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Design and Implementation of Customized Enhanced Patient Calling Device Using PIC Microcontrollers

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Abstract: *In both traditional and electronics based system of queue, queue management is still an issue for both customer and facility manager, especially in medical facilities. In the traditional queue, patients sit in chronological order and then continuously shift forward as early comers go into consultation with doctors. In this arrangement, order is usually disrupted when a queuee leaves and wanted to return to his former position. On it part, the electronics based queues call patient by means of dedicated electronic hardware but fails to account for absent queuee. While the problem of arranging patients in chronology order of arrival had been solved with the introduction of electronics queue management system, the issue of absent queuee is still beyond present technology even the most advanced system in which patient calling system is linked with patient database that solves the problem of physical file movement. The Enhanced Patient Calling Device [EPCD] is a microcontroller-based queue management system designed with the ability to handle absent patients from the queue in the form of a 'slot-back', using 'slot-back model equation' coded onto PIC18F45K22 and PIC16F877A microcontrollers. The developed device presented here is capable of electronically queuing patients for consultation with doctors, enables a doctor to send patient to pharmacy or other units within the facility, allows the doctor to slot-back an absent patient, and permits the doctor to attend to other issues like emergency via the use of 'busy' key.*

Key words: *Queue management, Slot-back model equation, Patient calling, absent queuee, and Microcontroller*

1.0 Introduction

The customized enhanced patient calling device (EPCD) is a microcontroller based electronics device, designed depending on the prevailing situation in a specific medical outfit in order to help medical workers to manage queues. It works by electronically queuing patient in chronological order with extra ability to take care of patient(s) that is/are absent on the queue when called (absent queuee) using the slot-back model

equation in Aboaba , Abideen, & Dibal (2017). Thus, leading to drastic improvement in managing patient's queues. Traditionally patients that come to consult with doctor in the hospital sit in a chronological order, with patients facing the problem of lengthy queues and unpredictable waiting time. This situation is still in existence in the developing countries. This method of managing queue results in stress especially for seriously ill patients and even the facility staff related to queue management. In advanced situations, an electronics calling system is used where patients are tallied and the tally number is displayed on a screen when it is the turn of the patients to consult with the doctor, and files are collected manually at the record office and then arranged before the doctor. In a more advanced situation, the electronics tallying and calling system are linked with patients' electronics database in which a called patient medical record appears on the doctor's PC from where he reads and writes his observation and prescriptions and passes the record to the next location. However, all the aforementioned queue management systems do not take care of patients that are absent from the queue as at when called (absent queuee).

2.0 RELATED WORKS

Many research works had been presented aimed at addressing specific area in queue management in general and patient queue in particular. In Mucsi (2011) an Adaptive Neuro-Fuzzy Inference System for estimating the number of vehicles for queue management at signalized intersections was proposed. The main purpose of the work is only to count the number of vehicle approaching and leaving a traffic junction but work succesfully at the prototype level. It can also be expanded to work in real life. Basil & Aswin (2013) presented a novel intelligent System for Efficient Queue Management.The system was tested and the results show a lot of efficiency in managing queue for the public places but the system was unable to call out token numbers with speaker and can handle only 100 customers. Software based Queuing Model for Health Care Pharmacy was also proposed in Mohammed et al (2015). The main purpose of the work is to manage queue for outpatient pharmacy workflow in the hospital. But it only stops at the prototype and also does not have the capacity for slot-back which enables the patient to attend the call of nature and other exigencies. The use of GSM Technology in queue management was reported in the work of Arun & Priyesh (2013). The design was tested and found to be working according to the specification but the system cannot get location of the customer and cannot calculate distance between customer and the service area. Ramasamy & Chua (2012) advanced a new way of queue management which is electronics based with SMS notification. At the beginning, a queue management devise will issue a queuee with ticket and the device later announces the ticket number when service is available. This eliminates the need to stand in line while waiting. This work was design to manage queue in banks and does not have the ability to handle slot-back if a customer is absent. More so, the design stops at the prototype, cannot handle search function and does not generate customer information by range of date. Bhupender et al (2017) proposed a heterogeneous queuing system with reverse balking reneging but the limitation of the work is that it is limited only to two heterogeneous servers and does not have capacity for slot back. Bylayat et al (2011) designed a microcontroller-based systems aimed at maintaining queues with order and efficiency using two different queue control systems. The two systems were implemented with slight difference features resulting in EQC system-1 and EQC system-2. EQC system-1displays token number and service counter number whereas EQC system-2

display token number individually in each service counters with separate displays. However, the system cannot determine the total number of customers per certain time. The description of the implementation of paperless queue management system with the aid of Arduino UNO microprocessor board was presented in Jidin & Yusof (2016). The system has the potential to reduce paper usage at customer service premises. Furthermore, it also provides additional features such as SMS Reminder generation and ability to process remote ticket requests via SMS which allows more efficient queue management. However, there are rooms for improvement, to make the system more useful, more reliable and effective. It may contribute to green technology.

Furthermore, Rashid at el (2016) proposed a system called Automation of Queue Management System for organizing queuing systems; it works by initially analyzing the queue status and then takes decision as to which customer to be served first. The work focuses on the banks queuing system, and different queuing algorithm approaches which are used in banks to serve customer and the average waiting time. The queuing architecture model can switch between different scheduling algorithms according to the testing result. However, the work stops at prototype and camera is also needed for the bank manager to see customer from far away. An attempt to retain bank customers at the ATM points who are dissatisfied with lengthy queues and unpredictable waiting time was implemented only to the level of simulation by Rahman (2013). The work of Aboaba, Dodo, Umar, Samuel, &Amaza (2015) tries to solve the problem of inability of both the traditional and modern queue system in handling absentees. It is a microcontroller based system that tallies patients and displays the tally number on the LCD, and also has the ability to handle absentees in the form of slot-back model equation. However, the work only end at the prototype stage and the slot-back model equation is deficient. Nevertheless, the deficiency in the slot-back model equation was corrected in Aboaba et al (2017).

The current work is an improvement on Aboaba et al (2015) and Aboaba et al (2017) in that both the slot-back model equation and hardware implementation have been modified and implemented in real life. Thus, an absent patient would be slot-back into the queue owing to the slot-back position (SbP) equation already coded into the microcontroller, the equation is given as:

$$SbP = LAT\ A \times \frac{1}{(\frac{ACT}{NDD})} + C \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (i)$$

where: LATA is Longest Average Time of Absence
ACT is Average Consultation Time
NDD is Number of Doctor on Duty

3.0 Methodology

The focus of this study is to design and implement the enhanced patient calling system (EPCS) using parameters like LATA, ACT, and NDD derived from data collected from University of Maiduguri (UNIMAID) Medical Centre. Owing to the plan to enable EPCS to handle absentee patient (queuee) in the form of slot-back, the needs of a patient on queue that will warrant him/her to leave the queue were determined. These were found to be needs like snacking, and attending to call-of-nature (visiting conveniences), hence the

needs were parameterizing into quantifiable units of action Aboaba et al (2017). As reported in Aboaba et al (2015), the methodology adopted for this work is to data collection and analysis, and resulting into mathematical model of the slot-back position (SbP) equation Aboaba et al (2017). These culminated into development of circuit for the implementation of EPCS.

a. **Field work**

To know the position to be reserved (known as slot-back) for an absentees' patients, there is need to know and record the average consultation time per patient, average number of patient that could be consulted per day, average number of Doctors present per day, the availability of conveniences within the medical centre, and the total time taken to go and return from the nearest snacking point to the medical centre owing to absence of one in the centre premises. Several days were spent recording the time spent by individual patient with the doctor (consultation time), and at the end, the average consultation time (ACT) per patient was determined.

b. **Survey**

For the survey, questionnaires were distributed among students and staff living on campus whose primary health care facility is the University Medical Centre to determine the time taken by individual to complete those activities deemed expedient while on queue. Eighty-eight percent (88%) of questionnaires distributed were returned and the received questionnaires were then analyzed and the average time it takes to complete any of the three (snacking, urinating, excreting) activities when sick was determined.

c. **Summary of Field Work Results and Data Analysis**

In this section, a summary of major indices in all data analyzed are presented in tabular form in table 1

Table 1: Summary of Major Findings

S/N	***ACTIVITY***	***TIME in Minutes***
1	Average Time for Snacking (ATS)	15
2	Average Time for Urinating (ATU)	7.5
3	Average Time for Excreting (ATE)	12.5
4	Average Time Taken to and fro from Snacking point (ATTS)	9
5	Average Consultation Time (ACT)	3

Based on the assumption that an absentee patient must have gone for the activity that takes the longest time, hence the average of the individual treks was found and added to the average time taken to snack. At the end, the longest average time of absence (LATA) of the patient called Longest Average Time of Absence (LATA) was defined

$$LATA = ATS + ATTS \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (ii)$$

3.1 The Model Equations

Based on the activities and time taken in table 1, a model equation was derived from the data analysis. The model equation was used to determine when next to recall an absent patient who has been queued before leaving, and invariably at what position he/she would be slot-back into the queue from the time his/her token number was displayed. This resulted into equation (i) called slot-back position equation derived in Aboaba et al (2017). It should be noted that equation (i) is a linear equation with NDD being the dependent variable that may vary from time to time even within a day. LATA and ACT are hospital specific, while C is a constant which could be zero (0) or one (1).

$$SbP = LAT\ A \times \frac{1}{(\frac{ACT}{NDD})} + C \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (i)$$

In which: LATA is Longest Average Time of Absence

ACT is Average Consultation Time

NDD is Number of Doctor on Duty, and

C = Ñ, & 0≤ C ≤1, in which C is 1 when mx is a natural number, and C is 0 when mx is non-zero real number round up to the nearest whole number.

3.2 Enhanced Patient Calling Device Design and Evaluation Algorithm

The Enhanced Patient Calling Device (EPCD) design algorithm is an outline of sequence of steps taken to actualize the device, the flowchart of the device design, and it also includes evaluation algorithm of the device.

3.5.1 EPCD Algorithm

Step one: The Slot-back Position (SbP) Equation is programmed into the Microcontroller in Assembly Language.

Step two: The two slave Microcontrollers were also programmed in Assembly Language.

Step three: The two slave Microcontrollers were linked to the Master Microcontroller via COM PORT.

Step four: In conjunction with other discrete components that supports the Microcontrollers, the device is first implemented in PROTEUS Environment.

Step five: The PROTEUS Environment version of the EPCD is simulated.

Step six: The EPCD was then assembled on Breadboard.

Step seven: Conduct specification test on the Breadboard version of the EPCD.

Step eight: Transfer the device onto Circuit board.

Step nine: Conduct specification test on the Circuit version of the EPCD.

Step ten: Evaluate the performance of the EPCD following the test sequence in section 3.5.3

3.5.2 EPCD Design Program Flowchart

Figure 1 shows the flowchart which described the working of the device.

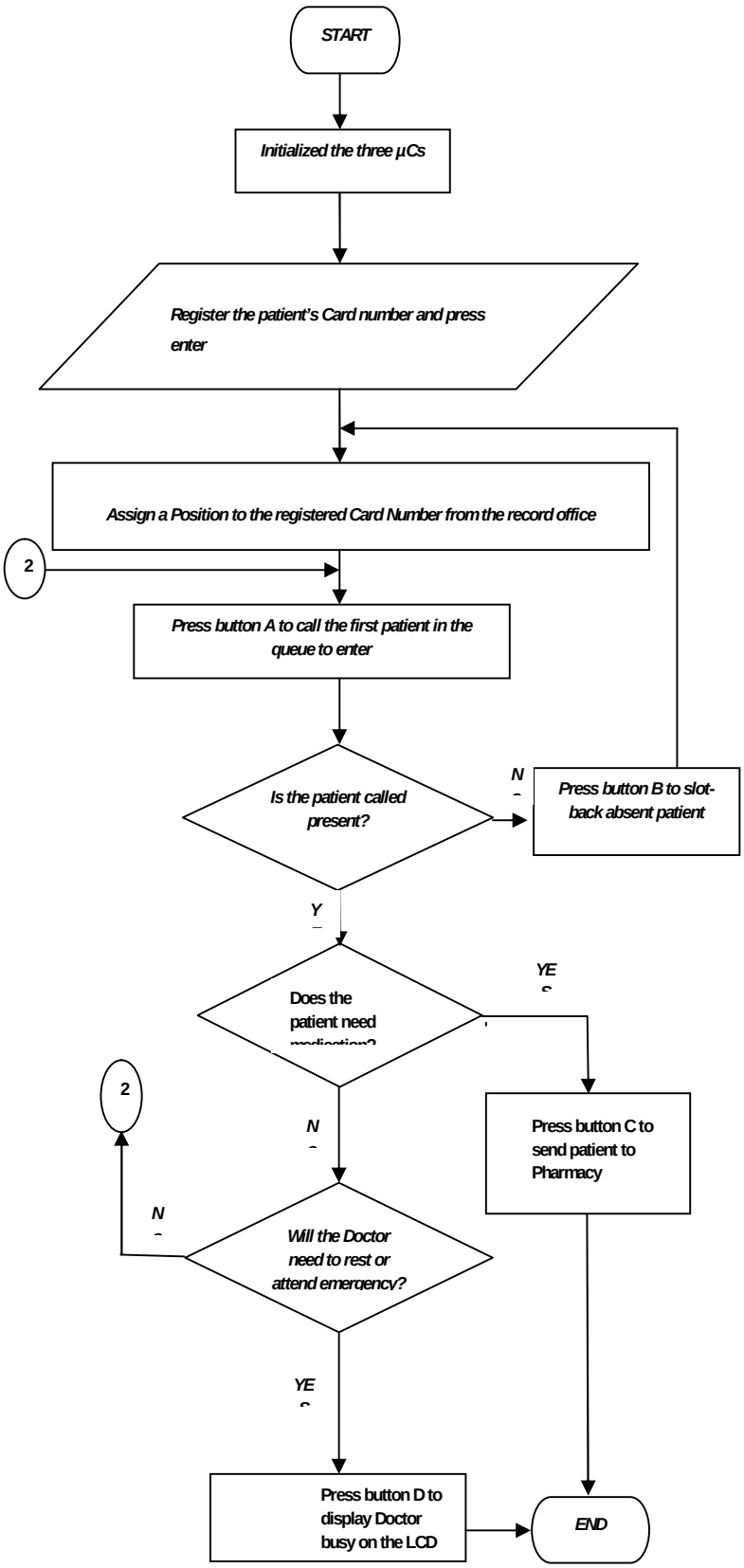


Fig.1: Flowchart diagram of EPCS

3.5.3 Enhanced Patient Calling Device Evaluation Algorithm

The evaluation algorithm is a sequence of steps to test for the functionality of the different parts/aspects of the device.

Step one: Microcontrollers of the EPCD were initialized.
Step two: Patients were queued on the EPCD using tally numbers according to arrival sequence.
Step three: The doctor pressed button A to call up the first patient on the queue; the tally number will be display on the LCD so that all the patients on the queue can see.
Step four: If patient is not around button B is pressed by the doctor to instruct the microcontroller to slot-back the absentee patient (queuee) by automatically inserting the absent queuee tally number in the queue using SbP Equation embedded into the Master Microcontroller.
Step five: Else, patient is present; the doctor will attend to him.
Step six: If the patient attended to needs medication, his tally number will be is sent to pharmacy unit by pressing button C.
Step seven: If the patient attended to does not need medication; meaning the patient need to leave from the consulting room, the Doctor calls the next patient by pressing button A.
Step seven: If the Doctor needs to rest, he presses button D; Doctor resting is displayed on the LCD.
Step eight: The Pharmacist presses button E to call up next patient in the pharmacy unit queue, and the patient tally number is displayed on the pharmacy unit LCD.

3.6 ENHANCED PATIENT CALLING DEVICE DESIGN

Since in the hospital there is only one pharmacy, one record office and even though there are more than one consulting room, only one consulting room is provided for in the design. The microcontroller in the Doctor's office served as the Master while the microcontrollers in the pharmacy and the record office will respectively serve as the slave2 and slave1. The medical record tallies the patients, and the tally number and the patient file number are saved in the memory of the Master. The Doctor then initiate call from his device, after consultation, he presses another button to send the patient to the next point or discharge him/her altogether. Microcontroller PIC18F45K22 was chosen as the Master, while PIC16F877A is slave1 and PIC16F877A is slave2 as shown in figure 2

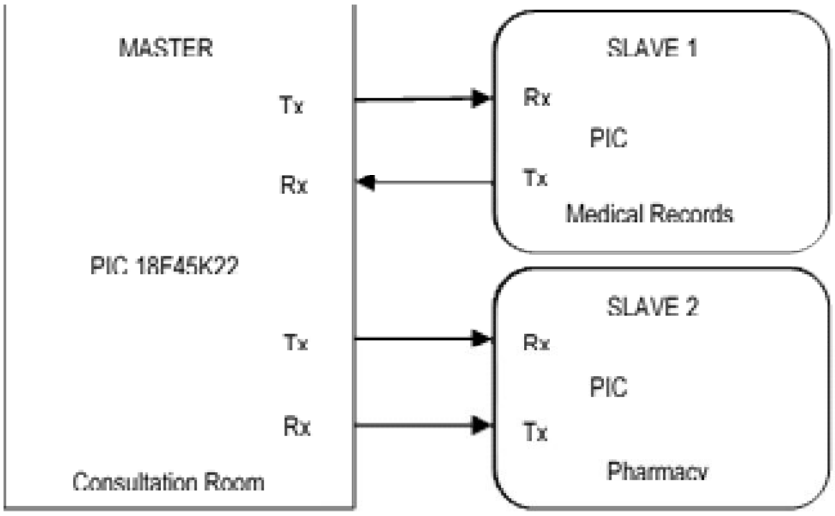
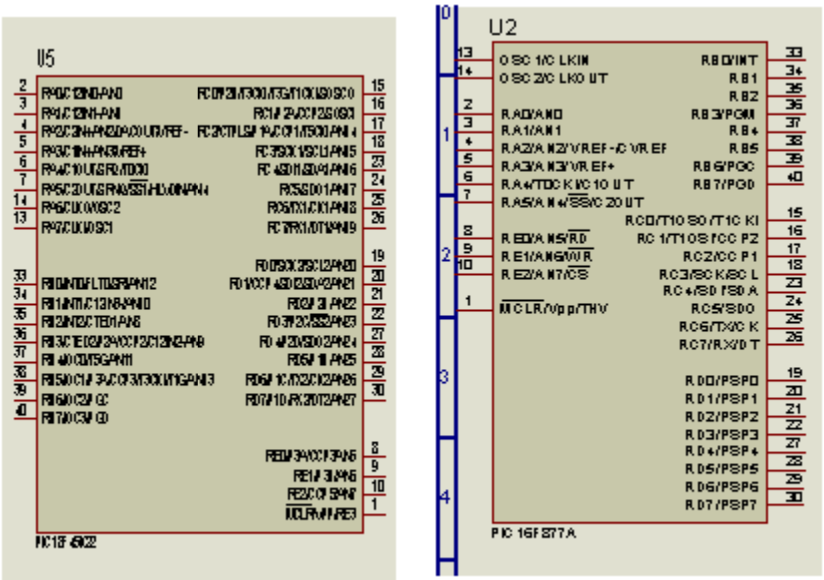


Fig 2: Design Block Diagram

The Master microcontroller (PIC 18F45K22) has two Universal Asynchronous Receiver Transmitter (UART) ports situated on pins 25 &26, and pins 29& 30 that is Tx1 & Rx1, and Tx2& Rx2 respectively. More so, the two Slave microcontroller used are of the same type (PIC 16F877A) having one UART port each. The port is on pins 25 & 26, that is Tx & Rx. Each one of the UART of the Master is connected to the UART of one of the Slave named Slave 1 and Slave 2 respectively. Figure three shows Master-Slave configuration.



As shown in figure 4, each of the microcontrollers is connected to their respective LCD Display to display patient's tally number and beside the LCD; the slave1 microcontroller is also connected to the keypad to enable the medical record officer to enter patient's card number on first-come-first-serve basis.

