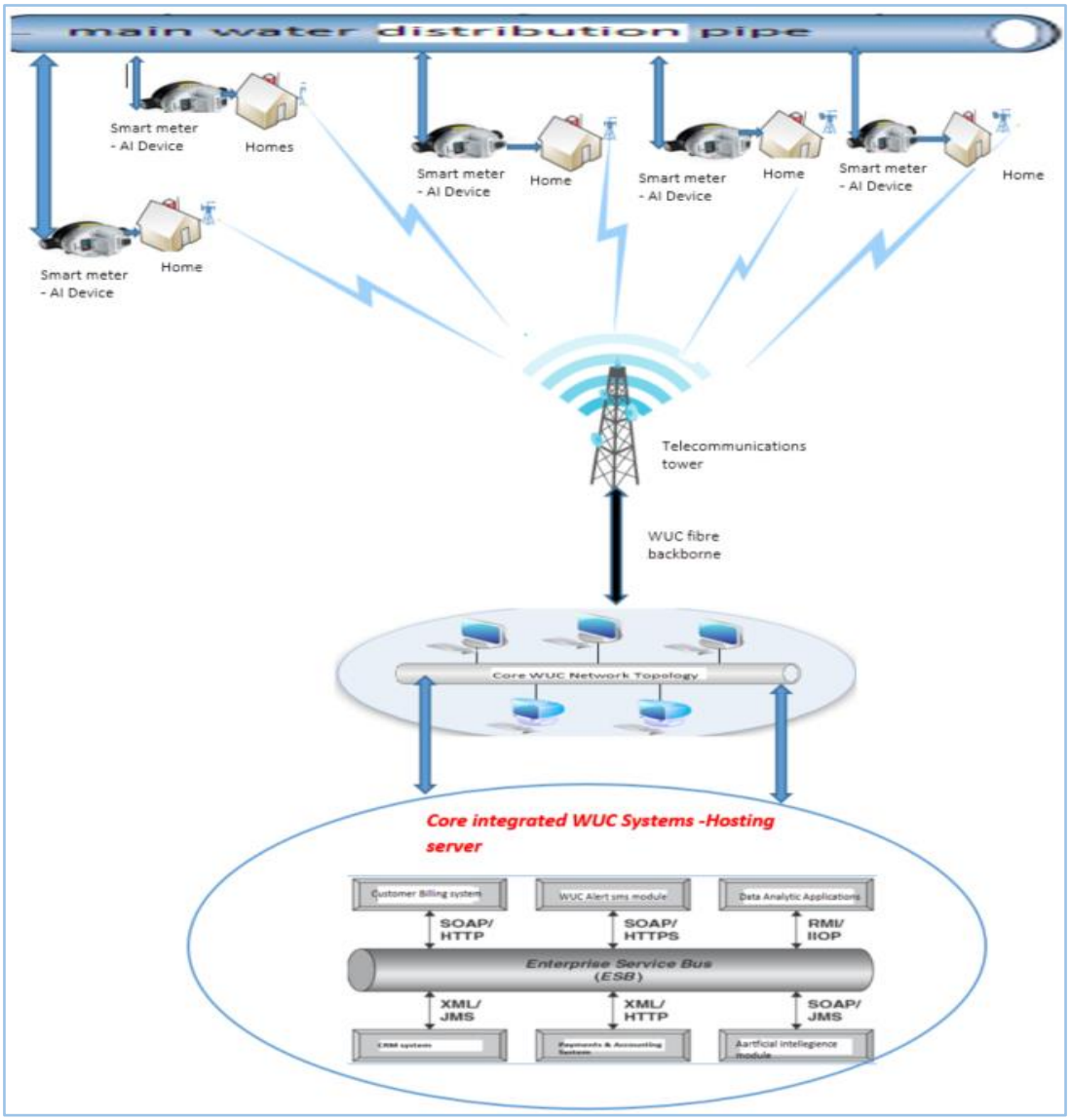

Fig 1.0 Core IT infrastructural design for WUC AI and Data Analytic software design model

5.2. How software design model works?

The software architecture of the system is the design map of how data structure, metaphor and connection strings of the system flows and the instructional format of the software as well as the physical connections in which data flow will take place (Imran et al, 2016). These software design model is based on the integrations of the WUC core business applications including customer billing systems, accounts and payments, SMS Alerts module, Data analytics and Artificial Intelligent modules. The core of the software design model is based on the web service

architecture called Service Oriented Architecture (SOA). SOA will interface different functional systems of WUC including AI and data analytic applications. SOA is an application architecture where individual functional systems are enclosed as a software components which are interfaced externally through a global access implementation interface (Bruce Silver Associates, 2004). These integrations will be handled by Enterprise Service bus (ESB) layer which is platform independent. The software model will function like responding to requests but the AI device would trigger automatically the Alerts SMS module as it learns an anomaly of smart meter flows which the SMS alerts system will alerts individual household of the water situations. However, the service rendered is transparent, independent of technical implementation, protocol used for service request, platform and vendor independent and doesn't matter of either local or remote service request (Bruce Silver Associates, 2004). The study proposed WUC AI and data analytic software design model is implemented through independent web services of SOA. These design will benefit from the scalability and extensibility of SOA web service architecture and software design model will integrate multiple enterprise applications of WUC to provide relevant informations and consolidations of meter reading collections in one big data analytic dashboard or reporting tools for WUC management decision making.

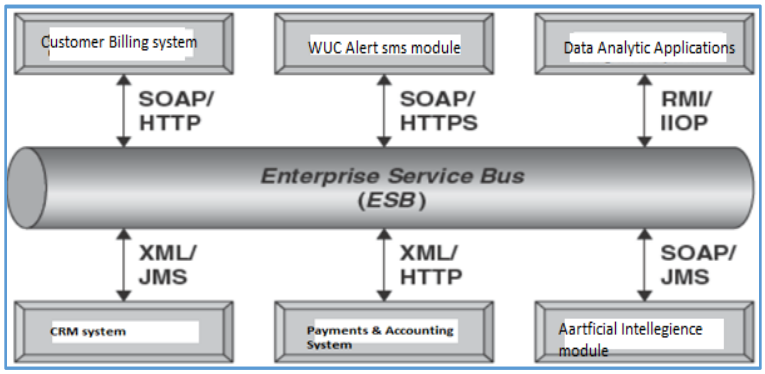

Fig 2.0 AI and data analytic Software design model

5.3. AI and data analytic software model components

The software model is based on the SOA integration services which is rendered through a universal mechanism to interface all the services without compromising security, reliability and performance scalability. In these sub chapter of the research, components which forms part of

these software design model are briefly discussed on how they will work together for these study model;

5.3.1. Communication Protocol for the software model

As it has been illustrated that the AI and data analytic software model is based SOA above and communication protocol is based on remote procedure call (RPC). RPC has been commonly adopted as a de factor standard of communication protocol in most distributed systems because of its simplicity to implement and transparency to users. RPC has been choose above other protocols like Remote method invocation and socket because of its simplicity to design the WUC proposed AI and data analytics software design model. However, these research has noted RPC cons of platform, language dependency and coupling of some application functions but that the study has overcome such RPC design issues with the use of other web services protocol like extensible mark-up language (XML) to implement both client and server communications. The XML document format enables RPC to be portable calls and rendered in HTTP browsing (zhang, 2002). The nature of RPC communication protocol, it is tightly coupled and less reusability, integrating the client and the server application in a point to point manner, however, the inclusion of XML in RPC message communications overcomes some of the issues with regards to language and platform dependency(Krzyzanowski, 2002). Since the communication is within WUC organization, these software design model capitalize the pros of coupling procedures and functions to ensure completeness of data delivery and guaranteed during household meter reading data collections. In these software model based on RPC communication protocol, the client makes a call and waits for the response from the server side which is the provider to return the remote procedure, and it is at the time of calling when arguments are passed to a remote procedure on the server side (Anusha et al, 2011). Since the model is based on RPC message communication which is synchronous, the calling procedure or function is blocked from doing any work until the pointer from called code is returned. The operation of RPC protocol shown on Fig 3.0 below and its implementation model will be illustrated on the AI device on the household smart meter later;

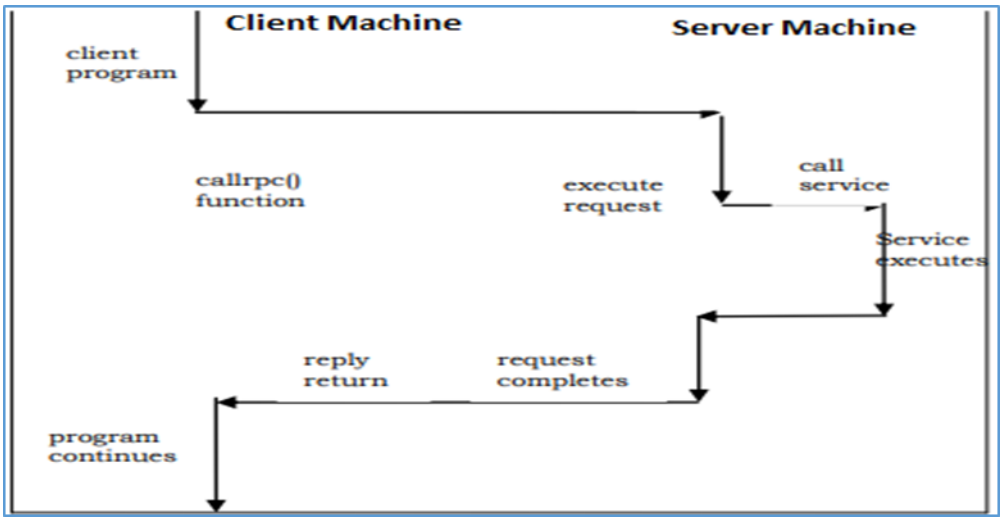

Fig 3.0 Client /Server RPC call function process (Anusha et al, 2011)

5.3.2. Enterprise Service Bus components

The backbone of these software design model is based on Enterprise Service Bus (ESB) infrastructure layer to provide seamless technology of interconnecting service requesters and providers (Kodzo, 2014). ESB has other messaging communication mode but however in these study the software design model is based on the asynchronous messaging systems which is more scalable to accommodate high volumes data from AI device meter reading collections during peak periods of household meter readings collection. The model would utilize the capability of asynchronous ESB communications to integrate a more diverse set of applications and guarantees that no meter readings data can be mistakenly lost in these ESB communication mode hence prove to be reliable mode of communication in these software design model study (Kodzo, 2014).. The ESB asynchronous communication would ensure meter reading data reach the intended destination like Data analytic applications and customer billing system for further processing.

5.3.3. Simple Object Access Protocol (SOAP)

The software design model is based on the enterprise application integrations using platform independent protocol like SOAP to provide web services. SOAP provides API interface modules to integrate all WUC enterprise applications. A web services are programmable web application API which is accessible using any standard web technology protocols (Zhang and Chung, 2002). These research work proposes the WUC software

design model deployable and implemented on SOAP messaging protocol web services platform which encodes information for both SMS alerts requests and server response messages independent of operational platforms (Skaaden, 2004). SOAP is a lightweight protocol in nature and utilizes XML technologies to exchange information in a decentralized way environment hence enables all different platform receivers like handset devices like cell phones to receive any message. It is with this feature that warrant the use of SOAP web services to design the software model for WUC AI and data analytic applications. The extensibility of framework in SOAP provides a message construct that is easily exchangeable over different underlying protocols. XML messages are moved from Data analytic application to Customer billing through extensible, usable and independent programming languages (Zhang and Chung, 2002). The SOP message framework of WUC AI and Data analytic design model architecture is shown below;

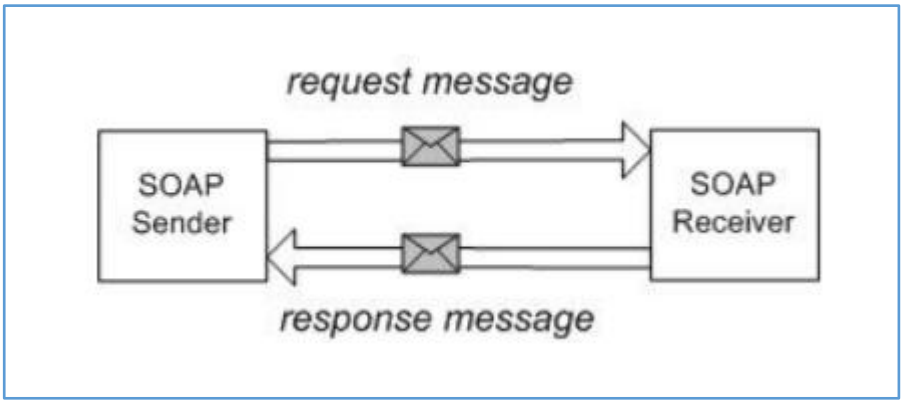

Figure 4.0 Simple SOAP framework (Zhang and Chung, 2002)

5.3.4. Artificial Intelligence Device module for the software model

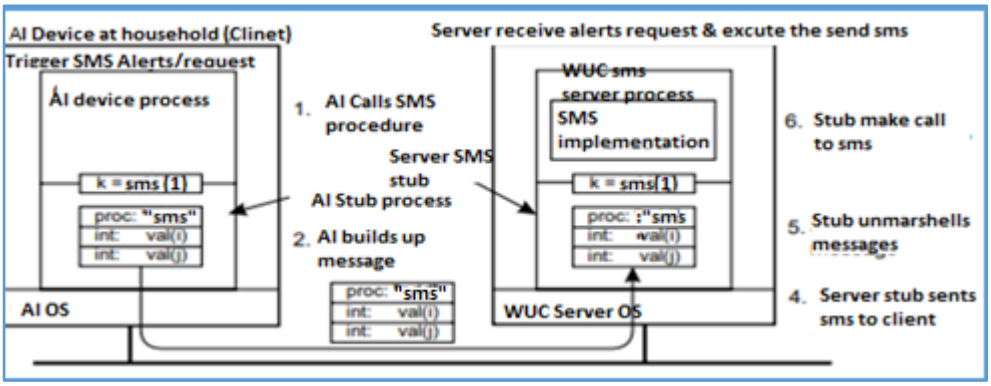

Fig 5.0 AI Device program SMS procedure call

The Smart Meter (SM) is a critical component in the design of AI and data analytic software model for water utilities in Botswana urban areas. These software model utilizes a cloud of smart meter networking integrated through Internet of Things (IoT) technology to collect individual household meter readings collections for every Botswana towns and cities (Lloret et al, 2016). The SM is embedded with an intelligence device capable of reading smart meter water consumptions and contains a subprogram to learn the meter readings flow of the individual household. The AI device learns the behavior of water flows and do stores daily meter readings within its subprogram storage arrays. These module compute the monthly water consumptions and push it over network to main water customer billing system at WUC head office. The AI device also learns any abnormal flow of the meter and trigger the SMS applications to alert the individual household. Individual household AI device baseline the daily and monthly water consumptions by setting the household threshold daily and monthly consumptions limit. These thresholds are based on the below algorithm;

DTL=AVG(d_1^{m3} , d_2^{m3}, d_3^{m3}, d_4^{m3}, d_5^{m3}) + P(d_5^{m3} - d_1^{m3})

DTL=Daily Threshold Limit,

AVG=Average

d_1^{m3} = day 1 cubic meters of water usage,

d_2^{m3} = day 2 cubic meters of water usage,

d_3^{m3} = day 3 cubic meters of water usage,

d_4^{m3} = day 4 cubic meters of water usage,

d_5^{m3} = day 5 cubic meters of water usage,

P=Provisional difference between day5 and day 1

The daily threshold limit for individual water consumptions is computed based on the average of daily water usage of first day through to 5th day of the month and any daily meter reading exceeding these DTL would trigger an alert module execution at WUC core business systems. The AI device follows RPC procedures to trigger the SMS subsystems and pass all parameter values to the hosting server side of client SMS program. Each household SM is assigned a meter ID which uniquely identifies a meter household with SM networking. According to Anusha et al (2011), the server executes the called SMS procedure by unmarshaling the passed values of amount of cubic meters of water and meter ID to implement SMS procedure. The SMS procedure send the alerts to the meter

ID household customer and inform them of exceeding of daily threshold water usages. The server through its RPC protocol makes the called program to appear as if it's being executed locally (within calling host) and all other network communications and transfers of alerts message across networks to household. The RPC calls are uniquely differentiated by program numbers, version number and procedure number (Anusha et al, 2011).