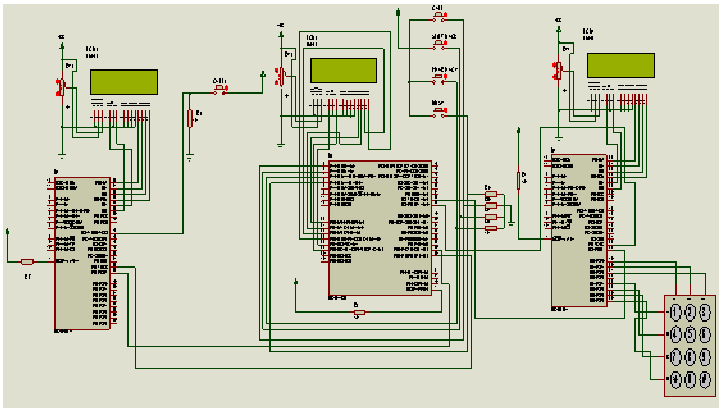
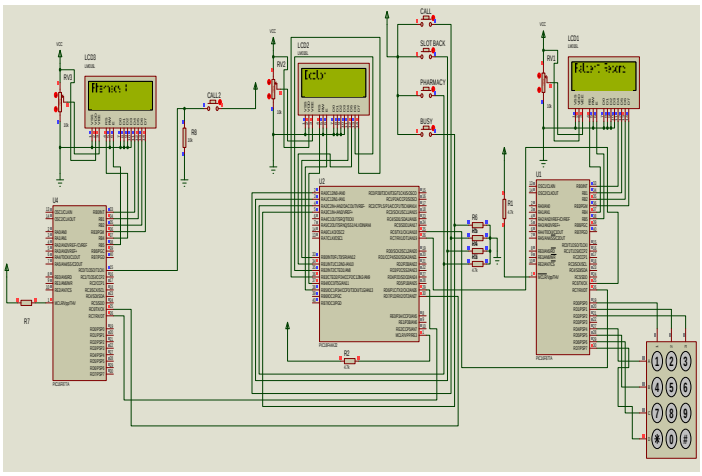


Figure 4: Interconnection of Master-Slave Microcontroller in Connection with LCDs

4.0 IMPLEMENTATION AND TESTING

Following the algorithm design and the flowchart, and using programmable microcontroller ICs (PIC16F877A and PIC18F45K22), the source code was compiled using micro C COMPILER. Proper consideration was given to the code during compilation in



order to avoid any logical errors. The test-run was done using interactive electronic simulation software called Proteus 8.5. The hex file was then generated and transferred to the PIC18F45K22 and the two PIC16F877A Microcontroller, using Kit3 USB programmer. The design was simulated on a computer to study and analyze the behavior of each stage before physical implementation was carried out, the implementation was finally assembled on Vero board after it initial assemblage on Bread board and tested.

4.1 SIMULATION RESULTS

Figure 5shows system initialization immediately after switching ON.While figure 6 Shows patient's number being inputted into the system via keypad.

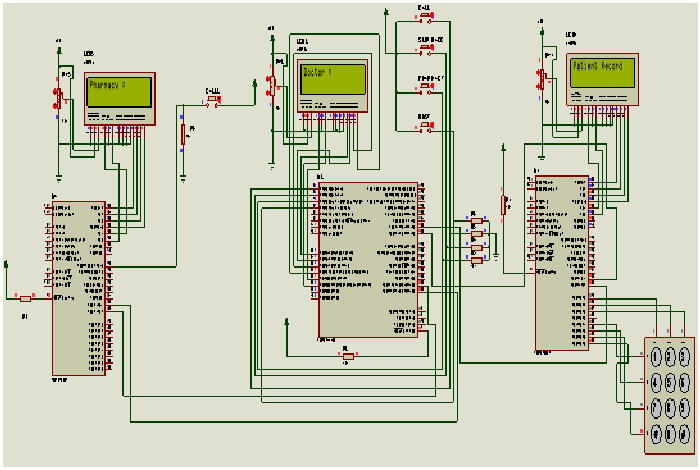


Figure 5: Simulation Results

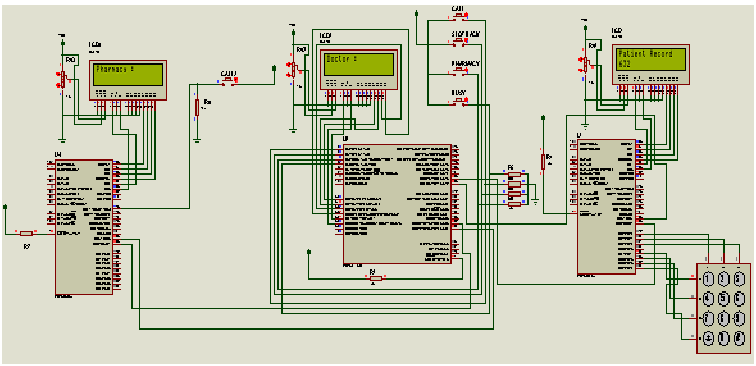


Figure 6: Inputting Patient's number into the system

In figure 7 and 8, the Doctor calls a patient by depressing the switch A (call button) and the recordedpatient number is shown on the LCD connected to the microcontroller controlling the consulting room devices. The card numbers had been previously stored in the system, and patients with card numbers 5 and 96 are called successively.

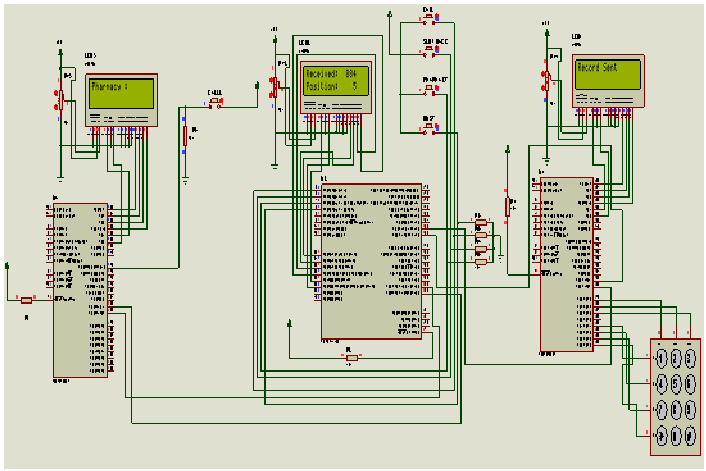


Figure 7: Doctor calling patient with card number 5

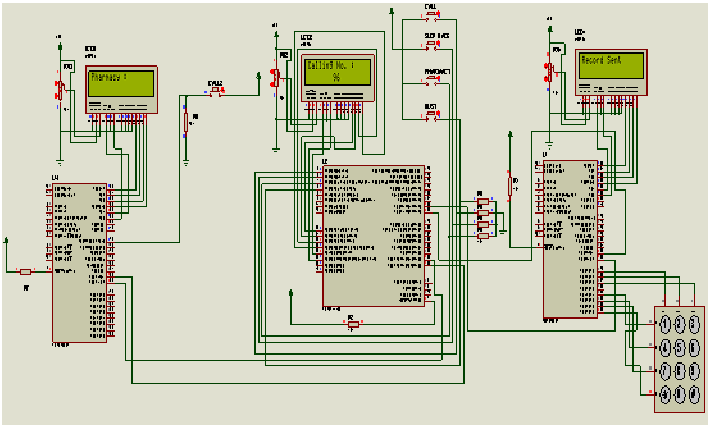


Figure 8: Doctor calling patient with card number 96

In figure 9, Pharmacist is shown calling patient with card number 057 sent by the doctor. The button for sending patients to the pharmacy from the consulting room is switch C.

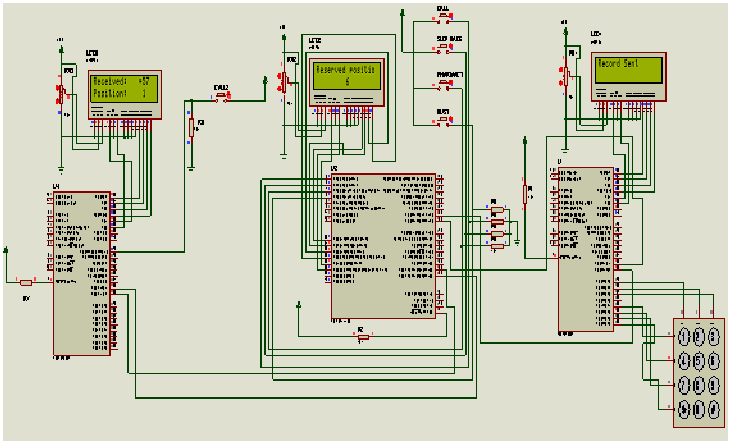


Figure 9: Pharmacy calling patient with card number 057

With respect to an absent queuee, the slob-back process is shown in figure 10 in which the absent queuee is slob-back into position 5 based on the slot-back position equation.

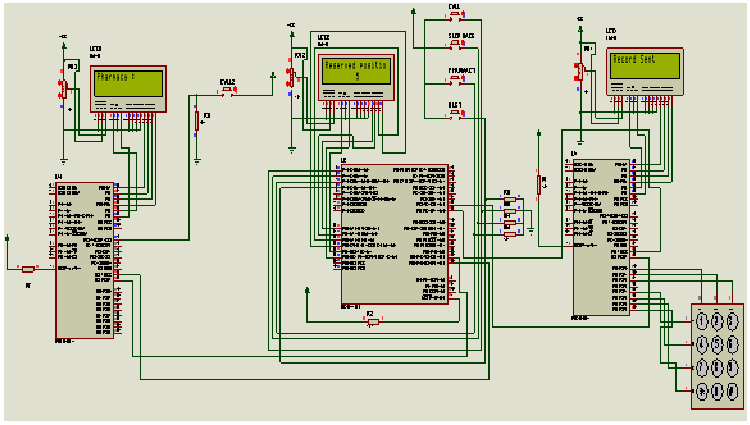


Figure 10: Absent patient (queuee) slot back into position 5

4.2 DICUSSION OF RESULTS

When the system is ON it will initialize the three microprocessors, then the clinic record office tallies the patients (the patient card number is registered on the system and it is automatically queued by the system and saved in the consulting room microcontroller) via the system's number keyboard connected to the microcontroller dedicated to the clinic's medical record office as shown in the simulations above. At the Doctors' side, four switches were provided labeled (A, B, C, and D) in which all the switches have specific functions to perform. The doctors switch on their stations devices when ready, and press the switch A to call the next patient. If the patient is absent switch B is depressed to slot the patient back into the queue based on equation 1. If the patient needs medication, switch C is pressed to send his/her card number to the pharmacy. When the Doctor is busy or attending immergence, switch D is pressed which indicates 'Doctor Busy' on the screen outside the particular consulting room. The doctor simply depresses switch A to call the next patient if the current patient is free to go home.

5.0 CONCLUSION

In conclusion, the sole aim of carrying out the design and construction of an Enhanced Patient Calling System has been achieved. The aim was to develop an efficient and reliable enhanced patient calling system, which was successfully realized at the end of the design and construction process. One factor that accounts for the uniqueness of the product is the ability to slot back an absent patient. The system was tested and found to be working to specifications and predictions. It is a model for cheap and reliable way of managing queues in public places, but the implementation of this produce is based on data collected from the university of Maiduguri Medical Centre.

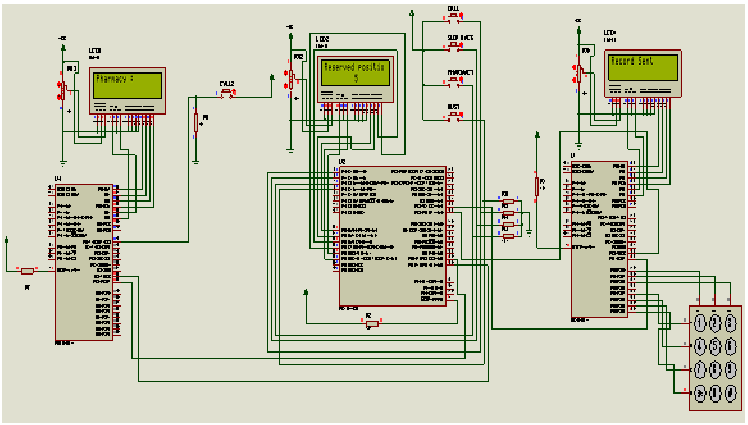


Figure 10: Absent patient (queuee) slot back into position 5

5.1 RECOMMENDATIONS

Although the aim and objectives of this work have been accomplished, there is still room for improvement on the work done as listed below:

(1) Provision could be made for GSM modem which could immediately send an SMS to alert an absent patient and inform him of the estimated time he would be called again.

(2) The EPCD presented here could, as a model be expanded to include more consultation rooms, laboratory test, radiology unit, ward, and all other sections the doctor may direct a patient to.

(3) The EPCD could be redesigned to interface with Computer system linked with the hospital database.

(4) The EPCD could be reconceived as an Application Software (Apps) to be installed on the Computer system linked to the Hospital database.

(5) Implementation of an intelligent QMS (IQMS) that learns the queuing pattern of the hospital and determines the peak periods and low period of activities thus providing the Hospital Management with the desired record to tackle and prepare in advance. In addition, using the cloud, the IQMS can learn more from various other IQMSs to optimize its performance.

(6) More importantly, it could be adapted to other areas where queue management is required such as banks, eateries, et cetera. Finally, the use of this device should be encouraged in our hospitals to engender order and increase efficiency.

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Machine Learning System for Detection and Classification of Some Diseases in Selected Plants

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Abstract: *The system will assist the farmer without formal training to diagnose plant disease through Mobile phone device. The user will start by capturing the image of the defected plant leaf using high resolution mobile phone camera and then sent the image to the server by selecting the options provided on the application. Then the MATLAB fetch the captured image from the server and apply for pre-processing for image enhancement. Segmentation of Captured leaf images is perform using k-means clustering algorithms to form clusters. Features of plant leaves are selected and extracted before applying the clustering algorithms and classification algorithm (Support Vector Machine classification algorithms) for testing and classification by comparing with pre-defined training images stored in the database. Finally, the classification result will then be sent back to user through the application on the phone.*

Key words: *k-means, leaf image, disease, farmers, Classification*

1.0 INTRODUCTION

The cost of agricultural products may increase significantly if diseases are allowed to infest plants. When these occur and are left unchecked, it would negatively affect plant's yield in terms of both quality and quantity hence, constant monitoring of plants is required in order to detect early signs of diseases before it spread Nikos (2017). Farmers looses large amount of money annually and consumers and the end of the value chain buy food products at high prices because of unchecked plant disease infestation. In view of this, there is hope that this research will be of benefit to farmers, consumers of agricultural products and also researchers who may wish to research or elaborate on their work in the future.

2.0 RELATED WORKS

Sandesh & Amit (2017) designed a system called "plant disease detection in image processing using MATLAB". The system which used k-means clustering for segmentation

and Artificial Neural Network techniques for training and classification that detect disease in both leaves and fruits with high accuracy but is very slow, and it can only detect the plant's leaves images saved in the MATLAB database.

In the work of Trimi & Sushma (2017) titled "Plant Disease Detection Using Different Algorithms" and "Artificial Neural Network (feed forward back propagation) for classification" used two different segmentation techniques thresholding and K-means clustering algorithm for segmentation. The system is fast but has limitation as it misclassifies some images which give low accuracy and can only work on MATLAB software only. The papers do not provide a clear comparison with other classification techniques.

Xin, 2017 present the application of machine learning in plant resistance genes discovery and plant diseases classification. The system used Support Vector Machine for classification which provides powerful tool to analyze tremendous amount of data and more machine learning based tools are needed to predict important plant resistance genes. (Bhog & Pawar, 2016) adopt the concept of neural network for the classification and K-means clustering for segmentation in cotton leaf disease analysis (Yellow spot, Red spot, white spot, Cercospora and Alternaria) which is able to achieved recognition accuracy of 89.56% and execution time of 436.95 second using Euclidean distance in MATLAB.

The absence of the labour-intensive phase of feature engineering and the general ability of the solution makes them a very promising candidate for a practical and scalable approach for computational inference of plant diseases in Sharada, David & Marcel (2016). The system used deep convolutional Neural Network for the training to demonstrate the technical feasibility of a deep learning approach to enable automatic disease diagnosis through image recognition. The Overall accuracy of 31.40% obtained is poor.

Only 75.9% of accuracy is achieved in the work of Suhaili et al. (2013) to classify Downey Mildew and Anthracnose for watermelon leaf diseases. Based on RGB color component, region of interest is identifying that is infected from the given testing plant leaf. The work incorporated the concept of Neural network pattern recognition toolbox is used for the classification, image pre-processing and segmentation median filter is used.

Jha, Bababe & Ashok (2017) Design a system called "Plant Disease Information Generating System Based on Android Application Technology" which uses HIS and k-mean for segmentation and clustering, Color Co-occurrence Method for feature extraction and Artificial Neural Network as classification Algorithms. The system is able to classify plant leaves with average percentage accuracy 73.648% which is too low and the researcher uses very few datasets for the experiment.

2.1 LIMITATION OF PREVIOUS RELATED WORK:

Optimization is needed for the previous work to obtain high percentage accuracy; as such best feature extraction method is needed. More information about the plant's leaf such as colour and texture is needed for segmentation as such the extension of database is required to obtain high accuracy.

The researchers were able to cover very few diseases in their work. So, more work needed to cover more diseases. One of the main reason of machine learning misclassification is because disease symptoms varies from one plant to another as such optimization of more plant features is needed for the training dataset to cover more disease cases and to obtain high result percentage accuracy.

3.0 METHODOLOGY

This research adopts a machine learning approach as the core of the system. Here, both unsupervised and supervised machine learning algorithms are employed. The k-means clustering algorithm which is an unsupervised machine learning algorithm is used to prepare and group the input data during the segmentation phase. After the segmentation phase, the support vector machine algorithm which is a supervised machine learning algorithm is then used to carry out the task of classification.

The machine learning approach to image processing is divided into five stages as follows;

i. Image capturing and acquisition;
ii. Image pre-processing and segmentation;
iii. Feature extraction;
iv. Training and Classification;
v. Reporting and evaluation.

3.1 IMAGE CAPTURING AND ACQUISITION

Image acquisition is the first step of any digital image processing and it is described as getting the plant leaf image (by snapping plant leafs image using high pixel camera from mobile phone device or any camera device) as shown in Figure 3.2 and sent to MATLAB for processing and classification. It is also the process of retrieving image from the mobile device for further processing. In this work, the healthy plant leaf and the diseased plant leaf images will be capture and stored in the server for MATLAB image processing system, this is called normality model.

This is done by interconnecting the mobile phone to the computer based server, so that the user can sent the captured image to the server for upward forwarding to the MATLAB for processing. The interfaced of the mobile phone is design in such a way that the user can conveniently use it with little training as shown in fig 3.1 below.

Figure 3. 1: Graphical Interface of Android Application

The first sub-system is the Android application installed on the android mobile phone as the system client that provides user with the interface to interact with the functions of the application. The user can choose to take a plant leaf picture from the mobile phone camera or select an image of the plant leaf from the gallery of the mobile phone to be diagnosed. Once the user selects or snap the image and press upload button, the android application will send the image to the web application server via HTTP protocol. Web application server sub-system is implemented with Java Servlet and Tomcat

3.2 IMAGE PRE-PROCESSING AND SEGMENTATION

The main purpose of image pre-processing is to improve the quality of image data by removing unwanted contortions. Pre-processing method uses various techniques such as changing image size and shape, percolate of noise, image conversion, improving image and morphological operations. Various MATLAB code to resize image, to enhance contrast and RGB to grayscale conversion is use for this work as shown in figure 3.2 for further operations like creating clusters in segmentation.

Figure 3. 2: Contrast enhanced

Image segmentation is the method of transforming digital image into several segments and rendering the image into a form that can be processed by the machine learning classifier. The main use of image segmentation is for locating the objects and bounding line of that image. K-means clustering method partitions the images into clusters so that at least one part of the partition (cluster) will contain the image with major area of diseased part.