However, on other hand the AI device baselines its monthly domestic household usage threshold on the cumulative of number of days multiplied by DTL. As depicted on table 1.0 below, if DTL is 1.5m^3 of domestic usage and the month year has 30 days, then the computational water consumptions is MDC = DTL x MD where MDC mean Monthly Domestic Consumption, DTL refers to daily threshold limit and MD is monthly number of days. Therefore MDC = 1.5m^3 x 30 Days, then the monthly readings for the consumptions is 45m^3 which is then passed to customer billing system for household domestic bills. See sample table below for five sampled household daily readings for the month of September 2018, DTL and MDC as well as monthly billings;

Household/MID	D1	D2	D3	D4	D5	DTL	Monthly days	MDC (m^3)
1q7467	0.1	0.3	0.2	0.1	0.3	0.4	30	12
1q7468	0.2	0.5	0.4	0.3	0.4	0.56	30	16.8
1q7469	0.7	0.8	0.8	0.7	0.9	0.98	30	29.4
1q7470	0.5	0.6	0.5	0.4	0.6	0.62	30	18.6
1q7471	0.6	0.7	1.0	0.9	0.9	1.12	30	33.6

Table 1.0 Sampled monthly consumptions for September 2018 households

In addition to triggering SMS procedure to send alerts messages to household, the Smart Meters via embedded AI device is capable to display instant warning messages on the SM display for the attentions of household.

5.3.5. Data Analytic Applications

These component of the software design model plays a pivotal role in these AI and data analytics software design model research work. Data analytic applications provides the right data privileges, data analytics processing and decision making model for WUC in an optimized and efficient manner (Ghernaout et al,2018). The big data analytic application

handles vigorous raw data volumes of meter readings collections across the cities and towns but process it for stakeholders usage reports, tunes data collections and pass it to other areas of business Enterprises systems of the WUC operations for other usage and informed decisions makings as well as predictions. The AI device at the household pushes the monthly meter reading from all angles of the towns and cities of Botswana through smart meter networks and the Data analytics applications handles all these huge meter readings collections hence drives big data collections. The data analytics software components leverages high computing rates of numerical data and existing algorithms of innovations capabilities that would perform big data analysis and output numerous reports as per configurations (Bhattacharya et al, 2018). During these process of data collections from various sources of water meters, some machine learning emerges to play a role to learn some big data patterns of domestic water usages as per individual household or per cities data receivables. The study design model has adopted big data analytic (BDA) processing capability and real-time activity functions for its efficiency of modular thread processing of huge data sets (Thompsona and Kadiyalab, 2014). BDA improves its efficiency of the data file stores and removes duplications when handling raw meter readings data collections. The data analytics applications receives numerous monthly meter readings data collections from different meter IDs across AI devices of towns and cities individual household.

5.3.5.1. How do WUC benefit from AI and Data Analytic design model?

The design model has demonstrated to use BDA which is a business strategic tool that will helps WUC to analyze large volumes of data from meter readings across Botswana towns and cities in an effective and efficient manner. The software model capitalizes the trending growth of Information Technology development of smart data analytical tools called Big Data analytical platforms through some business applications called Business intelligence (BI) systems. These BDA analysis helps the corporation to uncover domestic water usage patterns which are currently invisible and can give valuable insights for future predictions and decision making regarding water resources in Botswana. These research software design model would also assist WUC to use AI device to carry out smart meter readings across Botswana urban areas and submit the readings to big data analytic applications for further processing

and generates strategically smart graphical and textual reports from complex and various amount of large data (Romero et al, 2017). Furthermore, since the design model integrates all the corporate Enterprise business systems, the customer billings system will receive meter readings from data analytics applications and produces individual household domestic water bills in an efficient manner. The pros of these research study software model are summarized below;

- Data source validation and verifications: - It has been unfortunate for some past decades that water collection was done manually and prone to errors and unreliability of readings from different meter sources. Data Analytic application tool now verify and validate meter readings data collection patterns and verifies against specific defined datasets like Meter ID (MID). BDA brought together data and analyze it as one entity though from different sources and put under one data store (Shaw, 2017).
- Efficient and effective processing: - Data processing is performed by WUC ERP system and real-time time processing is observed.
- WUC strategic reports generations: - The Big Data Analytics applications turns the raw meter readings data collected into a meaningful and understandable data assert that communicates to all stakeholders, corporate utility management and other consumers as an understandable informations for proactive decisions makings.
- The design model integrates all WUC Enterprise applications and shares data across all applications as well as easing business operations including workers knowledge and actionable information.

The water utilities corporations will further takes advantages of BDA technology tool to do minor storage and viewing of data in a customizable manner. Through these BDA technology tool, water utilities corporations would add predictive models to finally know the future consumptions based on the previous patterns of water usage and consumptions in some previous years (Romero et al, 2017). They may also prevent man-made disasters, such as sudden drops in water quality, which may not be detected until after they are reported in the media or after the outbreak of a contagious disease. Through big data analytic technology, WUC Botswana can achieve better water management and overcome

the current crises of water management and high billing of water consumptions. It is therefore the future of WUC Botswana would look bright with the use business intelligence system for big data analytics reporting (Schultz et al, 2018).

5.3.6. Customer Billing Applications

These research aims to design an AI and data analytic software model that overcomes the high water billing crises in Botswana Urban areas where WUC experience high level of domestic water usages. Therefore a customer billing application module is one of the key components in these research work. The use of artificial intelligence device for smart meter reading technology automates and makes paperless operations for each household meter readings collections (Pelandiana and Ado, 2018). The seamless operations of meter readings and submissions for customer billings without human interferences is the core of these research study. In these era of one networked society through technological advancement, a web based customer billing system proposal that enables water consumers/users to login through their meter ID and passwords to access their billings with any web browsing technologies and devices. Hence the backbone of the WUC enterprise application integrations is based on SOA, SOAP and EBS which are platform and language independence, the application of web customer billing system is preferred. The billing module receives the meter readings through data analytic applications and compute individual household customer billings and sends the bills through emails or via SMS alerts module to come and pay for their monthly bills. Domestic water users is privileged to view their statics of monthly water usages tabulated and also in graphical forms in the dashboard of their home pages. Details of their billings and meter readings data collections are depicted for the verifications and clear any doubts of meter readings and consumption rate. Individual household is eligible to view their smart meter details, house details and their meter readings histories as well as meter collections records for their satisfactions and enquiries. Such availability of information to water consumers reduces the national outcry of high water billings and households are able to take control of saving water hence auto alerts are sent if the domestic water usage DLT is exceeded.

5.4. Research Design and methodology

The structural design of these research for exploring AI and big data analytic model as a solution to address high domestic water bills would be investigated through questionnaires and interviews. These chapter aims to solicit the idea of the study by carrying out minor study by sampling domestic household consumers from cities, towns and a small portions of villages residents. A mixed-methods of carrying out this AI and data analytic research study are discussed below;

5.4.1. Research Methodology

These study employ different methods of soliciting the technological idea of designing software model for AI and data analytic for water utilities to address the issue of high water billings from sampled household communities. Quantitative study of ten (10) village residents, twenty (20) city's residents and 10 town's residents household has been performed through structured questionnaires. Qualitative study was also performed on both sampled household communities and WUC employees to obtain their feeling regarding the study proposals.

5.5. Data Collection Tools

These chapter defines various techniques and methods of data gathering in a relevant form participating in water household residents and other sampled WUC employees in these research project (Canals, 2017). These research work will use questionnaires to quantify sampled data collections and interviews of WUC employees to qualify the need of the design model. These implies that there will be small interaction between water household residents, WUC staff and a researcher. The ethnography or conversational analysis has been performed to qualify some research case studies and obtain firsthand information as well as how respondents feel with regards to the design of the solution (Canals, 2017).

According to Canals (2017), the interviews would be performed at randomly sampled WUC employees and some community people around the cities and towns to try to reproduce real-life communication situations in which the participants make oral contributions that are useful for the research purposes as well as beneficial for the researcher learning process. However, both of structured and semi structured interviews has be conducted. Structured interviews is beneficial and predetermine list of questions to be asked with no scope of follow-ups questions to respond or further elaborations. This data collection technique are relatively quick and easy

to administer and may be of particular use if more clarities are required by researcher (Gill et al, 2008).

5.6. Data Analysis

Quantitative data analytics has been performed using both Ms Excel and SPSS to compute statistics of the domestic water consumption. A pictorial presentation is developed using spreadsheet as shown with results below. However, some non-parametric information obtained by interviewing WUC staff employees and will provide some other valuable data that would assist on the implementations of proposed solutions of AI and data analytics techniques for WUC (Tingyi Lu, 2007). Some methodological errors of recordings may like to feature and data cleaning may be required to produce quality data but due to time constraints, errors may likely to crop in time to time. Furthermore, heterogeneous study methodologies and results analysis may also deemed to be inappropriate (Tamason et al, 2016). Semi structured interview questions were set to conduct an interview and collect some valuable information which may not be quantifiable but yields results which may help decisions when findings and conclusions is drawn from the study.

5.6.1. Study Results Analysis

The parametric data analysis has been extracted from questionnaires responses and feedback from sampled towns, villages and cities residents. The structured questions on the questionnaires was designed to extract water household meter readings perceptions and reliabilities, ICT implementation factors with regard to Botswana, Software design model factors, technological challenges, stakeholders and WUC management predicament of the solutions to high water billing problems and complaints through AI and data analytic software model. The questionnaire used for data collections on these study is found on **Appendix-A**.

5.6.1.1. Part A: Accuracy of meter readings

Sampled communities were requested to respond to questionnaires by agreeing (A), disagreeing (D), strongly disagreeing (SD), neutral (N) and strongly agreeing (SA) with statements regarding the current situations of meter readings collections. Ratings were provided like **SD=1, D=2**, **N=3**, **A=4** and **SA=5** and the followings results were realized from returned questionnaires. Ten (10) village household, 20 city household and 10 town

household residents were distributed questionnaires and the analysis of returned ones are as follows;

	PART A: H/Hold meter readings				
	SD	D	N	A	SA
Q1	9	20	21	4	
Q2	7	26	15	8	
Q3				16	115
Q4				52	70

Table 2.0 Household meter reading data source

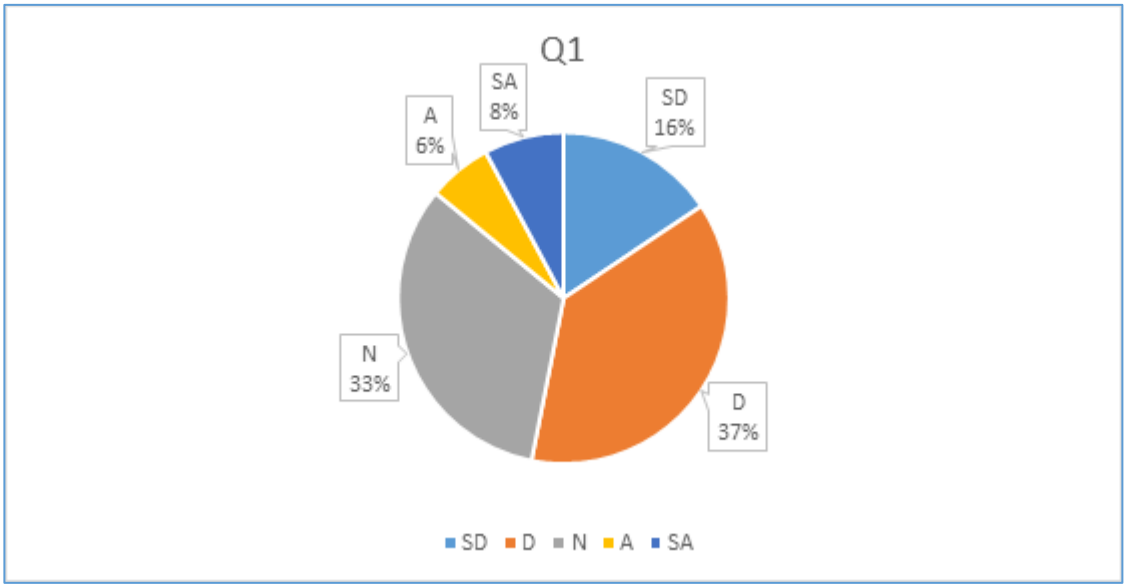

Fig 6.0 Q1 of Part A (Trustfulness of accuracy of data collected by WUC employee from your water meters readings) study results

Based on the fig 6.0 above, study analysis of Q1 of **Part A** (Trustfulness of accuracy of data collected by WUC employee from your water meters readings) of returned questionnaire respondents,16% strong disagree, 37% Disagree, 33% were neutral, 6% agreed and only 8% strong agrees with the accuracy of meter readings of their household from water utilities. Of the 33% neutral respondents, most households has assured the researcher that informations regarding their monthly water consumptions have never reach them and only

bills of payments are presented to them. Majority of the sampled community of 37% respondents proved disagreeing with water utilities readings and the need of proposed AI and data analytic software design model implementation.

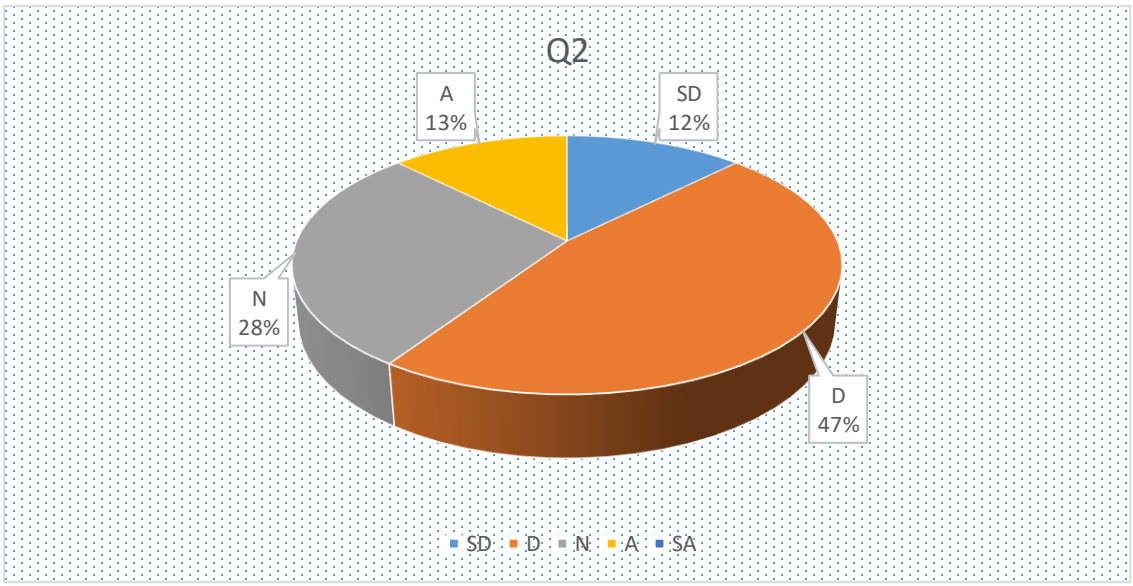

Fig 6.1 Q2 of Part A (Household domestic water billings are accurate and in line with meter readings)

The results analysis of Q2 of part A (Household domestic water billings are accurate and in line with meter readings) indicated shown above indicates respondents feedback as 12% strongly disagree, 47% disagrees, 28% neutral, 13% agreed with the meter reading accuracy and in accordance with billings received. However other hand, 12% strongly disagrees. The analysis indicates that meter households do not agree with accuracy of their domestic water billing and that is proved by the summations of the neutral individuals, disagreeing and strongly agrees which takes large portions of 87% (12%+47%+28%). Therefore only 13% of these study are receiving accurate records of their domestic water billings hence a need for a solution to address that abnormalities and untrusted water billing like these study of AI and data analytic software design model.