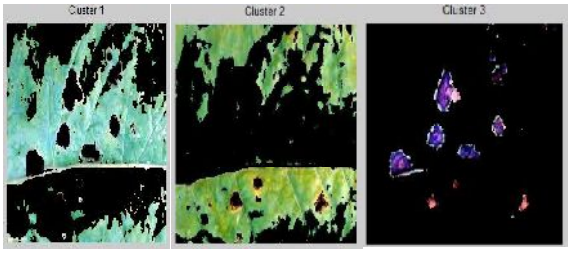


Figure 3. 3: Diseased plant leaf image clusters

3.3 FEATURE EXTRACTION

For this research, *Color Co-occurrence* (CCM) method is used in extracting features. CCM is a method in which both the color and texture of an image are taken into account, to arrive at unique features, which represent that image.

3.4 BLOCK DIAGRAM DESCRIBING THE APPLICATION OF THE WHOLE PROCESS

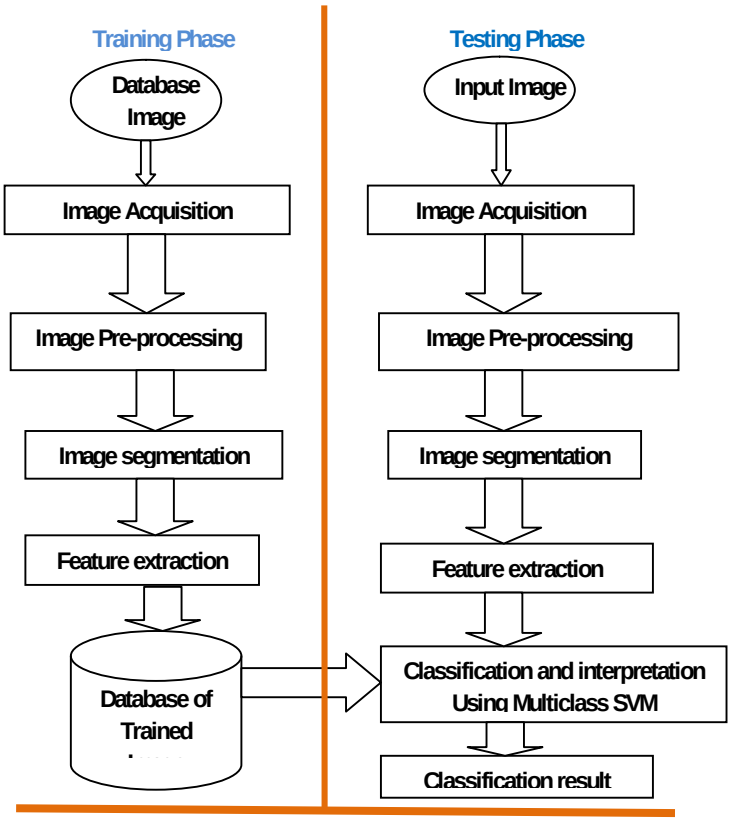


Figure3.4: Fundamental Steps of Digital Image Processing

4.1 ANDROID MOBILE PHONE APPLICATION IMPLEMENTATION

The important of this system is the ability of farmers without formal trainings to diagnose plant diseases in order to increase crop production, improvement in quality and quantity of agricultural products, burst economy and create jobs by making farming more attractive to people. It will benefit the user in a way that provide the user with the solution instantly with even low price smart phone (android) resource without having to wait for the human experts (Agriculturist and/or Agricultural engineer). The client android phone application is design and developed for android phones using java programming language. Android studio with Android SDK tools (maximum API level 23 Support) which is java based programming language software is used in designing and implementing the application software. This mobile phone application software supports all versions of androids including Android 7.2 "KitKat". The developed application software has two major

functionalities button: Image capture from camera/image selection from gallery and upload image to server.

4.1.1 IMAGE CAPTURE FROM CAMERA/IMAGE SELECTION FROM GALLERY

After clicking the icon, the very first page of the application shows a basic layout content_main.xml having one image view feature and two buttons. One button is for snapping the image with mobile phone camera and the second one is for selection of image from the mobile phone gallery as shown in the fig 4.1 below.

Figure 4. 1: Interface of the Application

Once the apps is started, the MainActivity.java class starts and the On Create() method sets the layout view to content_main.xml. The intent ACTION_PICK is sends automatically to get the image from external storage of the phone by this class. On the image view, the bitmap is set as shown in fig4.1.2 and fig4.1.3 below.

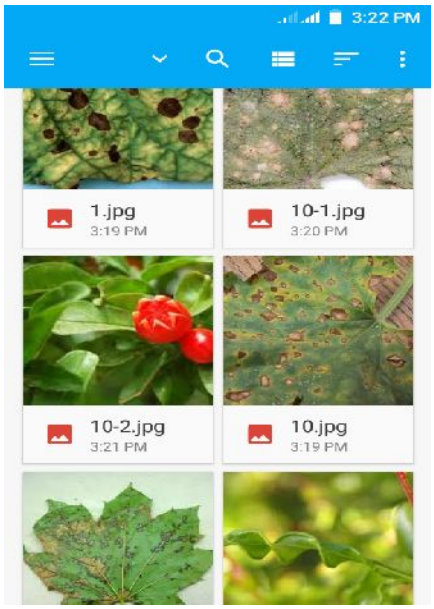


Figure 4. 2: Choosing the picture from gallery

Figure 4. 3: Selected image showing in image view

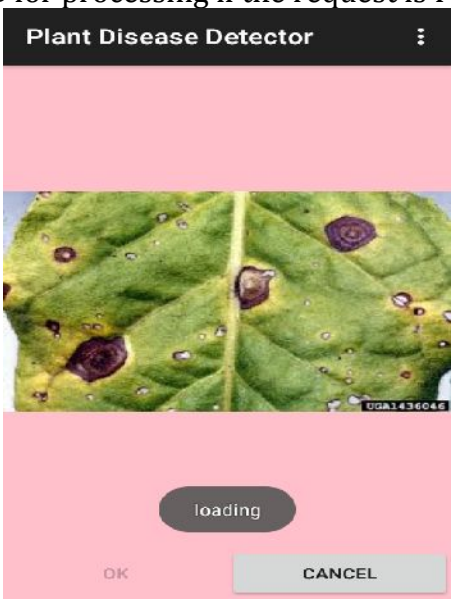
4.1.2 UPLOADING IMAGE TO THE SERVER

The main function of this button is to upload the image to the server for upward forwarding to the Matlab. Image uploading is done through the use of AsynchTask class. Asynchronous task class is a special class which enables the application to perform background work and transmit the result to UI threads without interrupting the UI thread or handlers. Normally, this class is designed to be assistant class around a thread or handler which should be used for very short time operations. Asynchronous programming helps the app stay functional when it does work in the background. The downside of using synchronous programming on the UI thread to upload content to server is that the app will

be abrogates until the method returns. The app will not respond to user request which might turn the user waiting. Thus the asynchronous class is the best choice for this type of work so that the user interface will remain active while the operation is done in the background. After completion of the task, the application will acknowledge that the image has been uploaded to server by showing image uploaded successfully on a toast and if there is a problem it will display error message in the toast. This asynchronous task mainly overpowers three methods that is pre Execute(), post Execute() and do In Background(). Firstly, the bitmap image is transform to string using the built in method Base64.encodeToString () method. It changes the bitmap image to Base 64 strings so that it could be transmitted to the server using HTTP web services. The bitmap image is initially compressed into byte array output stream before putting it into a byte array. Then this array is changed to base 64 strings. The image in string form is kept into a Hashmap data structure which will be transmitted as data using HTTP URL connection. The connection between the application and the server is done by the RequestHandler.java class. It establishes the connection link using

Http URL Connection class in java. Upload image class transfer the Hash map and server address to RequestHandler.java class

The connection time out is set to 10 seconds and the request method type is POST. In the server side, the server developed using java programming language on netbeans then verifies if the request is POST type. The data is then decoded from string to image and sent to MATLAB for processing if the request is POST type.



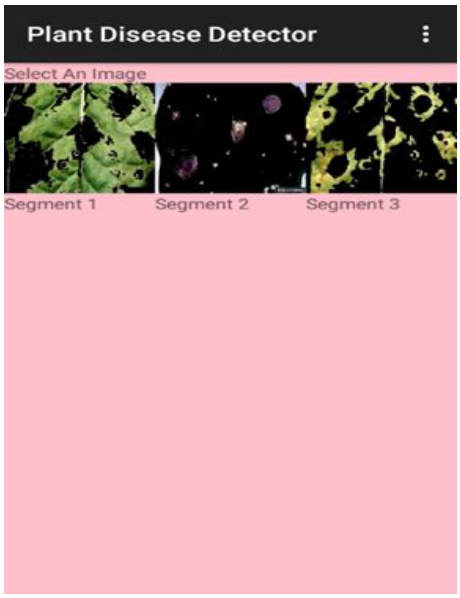


Figure 4. 4: Uploading the image to server

4.1.3 DOWNLOADING RESULT FROM THE SERVER

Once the mobile phone completed the image uploading successfully, automatically the MATLAB will sent the three segmented image (this work use k-means clustering algorithms and the value of k is 3) back to the mobile phone waiting for the user to choice one as shown in figu re 4.1.5 below.

Figure 4. 5: the three segmented image displayed on the phone for the user to choice

Once the user choice any one, then the selected (choosing one) segmented image is sent to the MATLAB for processing via the server. If the MATLAB completed the processing and the classification result is ready. The server will receive the result in form of string image and text string from the MATLAB automatically and the mobile phone will receive the result from the server on its layout which is set to activity_view_image.xml and the ViewImage.java class starts executing as shown in fig4.1.6 below.

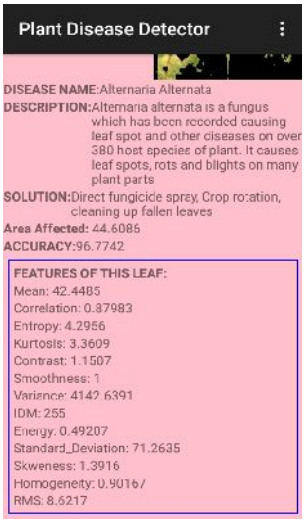


Figure 4. 6: Result of test plant leafs

Here also asynchronous programming is use for the same reason as we need the task to operate and function in background. The input stream is converted from string to bitmap format. The request method type is GET and the URL connection time out is set to 10 seconds. In the activity_view_image.xml layout have three text views and one image view, one text view for displaying the result, the second for displaying the brief explanation of the disease, the third one for displaying the solution and the one image view for displaying the segmented image. Both uploading and downloading image activities are done with the help of asynchronous programming and the RequestHandler.java class. The connection between the android application and the server is established by send Get Request() method in Request Handler.java class and the input stream is decoded inside the ViewImage.java class inside asynchronous programming.

4.1.4 CLIENT AND SERVER INTERACTION

This section of the system is executed once the client sends the images to the server via HTTP protocol using mobile phone application. The image received by the server using servlet script is stored in the assigned directory and the image processing is start on the assigned image automatically.

4.1.5 SHELL EXECUTION

For this research work, a local server was created in laptop using "TOMCAT server" software. The server has servlet scripts that will automatically receive and store image from the clent (mobliie phone device) into a particular directory and then send the image to MATLAB for pre-processing and segmentation. Before, an 'exe' file of MATLAB code was created and saved to local server. From the servlet script with function called exec(), the 'exe' file of MATLAB is executed through shell execution. The exec() method in the servlet is called immediately when image is receive and store in the server, so the whole process is done automatically without any human interaction on our server side. It reduces the possibility of errors in a way that we can depend on machines here completely. The MATLAB 'exe' file contains every step of the image processing algorithms.

4.1.6 PARSING THE RESULT

The servlet script fetches the data (the results) from the MATLAB as soon as the MATLAB code is done with the processing through shell execution and the results is ready and save in assign directory in the server. The servlet script fetches the data for the mobile application for request method type GET and sends to client. The result has two types of data. One is the segmented image which highlights the affected portion of the plant in Base 64 string form and the other part of the result is the disease name, brief description of the disease and possible solution about the the disease (all the three is contained as one in array form) in the MATLAB code generates after analyzing the image in string form. Both of them are fetched by servlet script and sent over the HTTP to the mobile application.

4.1.7 CLASSIFICATION

First all the necessary features of different plants with the various disease symptoms **(Alternaria Alternata, Anthracnose, Bacterial Blight, Cercospora Leaf Spot and Healthy Leaves**) is extracted and stored in pre-defined storage location. MAT file which is called training data sets. And then all the necessary features of plant to be tested is extracted so that the MATLAB will compare this features with the one of the training data

set to determine the one that match with the testing data set using Multiclass Support Vector Machine (Multiclass SVM) classifier for classifying the disease as **either Alternaria Alternata, Anthracnose, Bacterial Blight, Cercospora Leaf Spot or Healthy Leaves**. This Multiclass SVM use to assign labels to instances by using support vector machines, where the labels are drawn from a finite set of several elements. The dominant approach for doing so is to reduce the single multiclass problem into multiple binary classification problems. Common methods for such reduction include: building binary classifiers which distinguish between (ii) between every pair of classes (one-versus-one) or (i) one of the labels and the rest (one-versus-all).

In this case, the classification of new instances or input images for the one-versus-all case is done by a winner-takes-all strategy, in which the classifier with the highest output function assigns the class and detects the particular disease.

4.3 FINDINGS AND DISCUSSIONS

The results obtained are explained in details in this section. For this research work, a personal computer that has Windows 8, 4GB of RAM, 500GB of HDD, an Intel(R) Core(TM) i5 CPU and Android Mobile phone is used for performing the experiments. MATLAB Software, netbeans and Android Studio are used for the simulation of work and designing the interface of the Android Apps for Mobile phone. The automated System for Plant Disease Detection Using Image Processing and Machine Learning Integrated with Mobile Application starts with capturing of digital high resolution images. More than 500 different plant leaves' images with different disease symptoms (Cercospora Leaf Spot symptoms, Bacterial Blight symptoms, Anthracnose symptoms, Alternaria Alternata symptoms, and Healthy leaves) are obtained from https://github.com/spmohanty/plantvillage-Dataset and store in the Database for the experiment. Then the images were applied for pre-processing for image enhancement. Captured leaf images are segmented using k-means clustering method to form clusters. Features are extracted using GCCM before applying K-means and SVM algorithm for training and classification.

The main goal of carryout this research is to develop an automated System for Plant Disease Detection Using Image Processing and Machine Learning Integrated with Mobile Application that can detect and classify a given unknown plant leaf image as either Cercospora Leaf Spot, Bacterial Blight, Anthracnose, Alternaria Alternata, or Healthy leaves. The experiment is first performed by converting the RGB images into HSI, GLCM is used in extracting features of the plant leaf images before apply K-means Clustering to obtained three segment of the images. SVM Classifier is used to classify the image. The percentage accuracy varies from one plant leaves to another but with SVM Classifier; the average percentage accuracy obtained is 97.01%.

The result obtained for this research work produced high percentage accuracy compare to the percentage accuracy obtained by Sharada, David, & Marcel, (2016) that are able to achieved only average percentage accuracy of 31.40%, because the system used deep convolutional neural network (KNN) for training and classifier. The data source for both the work of Sharada et al. (2016) and this research is obtained from the same source. (Bababe et al. 2017) able to achieved 73.648% percentage accuracy which is low compare to this research that has average percentage accuracy of 97.01%. (Bababe et al., 2017) use Artificial Neural Network for classification while this research uses Multi-Class SVM.

4.5 CONCLUSION AND FURTURE WORK

Even though the work gives satisfactory output, more work need to be done to cover more plant disease. And also this work is limited to only plant leaves, more work can also be done to cover stems and roots of the plants.

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Design and Implementation of Microcontroller Based Ultrasonic Sensor Sliding Door

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Abstract: *Opening and closing of doors have always been a tedious and uninteresting job, particularly in places like; hotels, and shopping where an individual is always required to open and close the door for visitors. This human involvement can be avoided by automating the process using microcontroller based ultrasonic sensor sliding door that detects an approaching individual or person to allow access to automatically. The final output voltage required for the operation of this project is a DC voltage. The power was build up from A12V, 500mA transformer, and a bridge rectifier chip (BDR1), a filter capacitor (C1) and two voltage regulators (LM7809) and (LM 7805) were used. The ultrasonic sensor unit consist of the ultrasonic sensor module, limiting current resistors. Furthermore, the microcontroller unit is made up of the Atmega 328P microcontroller, a C6MHz crystal oscillator, and a pull-urge resistor. However, the sliding door control unit consist of four (4) base resistors R4, R5, R6 and R7 for transistors Q1, Q2, Q3 and Q4, in associate with Diodes D5, D6, D7 and D8. The system utilizes ultrasonic wave's technology to sense or detect an approaching individual or person to allow access automatically. Green LED is an indication of door closed, when person approaching the door; the Red LED light turn on and the door automatically open.*

Key words: *Door, Microcontroller, Sensor, Sliding and Ultrasonic*

1.0 Introduction

The microcontroller based ultrasonic sensor sliding door is an automatic sliding door that uses the ultrasonic waves technology to sense or detect an approaching individual or person to allow access to him/her by automatically. The sliding door opens and closes automatically if the person has entered or has decided to turn go back due to

other reasons. However, due to the fact that nowadays populations in the mega cities all over the world have greatly increased. Therefore, the use of manual doors in commercial buildings such as Banks, shopping malls and shopping complexes will bring about discomfort to the people because of the inconvenient of pushing the hard door to open it. Sometimes it even leads to delays and waste of time due to a queue that might arise. Therefore, this design is another step forwarding aiding the already existing automatic control sliding doors to help solve the problems and challenges that were associated with the manually controlled door system.

2.0 Literature Review

According to Mahmood et al., (2016), current access control systems for automatic door control require a sensor able to detect a moving object or a pedestrian crossing the gate. This approach does not take into account the trajectory of pedestrians, and therefore cannot estimate movements. As an example, if a pedestrian crosses the area in front of the door but does not want to cross the gate, the control access board detects his/her presence and anyway opens the door. In this case, the system is not efficient, since it leads to a waste of energy in terms of electricity, air conditioning, or heating and decrease the system lifetime with unnecessary open/close actions.

Lucky et al., (2013) proposed password protected home automation system with automatic door lock which works on the principle of breaking an infrared beam of light, sensed by a photodiode. It consists of transmitting infrared diodes and receiving photo-diodes. The system is to detect whether someone is coming in or not. The photodiodes are connected to comparators, which give a lower output when the beam is broken and high output when transmitting normally. Furthermore, biometric methods of door access control by numerous researchers. Personal authentication for access control, the system utilizes features such as face recognition, voice recognition, hand shape, finger print, and iris patterns of an individual (Kung et al, 2004; Osadciwet et al, 2002)

Mahmood et al., (2016) designed an automatic door system using a unique wireless ID by using infrared ray or Bluetooth technology. It consists of a sensing unit, control unit and drive unit to open and close doors at the entrance for a car that has the unique ID. This process is controlled by using Arduino Leonard and programmed with IDE free open source software, that receives the signal code from the car which sends the ID through IR LED or Bluetooth by using a mobile application, decode it and switch ON the driver that controls the DC motor.

3.0 Methodology

The analog input is the reflected ultrasonic waves that is transmitted initially by the ultrasonic sensor module intercepted by a person that approaches the sliding door. This analog input is converted to digital by the atmega328p analog to digital input pin.