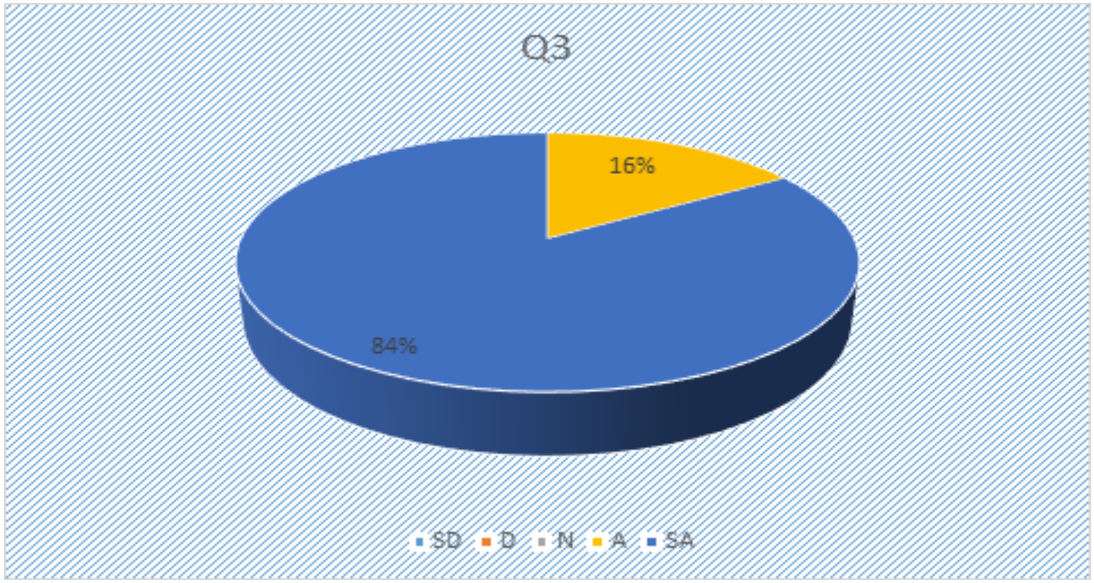

Fig 6.2 Q3 of Part A (Technology to automate meter readings for individual household is required)

Q3 results analysis above, Part A (Technology to automate meter readings for individual household is required) proved the outcry of unreliable and inaccuracy of their meter readings and their domestic billings. It is observed in the above picture that none of the respondents shows any disagreement or neutrality against the need for software design model technology to automate meter readings collections. Feedback from respondents proved that 100% (84% strongly agree +16% agreement) of AI and data analytic software model is highly required for to automate meter readings and address of high domestic water billings.

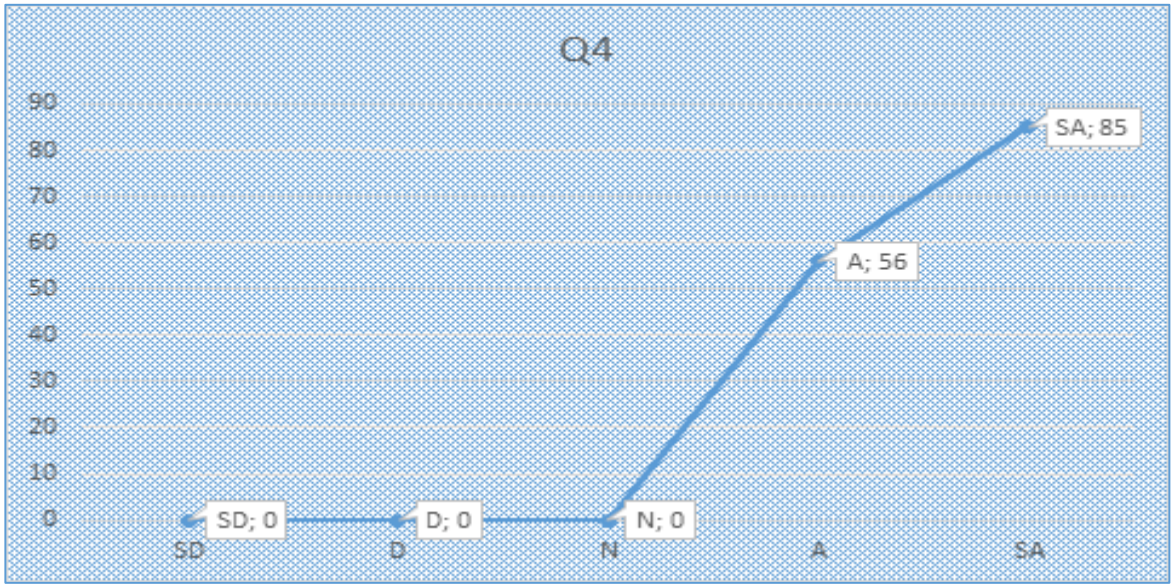

Fig 6.3 Q4 of Part A (Transformational technology requirements to manage usage of domestic water)

Results analysis for Q4 of part A in fig 6.3 above reveals that out of the little sampled domestic meter households, all respondents agreed of technological requirements changes to manage domestic water usages including water consumption billings. None of the feedback from respondents depict any disagreement, strong disagreement neither neutral but all are agreeing and strongly agreeing with transformation technology to address high water billing crisis in Botswana especial urban areas.

5.6.1.2. PART A Conclusions

Therefore the summations of part A from respondents indicates a total dissatisfactions of the accuracy, reliability and trustfulness of their domestic meter readings and hence untruthful high water billings. General observation proves requirements of technological changes to automate meter readings collections which is the purpose of these study.

5.6.2. Part B: ICT implementation factors for AI and Data analytics model

The technological study of WUC or Botswana ICT infrastructure feasibility factors were considered and semi structured questions were asked to seek how people and WUC employees perceive the proposed software design model. The rating scores was computed as follows from the returned distributed questionnaires;

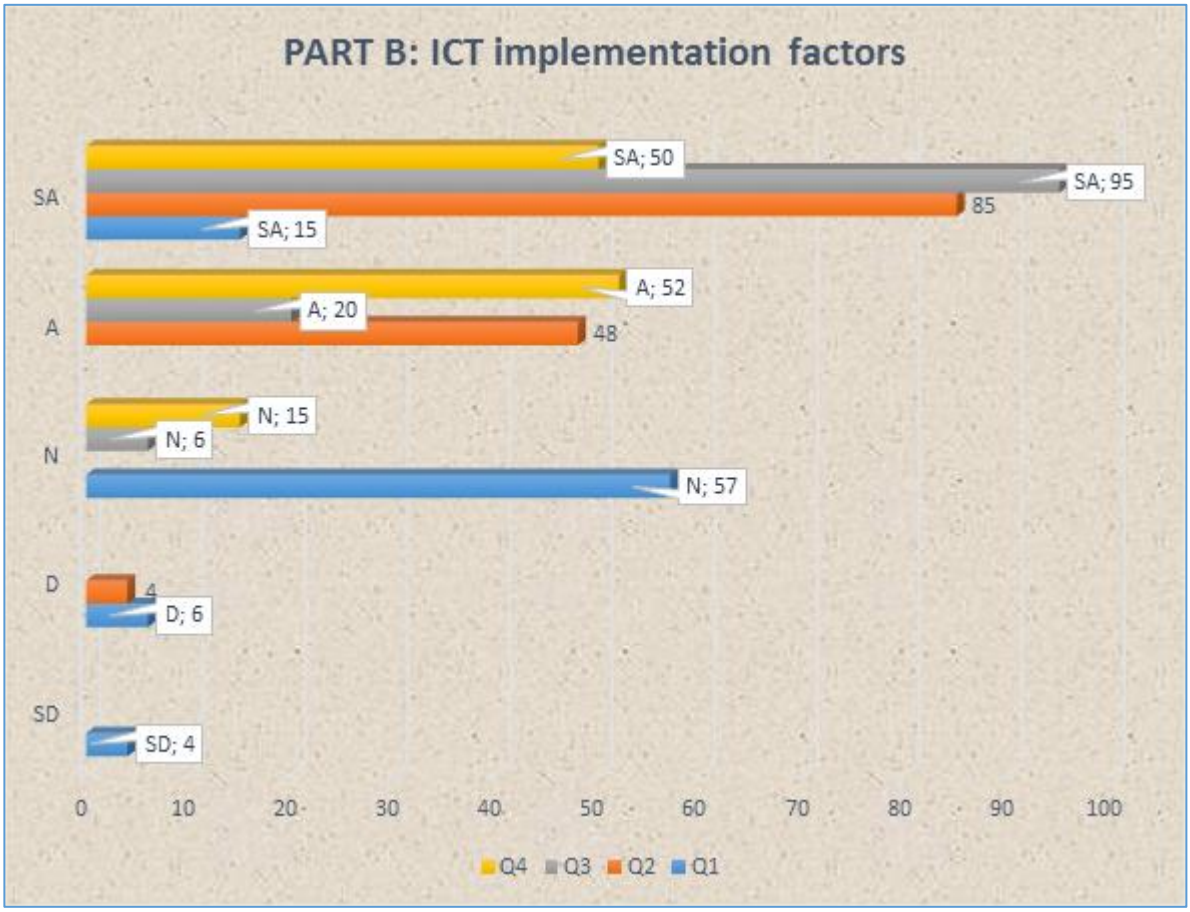

Fig 7.0 ICT Technology factors considerations

Figure 7.0 above consolidates the respondent's feedback from part B of the questionnaires. The scores indicated above depicts that out of thirty two (32) returned questionnaires of **Part B**, four (4) people strongly disagree that WUC does have ICT resources to implement the proposed research work software model, 3 people disagrees, 19 were neutral and only 3 people were strongly disagreed with the idea that Botswana does not have ICT infrastructure to implement the solution. In question 2, one person disagree, twelve (12) persons agreed and seventeen (17) people strongly agree that implementations of AI and data analytic design model can address high water billings and avail accurate meter readings. Regarding to question 3 of the questionnaire, respondents were that two (2) neutral, five (5) agreed and nineteen (19) households residents were strongly agreed with the integrations of SMS module to AI and data analytic software model to send short message alerts immediately once AI experience abnormal flow of smart meter. Question four of Part B seeks to identify the likelihood of job losses due to

implementation of the study software design model and respondents were as follows; three (3) were neutral, thirteen (13) agreed and ten (10) were agreed to that factor of loss of jobs due to implementations of the study.

5.7. Part C: AI & data analytics design factor

The AI and data analytics design factor seeks to solicit feedback from respondents with regards to software design model operations and its implications. Four (4) structured questions (Q1 – Q4) were asked in this section and response were as depicted as per computations on the scale rates of 1 to 5 and figure below consolidates feedback;

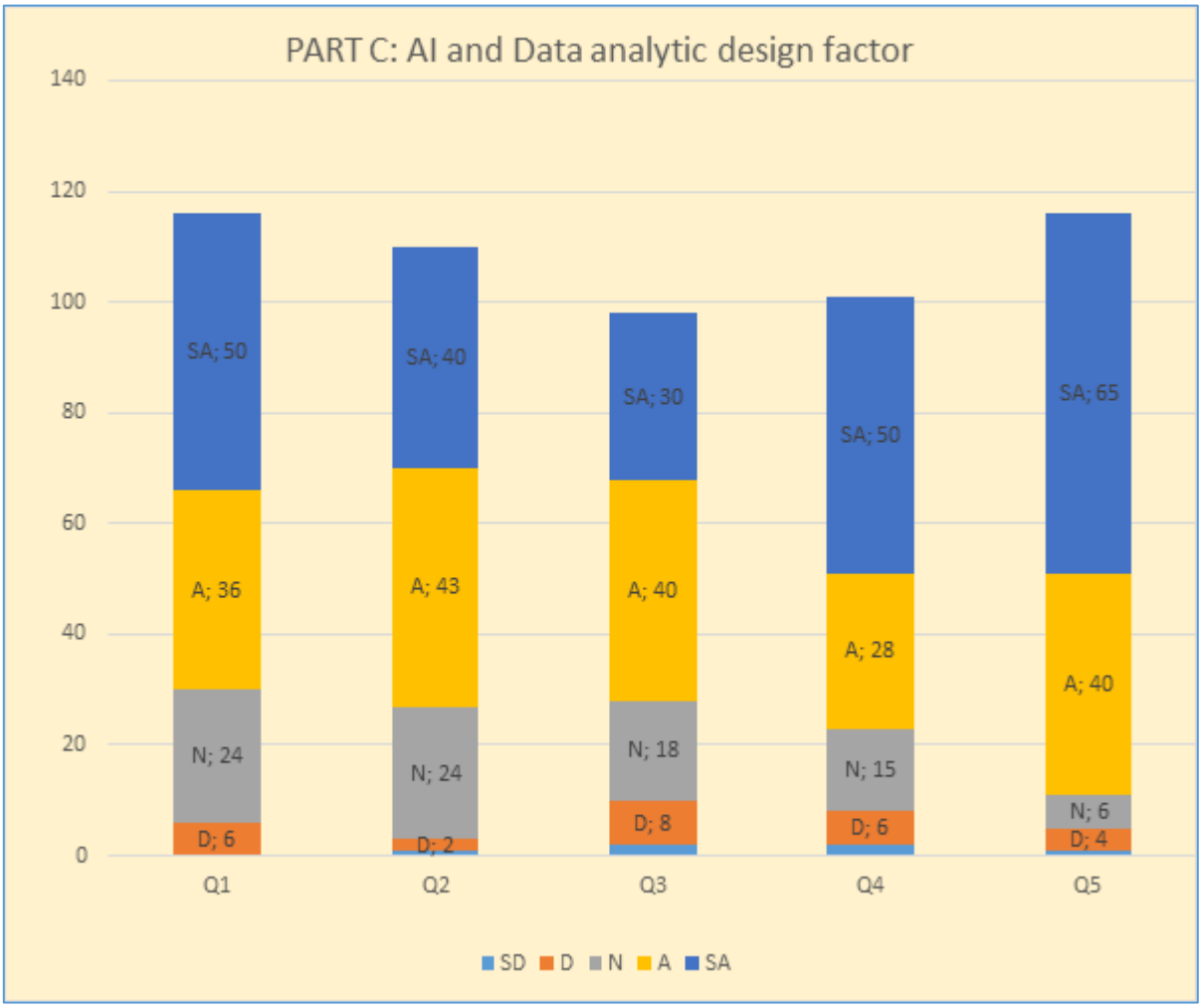

Fig 8.0 Part C-AI and data analytics design factors

According to the survey results analysis on fig 8.0 - AI and data analytics design factor considerations, Q1 of part C (AI device do monthly meter readings submissions to WUC) 3 households disagree with the ideas of AI device submitting readings on monthly bases, 8 were

neutral, 9 people agrees and 10 residents households strongly agrees with the proposals of AI automations of monthly submissions of meter readings. Q2 of part C (Data Analytics Applications receives data collections from AI device software) feedback appears, 1 person disagrees, 8 neutral, 11 agrees and 8 households were strongly agrees. Regarding Q3 of part C(WUC needs to set monthly water consumptions for each domestic household), 4 people disagrees, 6 people were neutral, 10 people agrees and 6 households residents strongly agrees with the idea of set aside monthly threshold limit. On other operational design factor of AI and data analytics software model, Q4 of part C (Acceding water consumption threshold triggers alerts message to household) responses were as follows; 3 people disagrees, 3 neutral, 7 agrees and 10 people strongly agrees with the proposal for the design model to be able to send SMS alerts notifications based upon acceding threshold limit, either daily or monthly consumptions.

5.7.1. Part C Conclusions

The study analysis for the operational design factor of AI and data analytics software model, majority of feedback are in agreements of ideal solutions of threshold limit, SMS notifications and the submissions of meter readings to big data analytics application for further processing to produce required decision making reports for the utilities corporations.