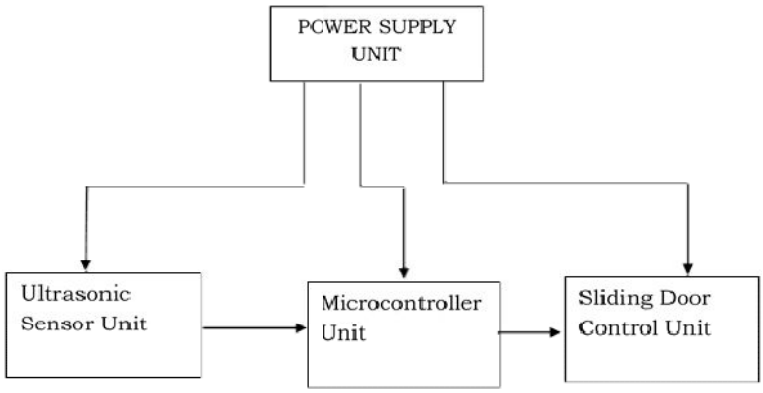

Fig. 3.1 Block Diagram of the ultrasonic Sensor Sliding Door

3.1 Design of the Automatic Sliding Door

3.1.1 *Power Supply Unit*

The final output voltage required for the operation of this project is a DC voltage. The power was build up from A12V, 500mA transformer, a bridge rectifier chip (BDR1), a filter capacitor (C1) and two voltage regulators (LM7809) and (LM 7805) as shown in fig. 3.2

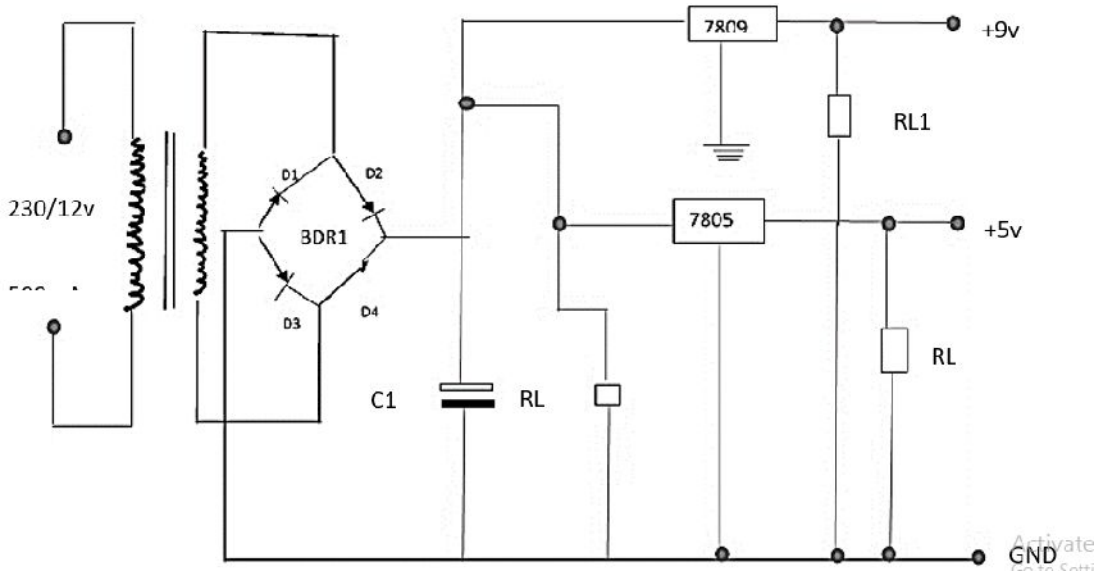

Fig. 3.2. The Power Supply Unit for Ultrasonic Sensor Sliding Door

3.1.2 *Ultrasonic Sensor Unit*

The ultrasonic sensor unit consist of the ultrasonic sensor module, limiting current resistors R1 and R2 as shown in fig. 3.3

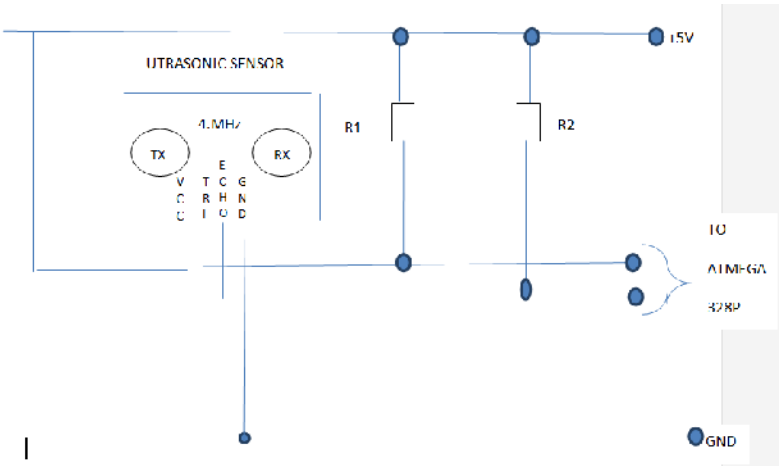

Fig. 3.3 The Ultrasonic Sensor

3.1.3 *The AtmegA 323 Microcontroller Unit*

The microcontroller unit is made up of the Atmega 328P microcontroller, a C6MHz crystal oscillator, and a pull-urge resistor as shown in fig. 3.4.

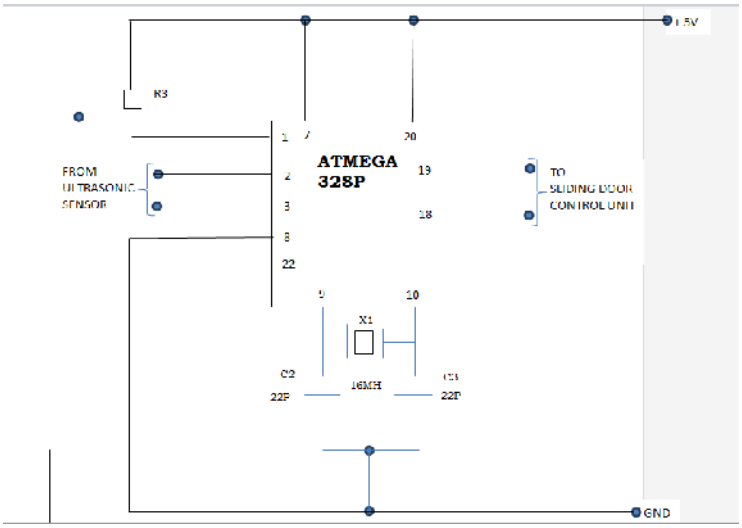

Fig. 3.4 the Microcontroller Unit

The values of capacitors C2 and C3 were chosen to be 22pf, which are used to stabilize the frequency of 16MHz of the crystal oscillator from interference, surges and other external factors.

3.1.4 *The Sliding Door Control Unit*

The sliding door control unit consist of four (4) base resistors R4,R5,R6 and R7 for transistors Q1,Q2,Q3 and Q4, in associate with Diodes D5,D6,D7 and D8 as shown in fig. 3.5.

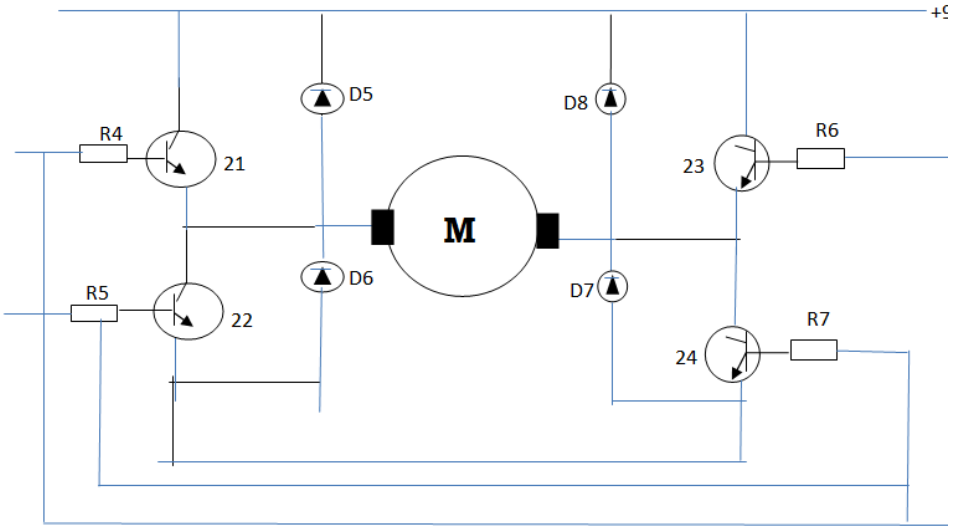

Fig. 3.5 The sliding Door control Unit

3.2 The Description of the Atmega 328P Microcontroller

The Atmega 328p Microcontroller is a 28pin, 8 bit microcontroller with 32KB flash memory with read – while – write capabilities. The Atmega 328p microcontroller is shown in fig. 3.6.

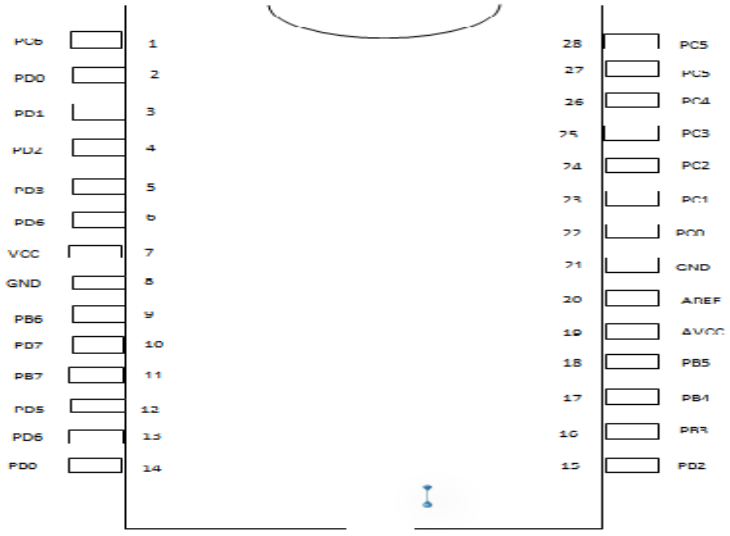

Fig. 3.6: The Atmega 328p Microcontroller

The pin Description of the Atmega 382p is shown in Table 3.1

Table 3.1 Description of Atmega 328p pins

Pin Number	Description	Function
i.	PC6	RESET
ii.	PD0	Digital Pin (RX)

iii.	PD1	Digital Pin (xx)
iv.	PD2	Digital Pin
v.	PD3	Digital Pin (pwm)
vi.	PD4	Digital Pin
vii.	VCC	Positive Voltage (Power)
viii.	GND	Ground
ix.	XTAL1	Crystal Oscillator
x.	XTAL2	Crystal Oscillator
xi.	PD 5	Digital Pin (pwm)
xii.	PD 6	Digital Pin (pwm)
xiii.	PD 7	Digital Pin
xiv.	PB0	Digital Pin
xv.	PB1	Digital Pin (pwm)
xvi.	PB 2	Digital Pin (pwm)
xvii.	PB 3	Digital Pin (pwm)
xviii.	PB 4	Digital Pin
xix.	PB 5	Digital Pin
xx.	AVCC	Positive voltage (ADC)
xxi.	AREF	Reference voltage
xxii.	GND	Ground
xxiii.	PC 0	Analog Input
xxiv.	PC 1	Analog Input
xxv.	PC 2	Analog Input
xxvi.	PC 3	Analog Input
xxvii.	PC 4	Analog Input
xviii.	PC 5	Analog Input

The Atmega 328p is also designed to have an endurance of 1000 write/erase cycles which means that it can be erased and programmed to a maximum of 1000 times without being damage or destroyed.

3.2.1 *The Voltage Regulator*

The LM7809 and LM7805 voltage regulators are fixed linear voltage regulator integrated circuit (IC). They belong to the family of the 78xx. The "78" is the positive output series, while the xx represents the output voltage. The LM7809 has an output of +9v and LM 7805 has an output of +5v, respectively. The voltage regulators are shown in fig. 3.7

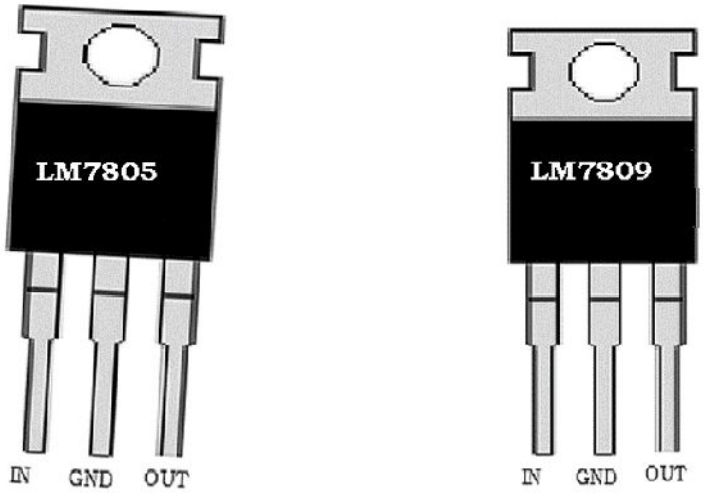

Fig. 3.7 Voltage Regulators

The LM7809 voltage regular was used to supply a regulated +9v to the sliding door motor, while the LM 7805 supplies +5v to the Atmega 328p microcontroller.

3.3 Components Used and Values

The Components used for the constructions of the ultrasonic sensor sliding door and their design values were shown in Table 3.2

Table 3.2 Components Used and Values

Components Used	Design Values	Standard values	Measured Values
Capacitors			
C1	$554\mu F$	$1000\ \mu F$	$992.7\mu F$
C2	22pf	22pf	21.82pf
C3	22pf	22pf	21.87pf
Resistors			
R1	12.76Ω	12Ω	11.93Ω
R2	12.76 Ω	12Ω	11.89Ω
R3	12.76Ω	12Ω	11.91Ω
R4	42.8kΩ	42kΩ	41.99kΩ
R5	42.8kΩ	42kΩ	41.94kΩ
R6	42.8kΩ	42kΩ	41.96kΩ
R7	42.8kΩ	42kΩ	41.97kΩ

Transistors			
21	$\beta = 20000$	$\beta = 20000$	$\beta = 198$
22	$\beta = 20000$	$\beta = 20000$	$\beta = 199$
23	$\beta = 20000$	$\beta = 20000$	$\beta = 192$
24	$\beta = 20000$	$\beta = 20000$	$\beta = 196$
ICS			
IC 1			
LM7809	+9v	+9v	+8.9v
IC 2			
LM7805	+5v	+5v	+4.98v
IC 3			
ATMEGA 328P	+5v	+5v	+4.95v

3.4 Software Development/Design

A computer software program called "source Code" controls the construction of the ultrasonic sensor sliding door. A source code is a collection of computer instructions or commands that controls a hardware. The source code was written in accordance to the flow chart shown fig. 3.9

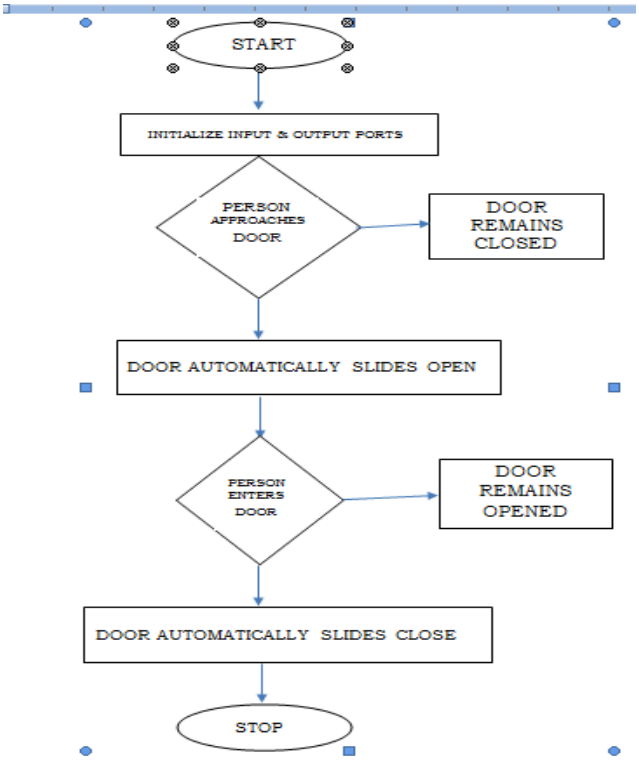

Fig. 3.9 flow chart for ultrasonic sensor sliding door

4.0 Results and Discussion

4.1 Results

Before assembling all units together to achieve the construction of the microcontroller based ultrasonic sliding door, the individual components of each unit is

tested including the microcontroller to make sure there were no faulty components before soldering them together. Some of the units tested include; the power supply unit, test on the ultrasonic sensor unit, test on the microcontroller, testing of slide door motor, and debugging the software program.

The final testing of the project work was carried out after soldering all units together. Table 4.1 shows the results of working process of the project.

Table 4.1 Test of overall project

Ultrasonic Sensor Detects			**Indicator lights**		**Sliding Door**
Person Coming	Person Standing	Person Standing	Green led	Red led	Door status
No	No	No	Off	On	Closed
Yes	No	No	On	Off	Opening
No	No	Yes	On	Off	Opening
No	Yes	No	Off	On	Closing

4.2 Discussions

The results of the tests performed above suggested that the system sub-units are effectively designed and when coupled will give a satisfactory results with regard to the system as a whole. After completing all the various units, the project was cased in a plastic casing for compact presentation and protection. The project operator on mains power supply but also has an alternative source of DC power from a battery.

When the project is powered on, the ultrasonic sensor detects if any person is approaching the sliding and if no one is approaching the red LED turns ON and the sliding door remains closed while the Green LED also remains OFF. Now if the ultrasonic sensor detects that someone or a person is approaching the sliding door, the red LED turns OFF and the Green LED turns ON and the sliding door automatically slides open. If the person enters the door, it automatically slides close, but if the person continues to stand in front of the door, it will remain open and the Green LED will remain ON, and if at any time the person leaves the proximity, the door automatically closes and the Green LED turns OFF while, the Red LED turns ON.

Conclusion

The study designed microcontroller based ultrasonic sensor sliding door. The following conclusions were drawn based on the tested results

(i) The system utilizes ultrasonic wave's technology to sense or detect an approaching individual or person to allow access automatically.

(ii) Green LED is an indication of door closed, when person approaching the door; the Red LED light turn on and the door automatically open.

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Challenges of Broadband Penetration in Africa (Nigeria)

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Abstract: *Deploying broadband access networks plays an integral part in strategic policies in the world in order to promote growth and innovation in all economic sectors, social and territorial cohesion etc. Despite the growth in the use of the internet and the availability of information technology, there exists a divide between societies that have access to internet facilities, those that have less access and those that have no access. Rural/Remote areas in most developing countries tend to impose a challenging environment in which to install communication infrastructure for broadband access networks. The main challenges include lack a of customer base, as these areas are highly scattered, have low incomes and there are fewer opportunities to upgrade their socio-economic status and low population density. As a result of these factors, most service providers tend to implement network infrastructure in major cities. Hence, leaving the rural/remote areas as unserved or underserved areas. The main focus of this work is to identify the factors that limit broadband penetration in Africa (Nigeria), evaluating the current state of broadband access in Nigeria and also describe some policies and initiatives laid by the Government in tackling the issue of the digital divide.*

Key words: *Broadband Access, Broadband Penetration, Network Infrastructure, Mobile Communication, Broadband Limitation*

Introduction

The adoption of mobile devices worldwide has created an unending demand for access to e-commerce, social media and entertainment application at a different times and places. This trend has not only resulted in an increase in the amount of mobile broadband data transferred by the host network but has changed its composition. Mobile traffic that was conventionally voice only is now dominated by video and data due to the design of applications that supports live video streaming etc. As this major trend continues to increase, the number of applications and triple-play services (voice, video and data) increases and leads to growth in the subscriber base. Hence, there is a need to effectively provide an access network that will meet the requirements of the consumer at all times

[13].