5.8. Part D: Benefits of the study design model to WUC

One of the objectives of these study is to identify benefits cost of the proposed software design model and these has been elicited in part D of the study questionnaire with the below respodents feedback;

		PART D: Benefits of the Design model to WUC			
	SD	D	N	A	SA
Q1				40	95
Q2			6	36	90
Q3		2	18	28	75
Q4			9	44	75

Table 3.0 Part D- Benefits of the software design model to WUC

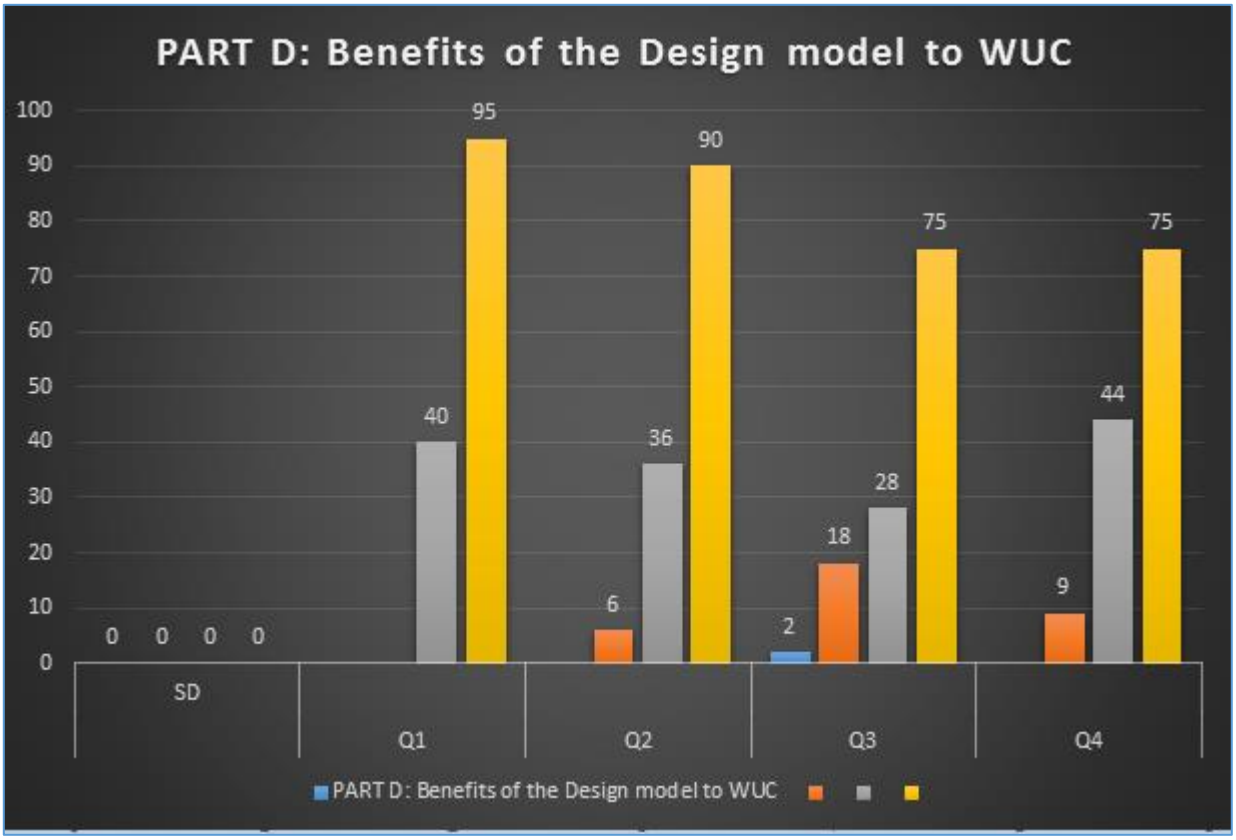

Fig 9.0 Part D-Benefits of the software design model to WUC

Q1 of part D (The technology could removes barriers of doubts and inaccuracy of meter reading data collections) has clear messages from respondents that they are 100% in agreement with the ideal technology and none of the respondents indicates disagreements neither neutrals. However, Q2 of part D (AI and Data analytics technology would provide accurate and reliable data from different meter readings of individual household in an efficient and effective manner) were as follows; 2 people scoring rates of 6 points were neutral, 9 agreed and 18 households scoring 90 points were strongly agreed that the study design model can provide reliable and accurate billings in an effective and efficient manner. Regarding Q3 of part D (WUC management and government decision making for water projections would be based on accurate informations and make decisions as how water could be apportioned across the cities and urban areas as compared to villages), 2 people strongly disagrees, 6 neutral, 7 agrees and 15 household respondents were strongly agrees that an informed and appropriate decisions will be made based on accurate informations. Q4 of part D (The technology would increases public

trust and confidence on the WUC water bills and lowers the customers complaints) as per table 3.0 above, none of respondents disagrees with these question, however 2 (6 points) people were neutrals. 9 and 18 respondents were respectively in agreement and strongly agreement.

5.8.1. Part D Conclusions

Based on part D results analysis of the respondents above, a conclusion could be drawn that majority of households from both areas of villages, towns and cities feedback are in agreement that AI and data analytics software design model could greatly benefits WUC and the country of Botswana at large. The overall agreeable effectives and efficiency improvement of AI and data analytics applications are approximately 87% from sampled household domestic water community studies.

5.9. Part E: AI & Data analytics Technology challenges

Respondents were also posed with some questions regarding technological challenges which are likely to hinder the implementations of the software design model and feedback were as follows;

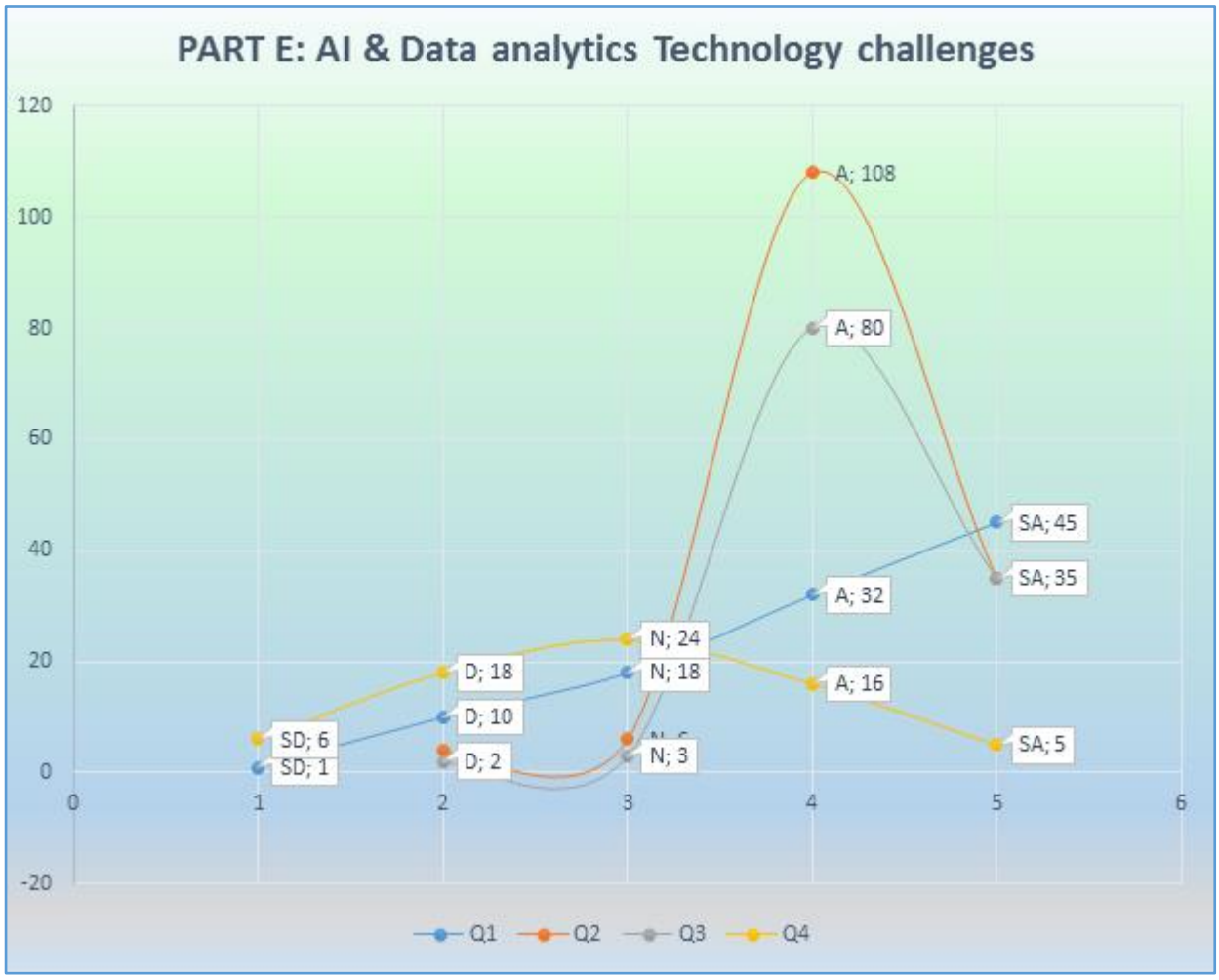

Fig 10.0 Part E- Data analytics Technology challenges

Fig 10.0, Part E denotes technological challenges feedback from respondents which may be predicted to implement the study solutions. Q1 of part E (Unreliable IT infrastructure will pose a resistance to AI and Data Analytic Software model adoption by WUC or government decision makers) responses were as follows; 6 people strongly disagrees, 5 disagrees, 6 were neutral, 8 agrees and 9 households respondents were strongly agrees. It is therefore indicates that seventeen (17) respondents in total agrees with the poor IT infrastructure in WUC would leads management to resist to adopt and implements the study proposed solutions. Only few respondents (11 of 34) feedback shows disagreeing with the ideology of failure to implement the study proposals due to management and stakeholder's resistance. However, six (6) neutral responses does were not sure. Q2 of part E focused on the awareness and training public usage of technology regarding the study and