The use of internet and mobile communication in recent years has increased around the world. In Nigeria, statistics shows that there are about 50 million or more internet and mobile users as of May 2012 [17]. Nigeria has the highest number of internet and mobile service users in the continent that is Africa and ranks amongst the top 20 in the world. Having a population of more than 180 million people, the rate of internet penetration in Nigeria is low, about 27% [7]. The majority of the population in Nigeria resides in remote areas with little or no access to the internet, telephony etc. Broadband wireless access technology is the primary means to meet the demand for rapid internet connection and integrated data, voice and video services around Nigeria.

Rapid increase or growth in wireless subscriber numbers, advancement in the deployment of multi-play application for mobile platforms, delivery of "triple play" service with voice, video and data and the related demand for excellent user experience are the driving forces requiring a high quality of service in the broadband access network. Despite its African/World ranking, Nigeria has an urgent need of broadband internet penetration in most areas. The existing broadband network infrastructure in rural areas in Nigeria shows a low level of broadband penetration having a lot of "white areas", where no broadband coverage is available [14]. The main focus of this work is to identify the factors limiting broadband internet penetration in Nigeria as well as describing the current state of broadband within the geo-political zones.

Broadband Access

Broadband access is to the 21st-century information age what electricity was to the industrial age. It has a significant transformative impact on how people live and work. It empowers the end users with capabilities that were previously unimaginable and a global reach [3]. Broadband solutions in general can be classified into two groups, fixed line technologies and wireless technologies. The fixed line technology communication is carried via a physical network which provides a direct "wired" (copper based and fibre based) connection from the service supplier to the customer, it relies mainly on a direct physical connection to the subscriber's residence or business, common examples are digital subscriber lines, broadband power line and hybrid fiber-coax cables [12]. Wireless broadband technology in general refers to certain technologies that use point to point or point to multipoint microwave transmission in various frequencies ranging between 2.5 to 43 GHz for the purpose of transmitting signals between hub sites and end user receiver, these include wireless Fidelity (Wi-Fi), Microwave links, Direct Broadcast Satellites (DBS) etc. [8]. There are several competing technologies which can provide the bandwidth needed to deliver broadband services, but each of these technologies has its limits in terms of reliability, bandwidth, cost or coverage. Optical fibers have effectively limitless bandwidth capabilities, with excellent reliability and are increasingly economical to install [4]. However, many competitive copper and wireless technologies are developing at a significant pace and some of the technologies have managed to continually meet the ever increasing bandwidth requirements of the end users.

Broadband is traditionally referred to as a high–speed communication network where connected end users can transfer data at a rate greater than 256 Kbit/s. Global organisations have chosen to define broadband in a manner that reflects the end user's experience. Broadband within the Nigerian context can be defined as an access experience

where the end users can access real-time content (voice, video and data) at a minimum connecting speed rate of 1.5 Mbit/s. This definition may well be reviewed over time to keep in line with subsequent developments in technology [15]. The term digital divide refers to the divide between individuals that have full access to modern communication technology and those that have less or no access. The definition of digital divide has evolved overtime, it was referred to as the divide between those with and without telephone access in the early 20th century. Afterwards, it was referred to as the gap between those with internet access and those without [10].

The Current State of Broadband Access in Nigeria

The national broadband supply link in Nigeria consists of an international connectivity, proposed national backbone network, metro-link access and the last mile network. The landing of several submarine cables at the coastal shores of Nigeria has provided about 9Tbit/s of combined capacity. Nonetheless, there is a growing concern relating to the cables landing only at the coastal part of the country while access to other areas (urban and rural) of the country are affected due to the limitation in communication infrastructure [16].

Figure 1 below shows the undersea cables landing in the coastal region of Nigeria. The major broadband submarine cables infrastructure in Nigeria includes; West African Submarine Cable (WACS), Main-One, South Africa Trans-Atlantic (SAT3) and Glo-1 fibre optic cables.

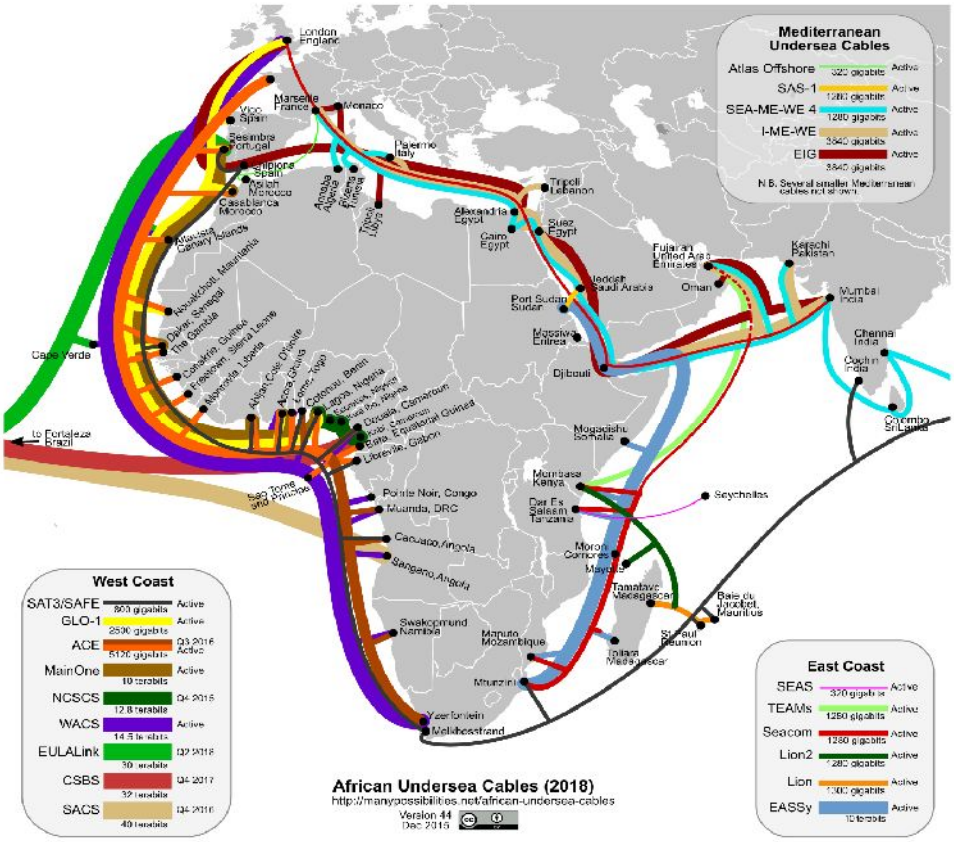

Fig 1 Fibre optic cable landing in Africa (African Undersea Cables 2013-2018)

As shown in the figure above the major part of development recorded is in the international connectivity known as the core networks. The capacity of the last mile access network to provide effective broadband services in terms of bandwidth, service quality and availability remains a major challenge that has deterred the growth of broadband access services.

In emerging economies like Africa, infrastructures are constantly being built. Roads are enhanced or laid, water and sewage pipes installed and replaced. This creates major challenges for network operators with fiber cables underground, these cables are cut far more often than they should be and as a result network service is disrupted. Judging by what has been achieved in the broadband sector in Nigeria today, the moderate success recorded so far in this sector is the landing of several high-capacity submarine cables, resulting in a drop in international bandwidth wholesale prices. However, inefficient inland bandwidth transmission and distribution has continued to pose a major challenge and is an obstacle for the desired broadband boom in Nigeria.

Wireless technology is the main means of last mile broadband connectivity in Nigeria. Studies reveal that about 80% of the households in Nigeria use wireless broadband (Microwave access) which is higher than those using fixed wired broadband access at 20% [16]. The recent advancement in wireless broadband access and usage in Nigeria is as a result of the wide rollout and upgrade of mobile network technologies as well as the introduction of smart mobile phones and devices with the potential to connect to the internet. About 58.1% of web traffic in Nigeria originates from mobile devices [19]. This statistic may appear to show a growth in microwave access usage but in reality, it shows low penetration of computer use due to the poor electricity supply and a major limitation in terrestrial networks making mobile devices a convenient and portable economic internet access tool despite the limitations in performance and applications.

Factors Limiting Broadband Penetration in Nigeria

Despite the growing need for mobile broadband access around the world, which is supported by the increase in the use of smart phones and other mobile devices. There is a vast need to increase the rate of internet penetration. The Nigerian Communication Commission has acknowledged the low percentage of penetration and provided initiatives to increase the rate. The factors limiting broadband penetration in Nigeria include;

- **Network Infrastructure**

  Infrastructure plays a major role in broadband penetration as it directly controls access, price etc. Broadband internet access in Nigeria is limited due to the lack of adequate communication infrastructure. The inadequacy of domestic backbone networks is a major underlying factor limiting the growth of broadband access. The fibre optic backbone infrastructure is not interconnected and is mainly concentrated in urban areas and a few rural areas. There is no provision for the long distance national backbone to transmit the capacities provided by the undersea cables to last mile end users at homes, offices, schools etc.

- **Poor Electrical Power Supply**

  The poor state of the power supply has a negative impact on socio-economic development in developing countries. Steady power supply is a major criterion in

accessing the internet, which unfortunately has not been addressed in Nigeria and has led to the limited use of the internet by those who desire to use it. The power supply has affected the installation and management of telecommunication infrastructure, leaving operators relying solely on power generators in powering their base stations, radios etc. which result in an increase in overhead cost thereby affecting productivity and return on investment (ROI).

- **Right of Way**

  This refers to the legal right granted to network operators to pass through certain routes either through the ground or over property that belongs to others. Telecommunication operators in Nigeria pay a huge amount of money to have access thereby limiting the building of network infrastructures and as a result contributing to lower broadband penetration.

- **Pricing**

  Broadband adoption can be affected by pricing, especially in developing countries. Service providers have increased the cost of providing broadband access to end users due to the high cost of installing network infrastructure. If the demand for internet is low because the end users can't afford these services, this affects the investors return on investment. Therefore, service providers are forced to move to urban centres with high income, high population etc. In other developing countries like Tanzania, Namibia etc. the government has built a nationwide broadband backbone infrastructure and leased it to private companies to operate at a low cost; the rate of internet penetration compared to Nigeria is high (Williams 2010)

- **Distance/Landing Point**

  Distance from the backbone base or landing station to the last mile users has made it difficult for those residing in remote locations to gain access to the internet. The farther away the users are from the base station the greater the effect of attenuation and fading on the quality of service. All the landing points are presently stationed at Lagos and the other regions of the country need to connect from this point resulting in limited distribution. Additional landing points in other coastal parts of the country will enhance faster fibre rollout around the country.

Conclusion

Providing adequate network infrastructure within Nigeria is an important factor in maintaining economic competitiveness of the unserved and underserved areas. The challenge of providing high-speed broadband access in these areas needs to be tackled effectively. Broadband penetration and access in urban communities is far better compared to rural and remote regions who often have poor or unreliable connectivity. This report identifies certain factors that limit broadband penetration in Africa (Nigeria), evaluates the current state of broadband in Nigeria based on fibre optic cable landing and rollout within the country and microwave access. It further identifies policies and initiatives laid by the Government in tackling the issue of the digital divide in Nigeria. To further overcome this issue, practical research into providing qualitative and economical broadband solutions should be carried out across all areas in the country.

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Design and Implementation of Digital Temperature and Humidity Data Logger and its Comparative Analysis with the Conventional-one

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Abstract: *Data acquisition systems have become inevitable tool for analyses in science and technology. With advancement in research and manufacturing processes, there is a growing demand for sophisticated yet cost-effective data logging systems to address the complexity in data acquisition and analyses. This work addresses the temperature and humidity data acquisition needs in research and manufacturing by implementing an embedded system suitable for monitoring and analyzing temperature and relative humidity at specified intervals of time. The hardware was designed and constructed using five functional parts that comprising of ATMega328P microcontroller, real-time clock, liquid crystal display unit, SD card and a low-cost DHT22 temperature and humidity sensor to capture the temperature and relative humidity. The hardware is powered by an AC source through a regulated power supply comprising of a shunt-regulated IC, LM7805. The captured data is processed and stored to a memory chip (SD card) which can be retrieved at any time and displayed in a Microsoft Excel format by inserting the SD card into a computer system. Data captured is displayed and managed with the aid of a visual interface display unit of a 16 x 2 alphanumeric LCD. This provides a handy system that makes data-logging easy and effective. The hardware was tested and errors of ±2.24 % and ±3.12 % were obtained for temperature and relative humidity respectively. Thus, this hardware is capable of performing the required task with high accuracy.*

Key words: *Temperature, Humidity, Comparative-analysis, Logger, Conventional-ones*

INTRODUCTION

Data logging and recording is a common measurement application. In its most basic form, data logging is the measuring and recording of physical or electrical parameters over a period of time. The data can be temperature, strain, displacement, flow, pressure, voltage, current, resistance, power, and many other parameters. A wide range of products can be categorized as data loggers, from basic devices that perform a single measurement to more

complex devices that offer analysis functions and integrated displays.

Temperature is a widely measured quantity in the industry. Accurate and repeatable temperature measurement and control are critical to products' quality and uniformity in many modern semiconductor manufacturing processes (Schroder, 1990).

The monitoring of environmental variables such as temperature, pressure and humidity has a long history of development and the variables have shown significant impact in the productivity of plant growth, the quality of food industry and the efficiency of many temperature and humidity-sensitive equipment (Vleeschouver *et al.,* 2017). The monitoring of temperature and humidity of laboratories, storages, halls, school and hospitals is important with respect to health and hygiene. The reliable measurement and monitoring are crucial in this competitive era of technology (Vleeschouver *et al.,* 2017).

Humidity is the presence of water vapour in air (or any other gas). High humidity makes hot days feel even hotter. Low humidity can give people a feeling of a dry throat, or sensations of "static" when touching things. Humidity affects many properties of air, and of materials in contact with air. A huge variety of manufacturing, storage and testing process are humidity-critical.

Humidity measurements are used wherever there is a need to prevent condensation, corrosion, mold, warping or other spoilage of products (Bell, 2011). This is highly relevant for foods, pharmaceuticals, chemicals, fuels, wood, paper, and many other products.

A data logger is a data-recording apparatus. For the purpose of this dissertation, the term "data logger" shall be taken to refer to a "temperature and humidity recording hardware". A data logger can be configured in a number of ways depending on the application. Loggers can be either stand-alone, i.e., self-contained, with no external supporting hardware, or interface with another hardware to provide ancillary or critical functionalities.

MATERIAL AND METHOD

Material used for the construction of the device are:

i. ATMega 328P 8-bit Microcontroller
ii. 5-volt DC regulated power supply
iii. DHT22 Temperature and Humidity Sensor
iv. SD Card
v. 2-row 16-character Alphanumeric Liquid Crystal Display
vi. DS1307 Real Time-Clock (RTC) Chip
vii. 24C02 Serial Electrically Erasable Programmable Read-Only Memory
viii. 3.3-volt SD Card Power Supply
ix. Power cord
x. Plastic pack

Device Description

The block diagram shown in Figure 1 represents the digital temperature and humidity data logger.

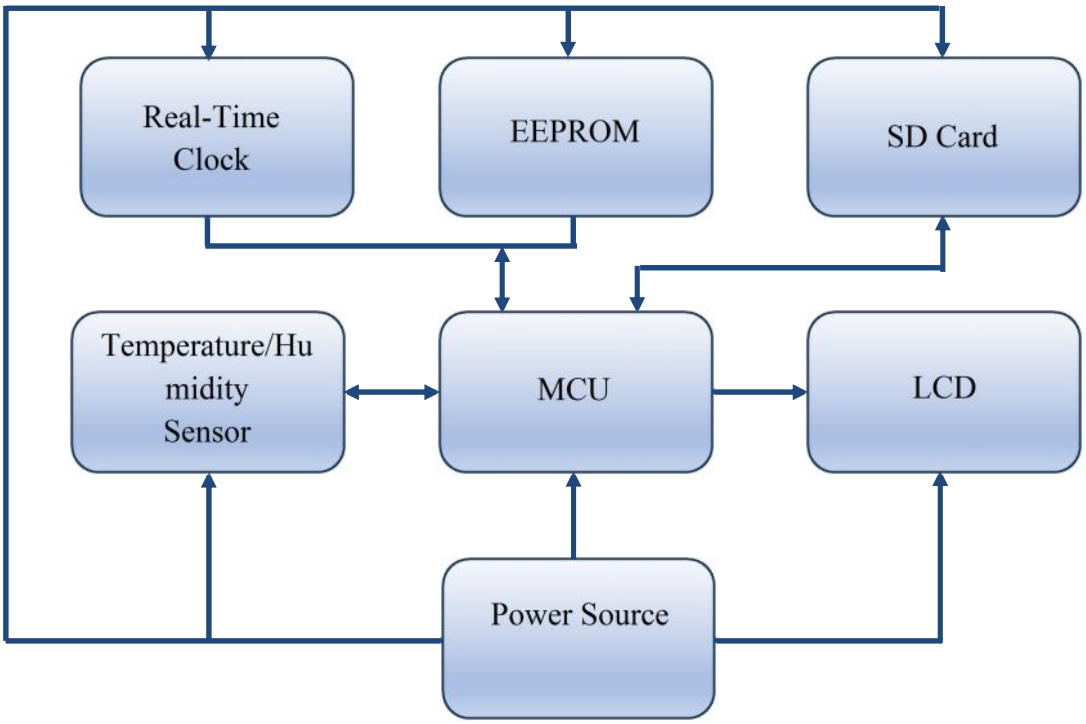

Figure 1: Functional Block Diagram

The hardware consists of five functional blocks: the temperature and humidity module for sensing the temperature and relative humidity of the environment, RTC (Real-Time Clock) for keeping the time and date, the EEPROM (Electrically Erasable Read-Only Memory) for keeping user's settings, SD Card (Secure Disk Card) for data storage (humidity and temperature history), the MCU (Microcontroller Unit) which is the core of the system: it communicates every other subsystem to read and write data, and LCD (liquid crystal display) for visual output. It also includes power source for every sub-unit of the system. The system captures the temperature and humidity data from the sensor module, processes and stores it on the non-volatile memory device (SD card).

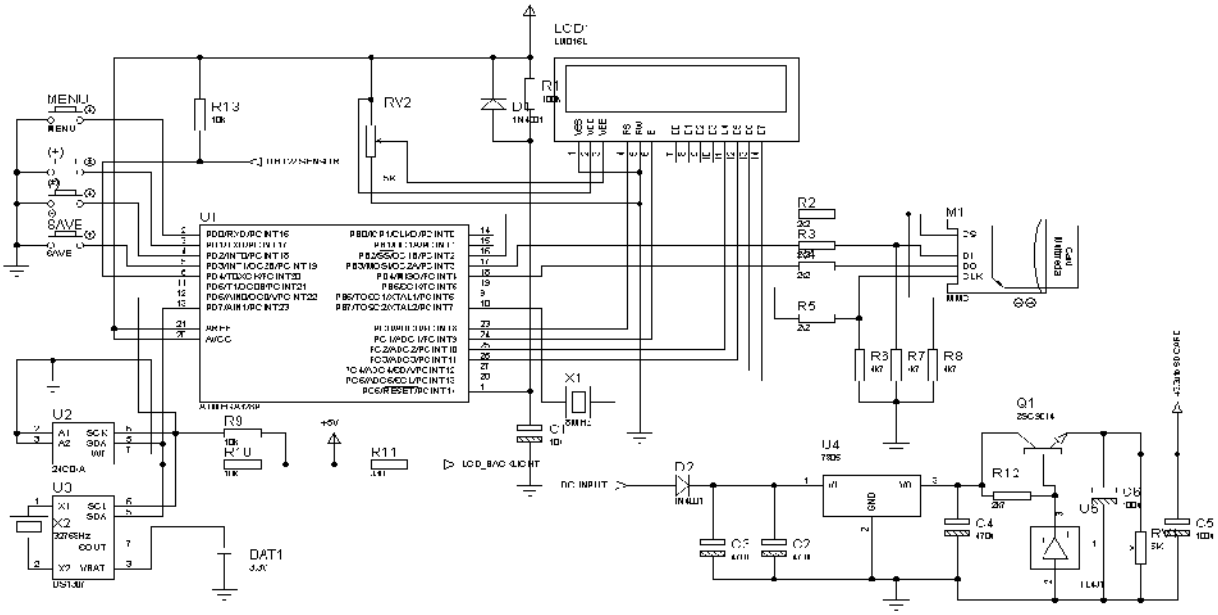

Figure 2: Complete Circuit Diagram of the Device

Operations of the Device

The temperature and humidity data logger was designed to sample temperature and relative humidity values of the surrounding environment of about 20-meters distance in every two seconds. The accumulated values over one minute (60-seconds) were averaged out and stored on the SD card, along with the date and time of logging.

The logs were formatted as (comma separated values) CSV, to allow easy importation into just about any operating system without the need for a custom software to read its content.

To set the system date and time information, four buttons were provided. These buttons enabled programming the integrated DS1307 RTC in the system to reflect the correct date and time required for time-stamping.

Results and Graphs

The table shows the results obtained for temperature and humidity measurements for 20-minutes testing of the constructed and reference devices.

Date (DD:MM:YYYY)	Time (HH:MM:SS)	Constructed Temperature (°C)	Constructed Humidity (%)	Reference Temperature (°C)	Reference Humidity (%)
25/03/2019	13:00:12	34.9	22.3	35.5	22.7
25/03/2019	13:01:12	34.7	21.5	35.3	22.8
25/03/2019	13:02:12	34.7	21.6	35.3	22.3
25/03/2019	13:03:12	34.2	21.9	34.8	22.6
25/03/2019	13:04:12	34.2	21.9	34.8	22.6
25/03/2019	13:05:12	34.1	21.5	35.2	21.8
25/03/2019	13:06:12	34.1	21.5	35.2	21.8
25/03/2019	13:07:12	34.1	21.4	35.2	21.6
25/03/2019	13:08:12	34.1	21.4	35.2	21.6
25/03/2019	13:09:12	34.1	21.4	35.0	21.6
25/03/2019	13:10:12	34.0	21.5	35.0	21.8
25/03/2019	13:11:12	35.1	21.5	35.4	21.8
25/03/2019	13:12:12	35.2	21.4	36.0	21.9
25/03/2019	13:13:12	35.3	21.4	36.1	21.9
25/03/2019	13:14:12	35.4	21.3	36.2	21.6
25/03/2019	13:15:12	35.4	21.2	36.2	21.4
25/03/2019	13:16:12	35.5	21.2	36.3	21.4
25/03/2019	13:17:12	35.5	21.4	36.3	21.9
25/03/2019	13:18:12	35.6	21.6	36.4	22.1
25/03/2019	13:19:12	35.6	21.7	36.6	22.2

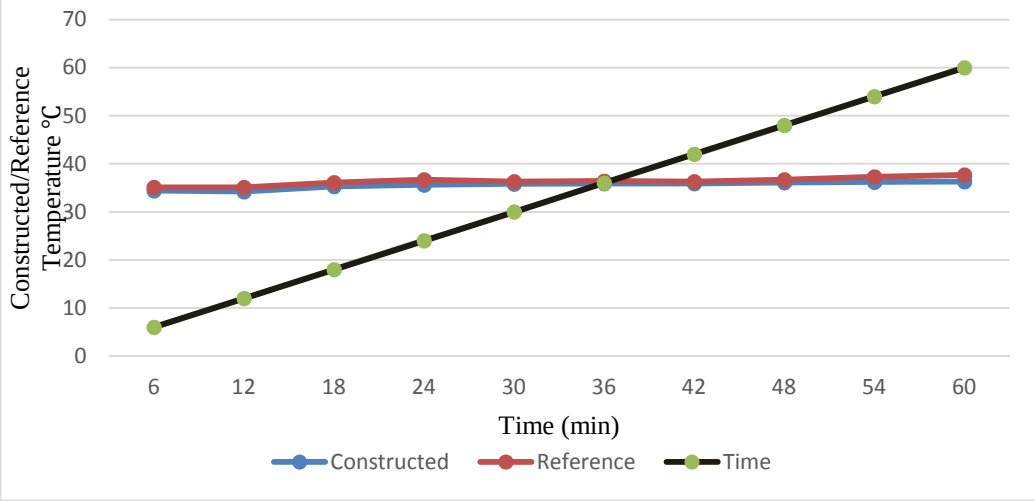

Figure 3: The Plot of Constructed and Reference Temperature against Time

Figure 3 shows the time series plot of the constructed and reference temperature against time. Both temperature measurement devices exhibit clear nonlinear and deterministic

trends. On average, the reference temperature is a little bit higher than the constructed temperature with evidence of structural breaks and this could be due to the fact that, the reference device has a probe incorporated to it which is not directly in contact with any object in the ambience. However, the two types of temperature measurement devices are approximately closer and little bit far at 48th and 60th minutes respectively.

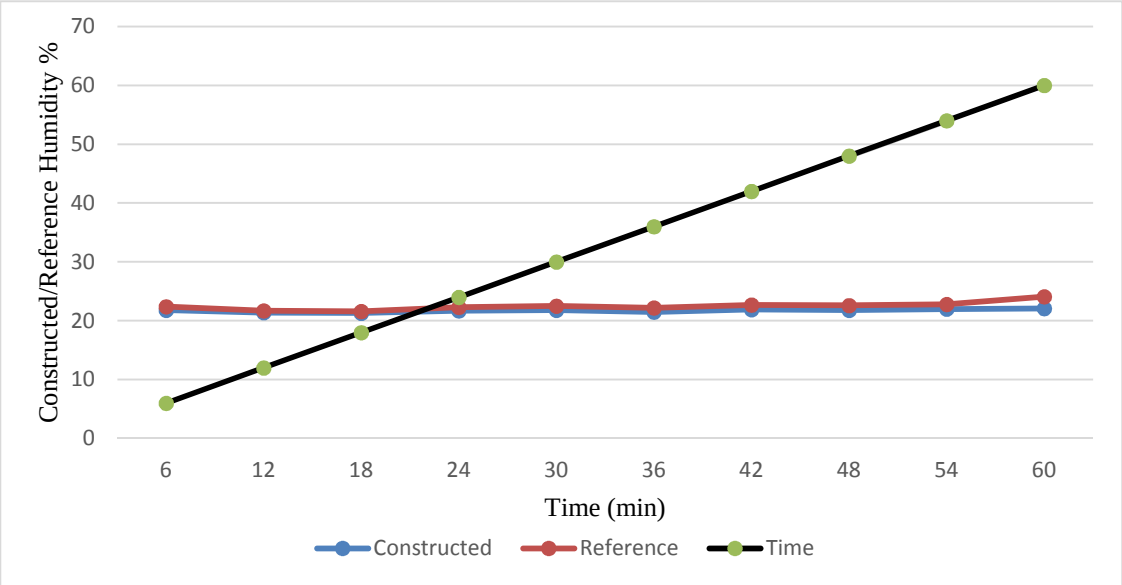

Figure 4: The Plot of Constructed and Reference Humidity against Time

Figure 4 is the time series plot of the constructed and reference humidity against time and both series shows a concurrent increase, decrease and stable trend. However, the constructed humidity measurement device suffers a shock decline of about 7.9% at the 57th minutes and this could be due to the fact that, the reference humidity device's probe was in direct contact with the moisture which indicates that, for it to continue giving a close related measurement(s) its probe ought to be kept moist or in contact with a moist object.

Conclusion

The designed and constructed hardware was capable of measuring temperature and humidity. More so, the device was compared with another device (reference device) to be certain of its capabilities. The results showed that, it can perform the required task**.**

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Evaluation of the Feasibility of Biogas-to-Electricity Plant in Maiduguri, Borno State, Nigeria

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Abstract: *There are concerns over inadequate supply of electricity to the local populace of Nigeria. Constantly increasing population has led to a wider gap between supply and demand of energy, leading to the privatisation of the power sector. Fluctuating fossil fuel prices has further increased the need to assess the available renewable energy (RE) resources. Municipal solid waste (MSW) is generally accepted to be a RE resource with wide availability, however, it has not been harnessed in Nigeria. This work will present an economic evaluation of the feasibility of investing in biogas-to-electricity projects that can process MSW generated in Maiduguri and its environments, thereby improving the supply of electricity within the city. The assessment will be carried out for energy generation by a biochemical process (Anaerobic Digestion) based on Primary and secondary data. It will also incorporate all the plants' output (digestate, recyclables, electricity and heat) as co-products which can be marketable, but heat was assumed to be used in-house. Results obtained indicates the investment would be feasible on wholesale and retail electricity distribution basis. However, trading directly to end users will pay back the investment cost of the project faster at 2 years and 361 days, at an NPV of $423,944,603.13 than having to distribute the electricity generated at wholesale prices to electricity suppliers which would pay back the investment after 3 years and 91 days. Thus, the project will help in increasing the amount of power available in the country, by 0.59%, which is an addition. Hence, the BTE project will have a positive effect on the power sector, thereby contributing to the improvement of the economy of the nation.*

Key words: *Biogas, Electricity, Anaerobic digester, Municipal solid waste*

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INTRODUCTION

The success of a biogas-to-electricity (BTE) project is dependent on the need of the local populace, since no profit will be made if there is no market for the BTE plant, resulting in a loss of the investor's capital. Nigeria is one of the major victims of shortage in global energy

amongst other sub-Saharan African countries. This shortage has led to a significant overdependence of households on traditional energy source, like forest-wood and the charcoal derived from it for its primary energy consumption. A likely reason for this energy shortage is a lack of access to modern energy supply, with only about 46% of households having access to electricity (Dassapa 2011, Sambo 2009). Figures from The World Bank (2013) shows a 2 percent increase in the percentage of households without access to electricity from the year 2010 to 2013 due to an increase in population. The subject of electricity generation, distribution and transmission has been a major issue in Nigeria and has been the centre of previous research over the years (Akinbulire *et al.* 2008, Mohammed *et al.* 2013, Ogujor and Orobor 2010, Oseni 2011 and Sambo 2009) due to the inadequacy of supply to the citizens of the nation. This has resulted in self-generation of electricity through the use of small personal generators that have low efficiencies and high CO_2 emissions.

This is very expensive to generate. Furthermore, it is harmful to the environment as a result of the high CO_2 emissions from the machines utilised for self-generation.

Options of RE sources that can be utilised for decentralized power generation are wind energy systems, solar photovoltaic, biomass (agro residues, waste streams) gasifiers, small-hydro systems and so on (Buragohain, Mahanta and Moholkar 2010). Biomass based energy is distributed more uniformly, widely available and has a more consistent 'source-stream' putting it ahead of the other RE sources in Nigeria (Buragohain, Mahanta and Moholkar 2010). The use of biogas, produced from the processing of municipal solid waste as a renewable and sustainable energy source, could be the solution to the recurrent energy challenges of the country. Biogas is a gas composed of methane, carbon dioxide and other constituents; it is produced through the anaerobic digestion of biomass (including waste). Since the country has more waste generation capacity than it has the ability to handle, this could also be a feasible approach to power generation, as well as waste management (International Energy Agency 2014).

This work argues that the use of biogas produced from anaerobic digestion of municipal solid waste (MSW) streams is an economically feasible alternative for electricity production in Maiduguri, Borno state. The most important issues and the key objective of this work are:

- To estimate the amount of MSW generated and collected which will be used to determine the potential biogas yield, total electrical, digestate and recyclables output (revenue generating output).
- To perform a comparative cash flow analysis of wholesale and retail electricity distribution alternatives to determine their economic feasibility and competitiveness.

METHODOLOGY

The procedures that will be used in actualising the objectives of this study are involves collection of primary data from the waste generated within the location. Also, a variety of secondary data collected from literatures both qualitative and quantitative, and used to generate the required figures for the economic model to be carried out successfully. Location specific data will be obtained from various sources and collated.

Average per capita waste generation will be obtained from taking the average of different locations in within the study area. These locations represent the academic,

commercial, industrial and residential areas, this is because waste generation varies significantly, thus, will yield errors if the average is not taken.

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Table 1: Important Data Utilised in the Research

S/N	DATA	USE OF DATA	SOURCE
1	Population	To assess the amount of waste generated	National Population Commission (2006)
2	Population Growth Rate	To assess the quantity of waste that can be generated over a number of years	UNFPA Nigeria (2014)
3	Waste Generation per person	To estimate how much waste can be generated by a person per day	Babatunde *et al.* (2013)
4	MSW Properties	General properties of waste generated in Borno state such as organic fraction of waste, carbon-nitrogen ratio and biodegradability of waste generated	Abubakar *et al.* (2013)
5	Waste Collection	To estimate how much waste can be made available for processing	Ogwueleka (2009)
6	Price of Electricity, Fees Payable, taxes and incentives, Licences	To estimate revenue that can be generated from sale of electricity, and power regulations and incentives offered	National Electricity Regulatory Commission (2010, 2012 and 2013) and KPMG (2013)
7	Energy Recovery Potential	To calculate the energy recoverable from the biochemical conversion of waste to energy	MUDGI (2013:15)
8	Plant costs	To estimate the costs of building municipal solid waste to energy plant	EIA (2013)

Population and per capita waste generation were used to calculate the total waste generated per day; this was converted to waste generated per year.

$$Total\ Waste\ Generated\ per\ day(Tonnes/day) = Population\ (hd) \times Average\ per\ capita\ Waste\ Generation\ (kg/hd/day) \quad (1)$$

This was according to calculations made by the Anderson centre, and GMU (2001). Future generated waste projections were made using the population growth rate of the state. The percentage quantity of total generated waste that can be collected was assumed to be 70% (Mattocks,1984). The MUDGI biochemical conversion model was modified according to the location specific data and used to calculate the biogas yield, net power generation and energy recovery potential of the biogas plant. Using MUDIG (2013:15) energy recovery potential as shown below;

Total Waste Quantity: W (tonnes)
Total Organic/ Volatile Solids: VS (50%)

$$Organic\ biodegradable\ fraction(66\%\ of\ VS) = 0.33 \times W \quad (2)$$

Typical Digestion Efficiency (60%)

$$Typical\ Biogas\ Yield\ (m^3) = 0.80 m^3/kg\ of\ VS\ destroyed \quad (3)$$

$$0.80 \times 0.60 \times 0.33 \times W \times 1000 = 158.4 \times W \quad (4)$$

Calorific Value of biogas = 5000kcal/m³ (typical)

$$Energy\ Recovery\ Potential(kWh) = B \times 5000/860 = 921 \times W \quad (5)$$

$$Power\ Generation\ Potential(kW) = 1339.53 \times W/24 = 38.4 \times W \quad (6)$$

Typical Conversion Efficiency (30%)

$$\boldsymbol{Net\ Power\ Generation\ Potential(KW) = 11.5 \times W} \quad (7)$$

$$Potential\ Energy\ Income\ (\$) = Net\ Energy\ Generated\ (kWh) \times Price/kWh \quad (8)$$

Percentage plant consumption (15%) and energy loss due to down time (10%) was subtracted from total energy generated in order to get the net energy generation. The capital cost and the operation and maintenance (O&M) cost of the proposed plant was calculated based on estimates of municipal solid waste power plant costs established by EIA (2013). The cost was given as 8,312 ($/kW) and 392.82 ($/kW-year) for capital and O&M costs respectively. These figures were given for plants with nominal capacity of 50 MW. This formed the basis for the cost estimation for this study.

A discounted cash flow for economic analysis will be constructed for a ten-year MSW to electricity generation project. Ten years was selected because the licences for power projects are only valid for ten years in which it can be renewed. The variables required for the project analysis are capital investment, operation and maintenance costs, cash flows, present values (PV), net present value (NPV), internal rate of return (IRR), payback period (PP) and benefit-cost ratio (BCR) and sensitivity analysis.

RESULTS AND DISCUSSION

The waste generated per year was calculated using the amount of waste collected through a period of three months within the study area. Only 70% of total waste generated is collected, thus yielding a total waste generation of 1,142,313.87 Tonnes/year of MSW in the first year and 1,543,370.87 Tonnes/year of MSW in the tenth year. Also, the amount of recyclable waste saleable was calculated to be 50% of the inorganic waste collected after pre-treatment and is shown in Table 2.

These results were used to calculate the amounts of all required outputs to be generated as stated in the methods section. These outputs include the biogas yield, electrical energy generated, digestate output after digestion and the amount of saleable recyclables gathered. The amounts generated as shown in Table 2 was used to calculate the income generating potential of the BTE project.

Table 2: Results Obtained for Revenue Generating Outputs

Year	Population	Total Waste Collected (Ton/year)	Organic Fraction of Waste Available for Digestion (Ton/year)	Biogas Yield (M^3/Year)	Solid Digestate Output (Ton/Year)	Amount of Saleable Recyclables (Ton/Year)	Net Energy Generated (kWh)
1	5,198,716.00	1,142,313.87	712,461.16	164,151,050.95	320,607.52	175,345.18	219,026,875.53
2	5,375,472.34	1,181,152.53	736,684.84	169,732,186.6	331,508.1	181,306.91	226,473,789.3

				8	8		0
3	5,558,238.40	1,221,311.72	761,732.12	175,503,081.03	342,779.46	187,471.35	234,173,898.13
4	5,747,218.51	1,262,836.32	787,631.01	181,470,185.79	354,433.96	193,845.38	242,135,810.67
5	5,942,623.94	1,305,772.76	814,410.47	187,640,172.10	366,484.71	200,436.12	250,368,428.23
6	6,144,673.15	1,350,169.03	842,100.43	194,019,937.96	378,945.19	207,250.95	258,880,954.79
7	6,353,592.04	1,396,074.78	870,731.84	200,616,615.85	391,829.33	214,297.48	267,682,907.26
8	6,569,614.17	1,443,541.32	900,336.72	207,437,580.78	405,151.52	221,583.59	276,784,126.10
9	6,792,981.05	1,492,621.73	930,948.17	214,490,458.53	418,926.68	229,117.43	286,194,786.39
10	7,023,942.41	1,543,370.87	962,600.41	221,783,134.12	433,170.18	236,907.43	295,925,409.13

Cost Estimates

For the plants, the capital cost for the tenth year was used for the purpose of the analysis as this was the point with the highest energy generation. It was calculated using the capital cost criteria stated in the methods section, and is given as $367,353,475.36. Both of the project alternatives have the same capital cost as they generate the same amount of electricity. The total capital investment comprises of the capital cost, and applicable licence fees required for each of the project alternatives to be evaluated. For project alternative one, the licences for generation, transmission, distribution, systems operations and trading are included in the capital investment. While the project alternative two only takes into cognisance the licence fees for generation and wholesale distribution.

Table 3: Total Capital Investment

	Alternative one	**Alternative two**
License Category	($)	($)
Generation	30,916.20	46,374.30
Transmission	306,107.99	N/A*
System operations	306,107.99	N/A
Distribution	81,107.99	20,610.80
Trading	81,107.99	N/A
Capital cost	367,353,475.36	367,353,475.36
TOTAL CAPITAL INVESTMENT	**368,158,823.52**	**367,420,460.46**

**Not Applicable*

The operating cost was also calculated according to the criteria stated in the methods section of this study. The two projects alternatives also have the same operating costs but different operating fees as shown in Table 4.