responses were; 2 people disagrees with technological trainings, none was neutral, 28 respondents agrees and 7 were strongly agreed that training and awareness of WUC staff and public domains on the use technology proposed by the study solution is requirement for the successful implementations of the study solutions. Q3 of Part E (The technology may faces a challenge of doubts by WUC management and staff as a loss of job to employees) feedback are as follows; only 1 respondents disagrees, 1 was neutral, 20 agrees and 7 strongly agrees that the study solutions may pose a challenge of management doubts when implementing the solutions. Regarding maturity of Botswana (Q4) as country to implement technological tools like AI and big data analytics, respondents were disagreeing that Botswana has no capacity to implement the study solution. Only 5 respondents disagrees but 8 people were neutral as indicated in Fig 8.0 above.

5.9.1. Part E Conclusions

Part E is concluded that majority of respondents agrees that the study proposal will hit decision makers challenges to implement due to unreliability of IT infrastructure in Botswana and job loses doubts. Although the respondents shows a higher hopes from the study that AI and data analytic software design model would address their outcry of high bills due to wrong meter readings but there is still a high perceptions of failure of the study implementations due to lack of management support. 100% of the respondents have agreed with the training and awareness requirements for the succession of the study proposals. However, 27 of 29 respondents regarding job losses due to implementation of study solutions were noticeable. Most respondents disagree with the idea that Botswana as a country is still immature to implement the study solutions.

5.10. Part E: Demographic data analysis

The demography analysis study of these research will focus on the age group of the sampled household water residents, residential types of the household, domestic water consumptions groupings and gender based analysis of the respondents.

5.10.1. City residents demographic analysis

As stated above that a total of twenty (20) questionnaires were distributed for city residents only but only 15 managed to respond and returned feedback. Their monthly approximate

consumptions are as follows; 5 households consumes 10-20m^3 of water, 4 response to 20-30m^3, 4 response to 30-40m^3 of water. However, 2 respondents were neutral without knowing their monthly consumptions due to lack of informations from water utilities corporations. Some were also complaining that they can't respond to their water consumption rate due to unavailability of information on their bills. Age grouping of respondents were also considered for these study to identify who supports the technological idea of artificial intelligent integrated with big data analytics. Of the 15 returned respondents, 12 were aged between 35-55 years and 3 were aging between 26-35. The results indicates that most water households in city areas are age group of 35-55 years and the embrace technology.

5.10.2. Town residents demographic analysis

Lobatse town residents were used to represents other towns in Botswana and ten (10) questionnaires was distributed to the households and only six (6) were retuned. Of the returned 6 respondents, only four (4) are able to know their monthly readings collections but other 2 did not know how much of their monthly domestic usage of water. Those fours who knows their water consumptions, 2 respondents ranked their monthly meter readings from 20-30m^3, 1 respond with 10-20m^3 and 1 with 50-60m^3.

5.10.3. Village residents demographic analysis

Village residents are not part of the scope of these study but were distributed to identify certain behavior in terms of the technological enhancements that could be used to improve humanitarian lifestyle like AI and data analytics applications. 10 copies of questionnaires were distributed and 9 were returned with feedback and only one did not return feedback. However, the village residents domestic meter readings were as follows; four (4) responses are 10-20m^3, 1 respond with 20-30m^3 and 1 respond with 30-40m^3. However, 2 respondents were neutral meaning they don't know their monthly meter readings.

5.10.4. Demographic analysis conclusions

Based on the demographical analysis of the villages, towns and villages, it is clear that lot of information regarding meter readings of respondents are unknown due unavailability of records hence most responses indicates the highly requirement of AI and data analytic

software model that would avail of informations regarding meter readings, billings and monthly trend analysis of individual domestic water usages.

5.11. Qualitative Results analysis

These chapter aims to qualify some relevant informations which researcher may not be able to numerically quantifies and these has been conducted through interviewing few WUC staff members and even sampled city's residents. The researcher has observed high hopes from the respondents during explanations and distributions of questionnaires indicating that the study is mostly welcome and would help to address their main issues with WUC Botswana. Household's residents were privileged to write their views regarding the AI and data analytic solutions which was provided in the questionnaires as a semi structured questions. However, WUC clerical employees were interviewed to gather their expectations regarding the AI and data analytic software design model to address issues of high water billings and customer complaints in Botswana towns and cities. Mixed feels were observed, however, majority of the feedback reveals high appreciation that there is mismanagement of water and unreliable billing data is used by water Utilities Corporation to maximize its profit. The researcher also noted that most employees reveals their grievance of mistreatment but it was evidence that something needs to be improved regarding domestic water billings. It was also evidence from both villagers and urban residents that a computerized solution for meter readings collections from individual's homes to overcome a lot of mistrusts and myths regarding their water consumption bills is required as per study suggestion. Two (2) Water engineers were also interviewed and they were complaining of water data records which are scattered around the user's computers and embraced the study's technology to integrate all systems that works with water data. The researcher has also experienced lots of questions from interviewees regarding the solutions and some were asking questions related to cost implications of the software and explanations was made clear for purpose of the study.

6. Ethical Consideration

Fouka and Mantzorou (2011) has explained that ethical considerations is a critical requirements in any research work. Ethics lay downs the standards and procedure for conducting the research

distinguishing between doing right or wrong. These study was conducted under the ethical guidance for all requirements of daily research work and information security of the consent sampled participants and their privacy is protected before any publication could be done (Fouka and Mantzorou, 2011). It is the responsibility of the researcher to safe guard participant's personal information and their rights are protected by the study. Information confidentiality of the research participants are highly considered and their private personal information is secured during the research project. The researcher's collaborative work between respondents of water household participants and WUC employees for trustworthiness, accountability, and mutual respect among researchers. The public is assured that researchers followed the appropriate guidelines for issues such as human rights, animal welfare, compliance with the law, conflicts of interest, safety, etc.

7. Conclusions

It has come to the conclusion that these research proposal of exploring and designing AI and data software model as solution would close the gap of doubts between WUC Botswana and its clients/ , domestic household water digital meters is an important tool to address high water billing crises in urban areas. The software design is modeled to integrate machine learning technology through AI module device, BDA applications and digital smart meters to automate the process of data collections from individual domestic household water meter readings. It is also concluded that the solution would employ internet of things (IoT), network architecture of digital meters within cities and towns through telecommunication authorities. BDA has proofed to be lower cost in terms of infrastructure resources usage both hardware and software technologies (Romero et al, 2017). Big Data analysis through machine learning is proven paramount important tool to support management decision making and trend water information prediction usages in domestics household. These study integrates numerous technologies to design an integrated enterprise systems through web services like SOA and employs RPC as its main communication protocol to render required services. The research has reviewed previous similar works of using BDA technology and proven that developers can create value based on specific identified data sources and perform processing through analytical tools to meet some specific business requirements (Ziman, 2016). The study base its Enterprise Service Bus on Synchronous communication mode for the proposed solutions. These research work utilized mixed methodologies of data collection tools through interviews and questionnaires to quantify analysis of randomly picked small sampled household and qualify the study ideology by WUC staff interviews. Qualitative data were collected by interviewing WUC employees to identify

some gaps and relevant informations as well as risk assessment techniques which could also assist for decision making. Based on results analysis of the study, 87% of respondents are in agreement that an efficient and effective meter readings collections needs to be automated and a software design model is required to handle huge amount of complex data across WUC enterprise systems. The study of exploring and designing an AI and data analytic software model to address high domestic water billing crises in Botswana urban areas has raised a high hopes to small sampled household communities. The research has experienced much appreciations from WUC staff for the proposed study technological advancement solution to water management.

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