Table 4: Total Operating Costs for the each of the two project Alternatives

Year	Alternative One			Alternative Two		
	Operating cost ($)	Operating Fee ($)	**Total ($)**	Operating cost ($)	Operating Fee ($)	**TOTAL ($)**
1	10,913,005.74	2,036,949.94	12,949,955.68	10,913,005.74	427,102.41	11,340,108.15
2	11,284,047.93	2,106,206.24	13,390,254.17	11,284,047.93	441,623.89	11,725,671.82
3	11,667,705.56	2,177,817.25	13,845,522.81	11,667,705.56	456,639.10	12,124,344.66
4	12,064,407.55	2,251,863.04	14,316,270.59	12,064,407.55	472,164.83	12,536,572.38
5	12,474,597.41	2,328,426.38	14,803,023.79	12,474,597.41	488,218.44	12,962,815.85
6	12,898,733.72	2,407,592.88	15,306,326.60	12,898,733.72	504,817.86	13,403,551.58
7	13,337,290.67	2,489,451.04	15,826,741.71	13,337,290.67	521,981.67	13,859,272.34
8	13,790,758.55	2,574,092.37	16,364,850.92	13,790,758.55	539,729.05	14,330,487.60
9	14,259,644.34	2,661,611.51	16,921,255.85	14,259,644.34	558,079.83	14,817,724.17
10	14,744,472.25	2,752,106.30	17,496,578.55	14,744,472.25	577,054.55	15,321,526.80

Comparison of Project Alternatives

In utilising the converted biogas, two project alternatives were analysed. Project alternative one details a total investment in the project, from generation of electricity to trading directly to the end users. Retail prices were used to calculate the income from electricity and kept constant over the ten year licences' validity period. Project alternative two details investment in just generation and distribution to electricity suppliers, wholesale prices were used to calculate the income from electricity, these were also assumed to be constant over the ten-year validity of the licences. Table 5 below shows the criteria for which the profit indicators used for the economic analysis of the project's viability will be acceptable for any particular project alternative. Outside of these criteria, the project will not make any profit and will therefore fail.

Table 5: Acceptability Criteria of Profit Indicators

Economic Profit Indicator	Criteria for Acceptability
NPV ($)	NPV > 0
DISCOUNT RATE (%)	Discount Rate < IRR
CBR	CBR >1

Table 6 shows the results of the profit indicators used in this project, obtained from the discounted cash flow analysis for the two project alternatives. The NPV of alternative one

was $423,944,603.13, which was higher than zero, indicating that the project has a high profit potential. To strengthen this result, the IRR was 42%, indicating that the project could be profitable. The BCR was obtained to be 1.78 which is greater than 1; hence for every $1 invested, the wholesale electricity distribution project option will deliver $1.78. Therefore, the project could recover its costs in about two years and 361 days, and still make further profits as high as $0.78 for every dollar spent.

The NPV of alternative two was $367,083,352.63, which was also greater than zero, but less than that of alternative one, thus indicating profitability less than that of alternative one. The IRR was about 3.56% less than that of alternative one, meaning that despite its apparent potential for profitability when distributed wholesale, would yield less profit than when the electricity is distributed on a retail basis. Also, the BCR was less than alternative one by $0.8 and the costs would only be recovered after 3years and 91 days.

Table 6: Economic Profit Indicator Results from Discounted Cash Flow analysis

Economic Profit Indicator	Alternative one	Alternative two
NPV ($)	423,944,603.13	367,083,352.63
IRR (%)	42.00	38.44
BCR	1.78	1.70

As can be seen from Table 6 above, installing biogas plant will yield profits whether the energy generated is sold on a retail or whole sale basis. Hence the project alternative having the highest potential to generate profit will be chosen by the investors.

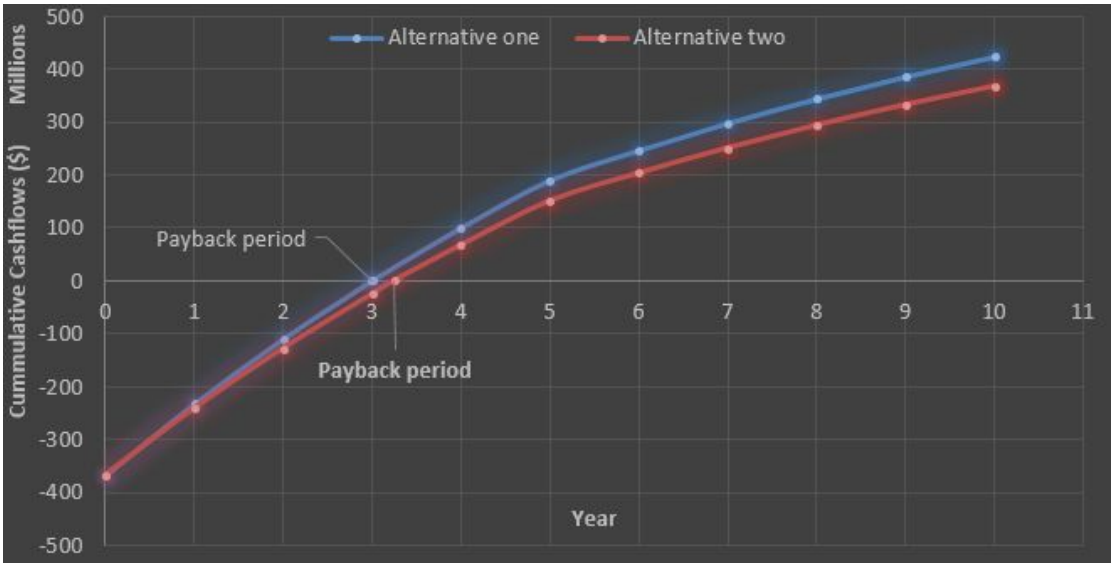

Figure 1: Cumulative Cash Flow of Project Alternatives

Figure 1 compares the cumulative cash flows of the two project alternatives being evaluated. As can be seen, there was a marked difference between selling as a retail energy provider than selling as a wholesale energy provider. Trading directly to end users will pay back the investment cost of the project faster at 2 years and 361 days, at an NPV of $423,944,603.13 than having to distribute the electricity generated at wholesale prices to electricity suppliers which would pay back the investment after 3 years and 91 days.

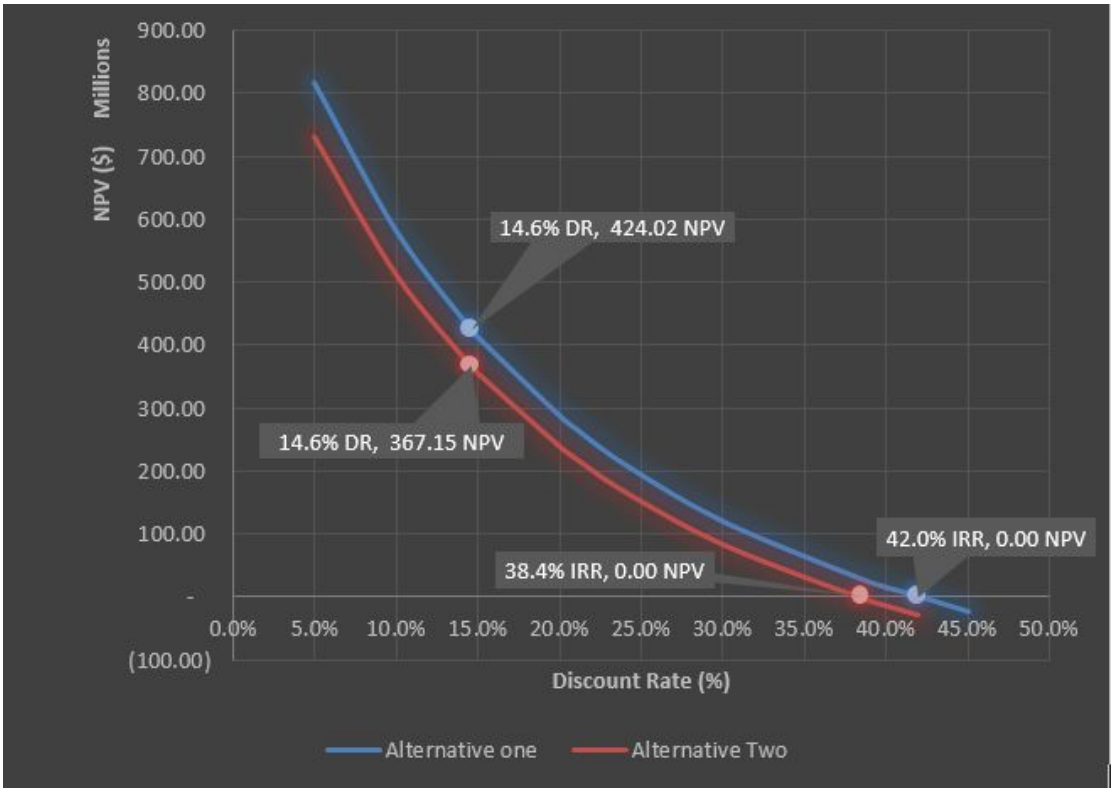

Figure 2: Relationship between the NPV and IRR for the Two Project Alternatives

As can be seen from Figure 2, the NPV becomes 0 at 42% discount rate for alternative one, and 38.4% for alternative two. This further confirms the profitability of Retail distribution over Wholesale. Therefore, the cash flow analysis of BTE plants shows economic viability of the project when all outputs (Digestate, Electricity, and Recyclables) are able to generate revenue.

CONCLUSION

From the discounted cash flow model adopted in this research, results obtained indicated that investing in Nigeria, and selling all of the plant's output (electricity, digestate, and recyclables) at current market prices, with a discount rate of 14.60%, will yield an economically viable investment. The results obtained and presented from the economic analysis of BTE plants in Nigeria, reveals that the argument posed in the introduction section of this work, which states that "the use of biogas produced from anaerobic digestion of municipal solid waste (MSW) streams is an economically feasible alternative for electricity production in Nigeria" is true and can be accepted. However, this argument can only be fully accepted if all plant outputs and benefits such as waste processing, reduction of landfill tax, reduction in carbon emission, digestate, electricity, and recyclables are inputted into the revenue generating stream.

Competition in the electricity market by new entrants in generation and retail supply will help in reducing the price of electricity, and also allow consumers to choose their suppliers, thus improving their confidence and reliability in the energy sector. This

will also reduce the amount of self-generation of electricity in the state, thereby reducing cost, noise pollution and CO_2 emissions into the atmosphere.

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Analysis and Prediction of Rain Attenuation: A Case Study of Maiduguri, Borno State, Nigeria

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Abstract: *This paper is aimed at determining the carrier-to-noise ratio, (C/N) during rain and clear sky, the Look angle, the Azimuth, and the rain attenuation analytically for a particular region over a location of (11.85N. 13.13E) to ascertain the impact of rainfall intensity and also the prediction of rain-induced attenuation. The parameters needed for these analyses were generated automatically through NIGCOMSAT 1R website. This result was achieved analytically using a formula, contour maps, and International Telecommunication Union (ITU-R) models. The result was verified to confirm their suitability and accuracy. These problems must be carefully examined for the accurate determination of the link budget.*

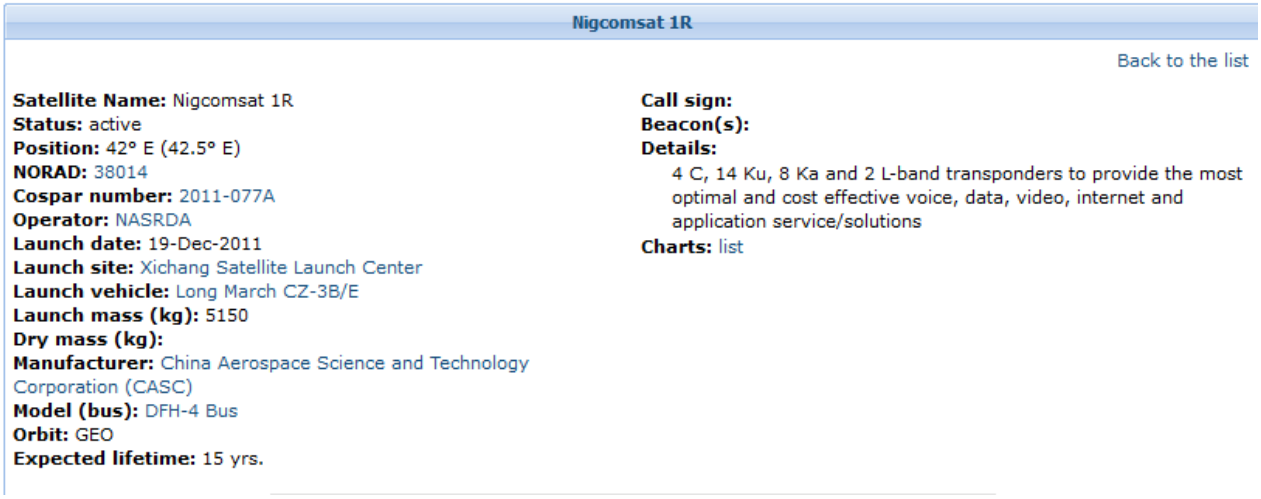
Key words: *Attenuation, Prediction, Satellite, Communication, Link Budget, Noise Ratio*

Introduction

The significance of communication in the development of human society is highly important. Access to information has thus become an important aspect of mass socio-economic development, as information underscores all aspects of development effort [1]. Africa remains the least continent in the world in terms of robust telecommunications infrastructure and systems to cover for its more than one billion people. Present infrastructure in the African environs is clearly insufficient, thus the need to develop national, sub-regional, and digital links with cross-border inter-connectivity as a means of closing the infrastructure deficiency. After due investigation and a request for proposals from various communications satellite companies, the Federal Government of Nigeria took the responsibility of signing a Communication Satellite contract with the China Great Wall Industry Corporation in December 2004. The high powered, Quad-band (Ku, Ka, C and L Band) geostationary satellite, with a service life span of 15 years, had 8 active transponders on the Ka-band, which were based on a feasibility field trial assessment of bandwidth demand projection for sub-Saharan Africa required to carry Africa's international voice and data traffic and the success of the ANIK F2 satellite with Ka-band [2]. Spatial and temporal

distribution of rainfall is the main research problem for telecommunication scientists and engineers because of its impairing effects on the propagation of microwave signals at frequencies beyond 7 GHz. However, rain data received over longer-integration times tend to average out and under-estimate worst cases of rainfall intensity. It was reported that at Ku-band, the attenuation is not up to 1 dB during the clear sky, but can reach 10 dB during the raining condition. Signal attenuation levels are more than 20dB in the most tropical region of the world so resulting in network signal loss, particularly for time-critical services like banking, defence, telemedicine, and in the military. It is very expensive to completely mitigate this degradation [3]. Atmospheric effects play a vital role in the design of satellite-to-earth links operating at frequencies above 10GHz. Raindrops absorb and scatter radio waves, causing signal attenuation and decrease system availability and reliability. The harshness of rain impairment rises with frequency and changes with regional locations. Therefore, the incidence of rainfall on radio links becomes more important for frequencies as low as about 7GHz especially in tropical and equatorial climates, where extreme rainfall events are common. Rain-rate and rain attenuation maps for the country of Nigeria were established using the models mainly designed for tropical zones and also a model for the estimation of point rain rate, while the ITU model is used for rain attenuation prediction method [4]. There is a need for reliable rainfall rate data for planning and designing of the satellite communications system, management of water resources and to assess the effect of climate change. Rain gauge measurement networks are not as dense or evenly spaced in Nigeria as in the other developed countries like the US and Japan; thus satellite observation of rainfall networks may be the best solution for adequate temporal and spatial coverage of rainfall [5].

Satellite communication allows two or more earth stations to communicate with each other through a radio relay system. The radio signals while being transmitted through the atmosphere, during rain events, are mitigated by absorption and scattering through the transmission medium. However, the troposphere has a lot of water vapor molecules, carbon monoxide molecules, oxygen molecules, and various aerosols such as snow, fog, and rain; and all these affect radio signals, leading to continual absorption, reflection, and scattering, which causes energy reduction (and attenuation). Rain attenuation can be defined as the product of “specific attenuation” in dB/km and the “effective propagation path length” in km. The ratio of the attenuation due to rainfall to the specific attenuation is referred to as the point rain rate while the product of the “path reduction factor” and the “physical path length”. The concept of effective path length is a method to average out the spatial inhomogeneity that is inherent in rain rate, and accordingly, the specific attenuation. Due to spatial inhomogeneity in rain rate which largely fluctuates with rainfall intensity, changes in path length reduction factor can be said as a function of rain rate or its corresponding time exceedances. Attenuation can, then, be derived from direct measurements or can be predicted from the knowledge of long-term rain rate [6].



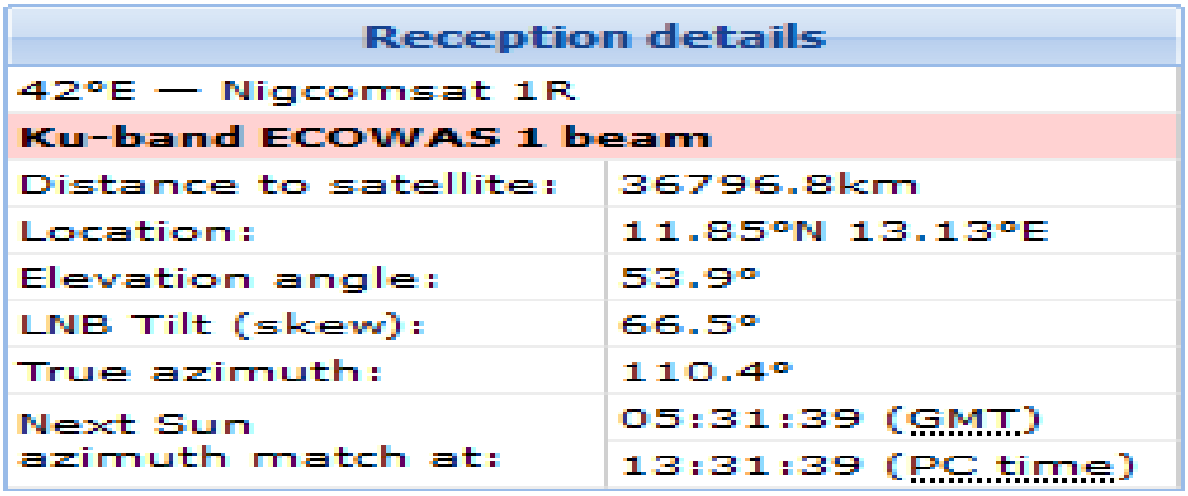
Nigcomsat 1R

Back to the list

Satellite Name: Nigcomsat 1R
Status: active
Position: 42° E (42.5° E)
NORAD: 38014
Cospar number: 2011-077A
Operator: NASRDA
Launch date: 19-Dec-2011
Launch site: Xichang Satellite Launch Center
Launch vehicle: Long March CZ-3B/E
Launch mass (kg): 5150
Dry mass (kg):
Manufacturer: China Aerospace Science and Technology Corporation (CASC)
Model (bus): DFH-4 Bus
Orbit: GEO
Expected lifetime: 15 yrs.

Call sign:
Beacon(s):
Details:
4 C, 14 Ku, 8 Ka and 2 L-band transponders to provide the most optimal and cost effective voice, data, video, internet and application service/solutions
Charts: list

Fig 1: NIGCOMSAT 1R Parameter.



Reception details	
42°E — Nigcomsat 1R	
Ku-band ECOWAS 1 beam	
Distance to satellite:	36796.8km
Location:	11.85°N 13.13°E
Elevation angle:	53.9°
LNB Tilt (skew):	66.5°
True azimuth:	110.4°
Next Sun azimuth match at:	05:31:39 (GMT) 13:31:39 (PC time)

Fig 2: Ku-band ECOWAS 1 Beam Parameter.

Reception details	
42°E — Nigcomsat 1R	
C-band ECOWAS 1 beam	
Distance to satellite:	36796.8km
Location:	11.83°N 13.13°E
Elevation angle:	53.9°
LNB Tilt (skew):	66.5°
True azimuth:	110.4°
Next Sun azimuth match at:	05:31:19 (GMT) 13:31:19 (PC time)

Fig 3: NIGCOMSAT 1R Parameter for C-Band ECOWAS 1 Beam

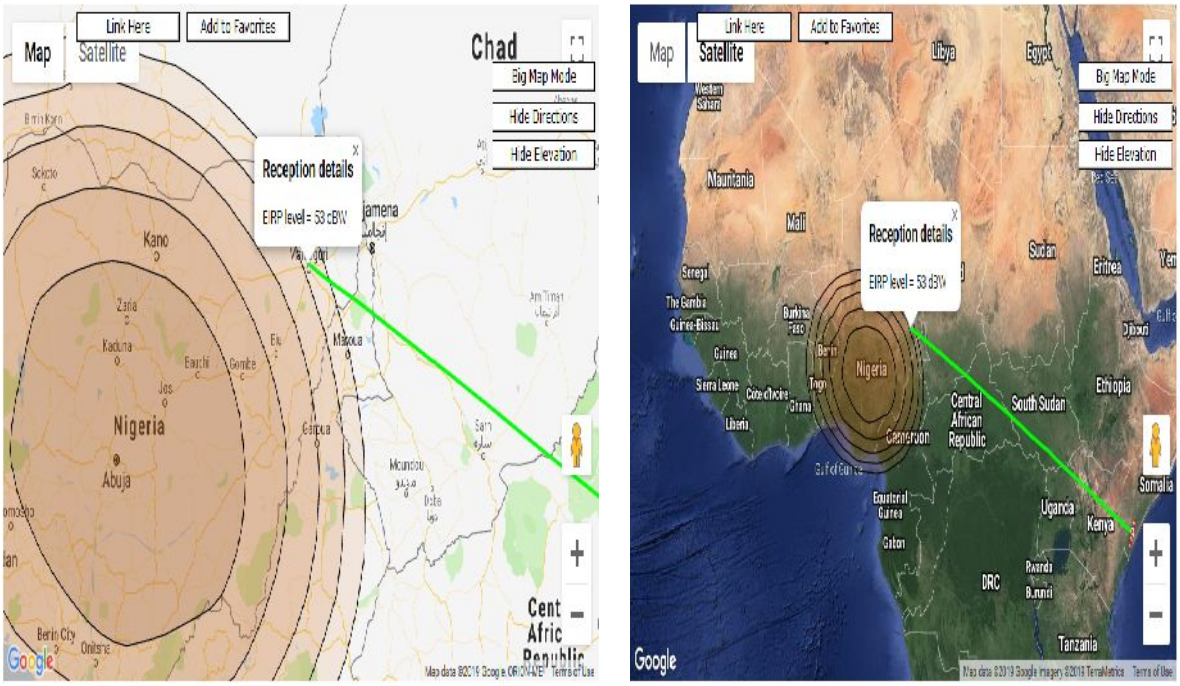


Fig 4: Automatic Parameter Generation On Map Showing Maiduguri and its Environs.

Fig 5: Automatic Parameter Generation On Map Showing Maiduguri and its Environs.

Determining The Look Angle and Azimuth Analytically

Parameter from NIGCOMSAT 1R

i. $ES \rightarrow 13.13°E,\ 11.9°N$

ii. $S \rightarrow 42°E,\ 0°N$

Resolving Using the Formula Method

$$cos(\gamma) = cos(L_E)cos(I_S\_I_E) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$= cos(11.9)cos(42\_13.13) = 0.857$$

$$\gamma = 31.03$$

$$r_s = 43174.94km,\quad r_e = 6378.14km$$

Determining The Look Angle and Azimuth Analytically

$$cos(EL) = \frac{sin(\gamma)}{\left[1+\left(\frac{r_e}{r_s}\right)^2 - 2\left(\frac{r_e}{r_s}\right)cos(\gamma)\right]^{\frac{1}{2}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$= \frac{sin(31.03)}{\left[1+\left(\frac{6378.14}{43174.94}\right)^2-2\left(\frac{6378.14}{43174.94}\right)cos(31.03)\right]^{\frac{1}{2}}}$$

$EL = 53.99°$

$$= \tan^{-1}\left[\frac{\tan(42-13.13)}{\sin 11.9}\right] = 69.494$$

$AZ = 180 - \alpha = 180 - 69.494 = 110.5$

$AZ = 110.5°$

Obtaining C/N During Clear Sky

Taken F = 12GHz for down link Ku band

$EIRP = P_t,\ G_t,\ = 53dBw,\ P_r = ?,\ G_t, = ?,\ N = ?,\ C/N = ?,$

$Recal\ P_r = P_t + G_t + G_r - L_p$ .....(3)

Looking for the antenna gain

Using $\eta = 60\%,\ D = 2m$

$but\ \lambda = \frac{C}{F}$ .....,(4)

$$= \frac{3\times10^8}{12\times10^9} = 0.025$$

$G_r = \eta\left(\frac{\pi D}{\lambda}\right)$ .....(5)

$$= 0.6 \times \left(\frac{\pi \times 2}{0.025}\right) = 45.8db$$

Looking for Free Space Loss

$L_s = 32.45 + 20log36796.8 + 20log12000MHz = 205.35dB$

Clear path loss= $2dB$

$\therefore total\ loss = 205 + 2 = 207.35dB$

$hence,\ P_r = 53 + 45.8 - 207.35 = -108.5dB$

$but\ N = BKT$ .....(6)

Equally

$T_S = T_{in} + T_R$ .....(7)

$T_{in} = 270\left(1 - 10^{-\frac{2}{10}}\right) = 100k$

$T_S = 100 + 100 = 200k$

$N = 1.3 \times 10^{-23} \times 200 \times 8 \times 10^8 = 2.208 \times 10^{-14} = -136.56dBw$

$C/N = P_r - N$ .....(8)

$= -108.5 - (-136.56dB) = 28.1dB$

G/T Ratio of Earth Station

The ratio of the earth station G/T

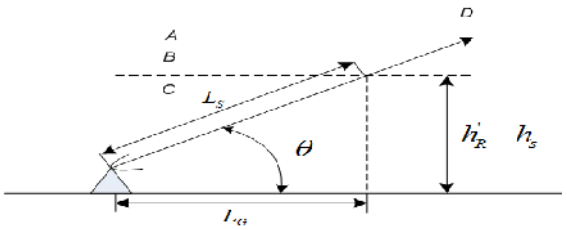
$G/T = \frac{G_r}{T_s}$ ..... (9)

$= \frac{45.8}{28.1} = 2dB$

Hence $C/N > G/T$

Determining Rain Attenuation

$A = \gamma_R L_{\text{eff}}$ .....(10)



Taken

$h_r = 5, \quad h_s = 0, \quad \approx 11.9°$

$\therefore L_s = \frac{h_r - h_s}{\sin\theta}$ .....(11)

$$\therefore \frac{5-0}{\sin 53.9} = 6.188$$

$$\therefore L_G = L_s \cos\theta \quad \text{.....(12)}$$

$$= 6.188 \times \cos 53.9 = 3.646$$

Rain rate contour map $R_{0.01} = 85$

$$\gamma_{R=} K(R_{0.01})^{\alpha} \text{Db} \quad \text{.....(13)}$$

$$\gamma_{R=} 0.0168(85)^{1.217} = 3.745 dB/km$$

Table 1: Table of Coefficient [4].

F (GHz)	k_H	k_V	$\propto_H$	$\propto_V$
4	0.00065	0.00059	1.121	1.075
6	0.00175	0.00155	1.308	1.265
8	0.00454	0.00395	1.327	1.310
10	0.0101	0.00887	1.276	1.264
12	0.0188	0.0168	1.217	1.200
20	0.0751	0.0691	1.099	1.065
30	0.187	0.167	1.021	1.000
40	0.350	0.310	0.939	0.929
50	0.536	0.479	0.873	0.868

Table 2. Local climatological parameters of the stations in Nigeria [4].

Station	Longitude (°N)	Latitude (°E)	Average annual accumulation (mm/year)
Akure	5.18	7.17	1485.57
Ikeja	3.2	6.3	1425.207
Calabar	8.17	4.58	2864.907
Minna	6.33	9.36	1196.751
Kano	8.3	11.58	924.850
Makurdi	8.53	7.32	1337.371
Sokoto	5.13	13.04	567.206
Maiduguri	13.08	11.51	648.455
Dikwa	14.52	12.08	657.433
Adamawa	12.3	9.10	1012.398
Ile Ife	5	7.5	1215.27
Ilorin	4.5	8.5	1232.775
Port Harcourt	7	4.2	2803.104
Warri	5.44	5.29	2617.503
Enugu	7.27	6.25	1876.301
Abuja	9.25	7.1	1777.538
Saki	3.23	8.39	1097.968
Jos	8.5	9.5	1186.89
Gombe	11.11	10.16	746.805
Bauchi	9.5	10.18	849.397
Kaduna	7.26	10.33	1103.464
Zaria	7.41	11.04	801.879
Borno	12.45	11.59	574.488
Gusau	6.4	12.09	650.288
Nguru	10.25	12.59	451.586
Katsina	7.35	13	556.336

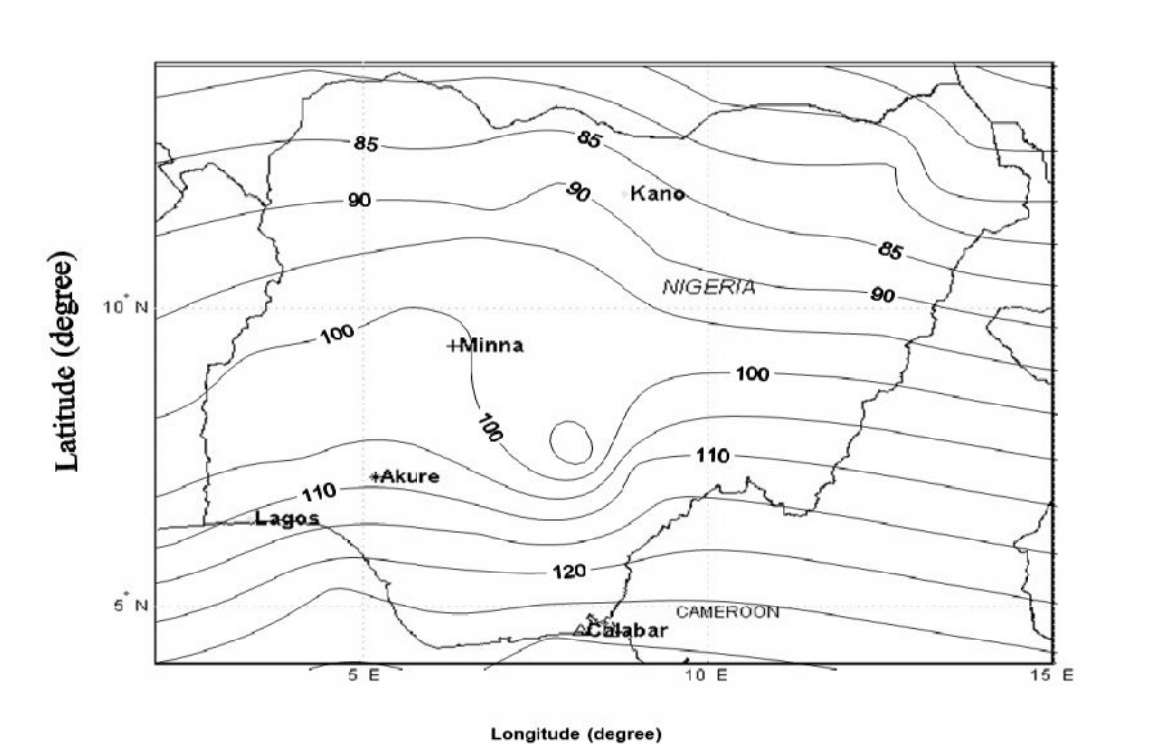


Figure 6. Rain Rate (Mm/H) Contour Maps For 0.01% Of Time In Nigeria [4].

The horizontal reduction factor $r_{0.01}$ for 0.01%

$$r_{0.01} = \frac{1}{1+0.78\left(\sqrt{\frac{L_G\gamma}{f}}\right)-0.38\left(1-e^{(-2\times L_G)}\right)} \quad \text{.....(14)}$$

$$r_{0.01} = \frac{1}{1+0.78\left(\sqrt{\frac{3.646\times 3.745}{12}}\right)-0.38(1-e^{(-2\times 3.646)})}$$

$$r_{0.01} = 0.688$$

Calculating The Vertical Adjustment Factor

$$\therefore \xi = \tan^{-1}\left(\frac{h_r-h_s}{L_G r_{0.01}}\right) \quad \text{.....(16)}$$

$$= \tan^{-1}\left(\frac{5-0}{3.646\times 0.6885}\right) = 63.34 \text{ deg}$$

$\xi = 63.34, \quad \xi > \theta$, satisfied for the condition. therefore

$$L_R = \frac{L_G r_{0.01}}{\cos\theta} \quad \text{.....(17)}$$

$$\frac{3.646 \times 0.6885}{\cos 53.9} = 4.26$$

Considering the latitude of Maiduguri Borno state. Nigeria (11.9°)

$\therefore$ *the latitute of Maiduguri* < 36

$$\chi = \begin{cases} 0, & \phi \geq 36^\circ \\ 36 - |\phi|, & \phi < 36 \end{cases}$$

hence, $X = 36 - 11.9 = 24.1$

The Vertical Adjustment Factor

$$V_{0.01} = \frac{1}{1+\left(\sqrt{\sin\theta}\right)\left[31\left(1-e^{-\theta(1\div x)}\right)\times\left(\sqrt{\frac{L_R\gamma}{f^2}}\right)-0.45\right]} \quad \text{.....(18)}$$

$$V_{0.01} = \frac{1}{1+\left(\sqrt{\sin 53.9}\right)\left[31\left(1-e^{\frac{-53.9}{1+24.1}}\right)\times\left(\sqrt{\frac{4.26\times3.745}{12^2}}\right)-0.45\right]} \quad \text{.....(19)}$$

$V_{0.01} = 0.114$

Calculating Attenuation

Effective path loss

$$L_E = L_R \times V_{0.01} \quad \text{.....(20)}$$

$$= 4.26 \times 0.114 = 0.48km$$

The Predicted Attenuation

$$A_{0.01} = \gamma L_E \quad \text{.....(21)}$$

$$= 0.48 \times 3.745 = 1.82dB$$

Calculating CNR During Rain

$$T_S = T_{in} + T_R \quad \text{.....(22)}$$

$$T_{in} = 270\left(1 - 10^{-\frac{A}{10}}\right),\ A = 2 + 1.82 = 3.82$$

$$T_{in} = 270\left(1 - 10^{-\frac{3.82}{10}}\right) = 158k$$

$$T_S = 100 + 100 = 257k$$

$$N = 1.3 \times 10^{-23} \times 258 \times 8 \times 10^{8} = 2.68 \times 10^{-12} = -115dBw$$

$$C/N = P_r - N \quad \text{.....(23)}$$

$$= -108.5 - (-1156dB) = 7.21dB$$

Ratio of The Earth Station $^{G}/_{T}$

$$^{G}/_{T} = \frac{G_r}{T_s} = \frac{45.8}{24.1} = 1.9dB$$

Hence $C/N > {}^{G}/_{T}$

Result

The result summary.

Name	Result
Elevation Angle Analytically	53.99^0
Azimuth Analytically	110.5^0
C/N During Clear Sky	28.1Db
Predicted Rain Attenuation	1.82dB
CNR During Rain	**7.2**1dB

Conclusion

Conclusively the formulas ware proven reliable as can be seen during determining the elevation angle (EL) which is 53.99^0 compared to 53.9^0 which was generated automatically from NIGCOMSAT 1R website. However careful measures must be taken to ascertain the accuracy of the result. The result obtained will be very helpful in the satellite link budget and design.

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Design and Construction of a Motorized Okra Slicer

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Abstract: *The motorized Okra slicing machine was designed to help farmers' process okra with ease and stress-free. The machine was designed, constructed with locally available materials and it performance was evaluated. The average slicing efficiency, throughput capacity and scattered losses were 90.37%, 62.2kg/hr and 8.32% respectively.*

Key words: *Okra, Designed, Constructed, Evaluated, and Slicing Efficiency*

1. INTRODUCTION

1.1 BACKGROUND

Okra or Okra, known in many English speaking countries as Ladies fingers, Okro or gumbo, is a flowering plant in the mallow family. It is valued for it edible green seed pods. The origin of Okra is disputed, with supporters of West Africa, Ethiopian, and South Asian original. The plant is cultivated in the tropical, subtropical and warm temperate regions around the world (John, 2000).

The main objective of the project is to design a simple okra slicer. The specific objectives are:

i. To design a machine to cut okra.
ii. To construct the machine.
iii. To test the performance of the machine.

Using Okra slicing machine help to reduce difficulties that are encountered with the processing of okra using hands which is laborious and very slow and result in wastage of okra. This machine makes it easy for okra processing. This machine was constructed using local materials which make it affordable for local farmers to own and use.

2. DESIGN METHODOLOGY

2.1DESCRIPTION AND WORKING PRINCIPLE OF MACHINE

2.1.1Description of machine

The okra slicer consists of the following main features:

i. A feed hopper

ii. Casing
iii. Shaft
iv. Transmission unit.
v. Outlet chute
vi. Slicing units (cutting blades)
vii. Power unit

2.1.2 MATERIAL SELECTION

Materials for the construction were selected base on strength, functionality, durability, ability to withstand vibration and the cost of such material. In the choice of material, their physical properties and behavior were considered such that when subjected to the machine running condition should be able to withstand their service condition.

2.2 WORKING PRINCIPLE OF THE MACHINE

The crop (okra) is fed into the machine through the hopper and it goes into the slicing chamber with the help of the force of gravity where there are blades attached to the shaft. The machine is operated by an electric motor. As the electric motor is on, then the power is transmitted to the slicing chamber by the transmission units such as the pulley and the belt which rotate the shaft and cut or slice the okra. As the okra is sliced it goes out of the machine through the outlet chamber.

2.3 DESIGN CALCULATIONS

2.3.1 Feed hopper:

The hopper will be designed to be a frustum, trapezoidal in shape and the dimensions will be chosen based on proportionality and aestatics (Ndirika, 1993). The angle of the base to the vertical is (α) which will be the measured angle of repose of okra.

Volume of hopper will be determined from the following equation.

$$V_f = \frac{h_f}{3}(A_1 + A_2 + \sqrt{A_1 \times A_2}) \qquad \text{(Ndirika, 1993)}$$

1

$$A_1 = L_f \times B_1$$

$$A_2 = L_f \times B_2$$

$$A_3 = L_f \times h_f$$

Where;

V_f = Volume of frustum, m^3

A_1 = Area of the top of the frustum, m^2

A_2 = Area of the base of the frustum, m^2

A_3 = Area of rectangular side of frustum, m^2

h_f = Height of frustum, m

H_h = Height of hopper, m

L_f = Length of frustum , m

B_1 = Breadth of the top frustum, m

B_2 = Breadth of the base frustum, m

2.3.2 Angle of repose of okra

The angle of repose is the angle between a base and a slope of a cone formed on a free vertical fall of grain mass to a horizontal plane.

Formula for calculating angle of repose

$\theta = \tan^{-1}\left(\frac{2HP}{DP}\right)$ (Ndirika, 1993)

The angle of repose of okra was determined by allowing the fruits to fall freely from a height, and a rule was used to measure the height of the heap formed. The following values were obtained:

Height of the pile HP = 20cm

Diameter of pile DP = 40cm

$$\theta = \tan^{-1}\left(\frac{2HP}{DP}\right)$$

Where HP = height of the pile in cm

DP = diameter of the pile in cm.

2.3.3 Weight of shaft

Main shaft: shaft material is mild steel with density of 7.83 x 10^3kg/m^3

D = 10mm

$$Area = \frac{\pi D^2}{4}$$

Volume of the shaft V = A x L

Mass of shaft M = PV

Where P = density of shaft material

2.3.4 Determination of pulley dimension

$N_I D_I = N_2 D_2$ (Ndirika, 1993)

Where N_I = speed of electric motor (1426rpm)

D_I = diameter of driving pulley (50mm)

N_2 = speed of driven pulley (366mm)

D_2 = diameter of driven pulley?

Belt drive dimension

The amount of power transmitted depends on the following;

i. The velocity of the belt,
ii. The tension under which the belt is placed on the pulleys,
iii. The arc of contact between the belt and the smaller pulley,
iv. The conditions under which the belt is used.

V-belt: According to Khurmi and Gupta, (2013) V-belt is mostly used where a great amount of power is to be transmitted, from one pulley to another, when the two pulleys are very near to each other. And where both pulleys rotate in the same direction open belt drive is used (Figure 4). Therefore V-belt will be used.

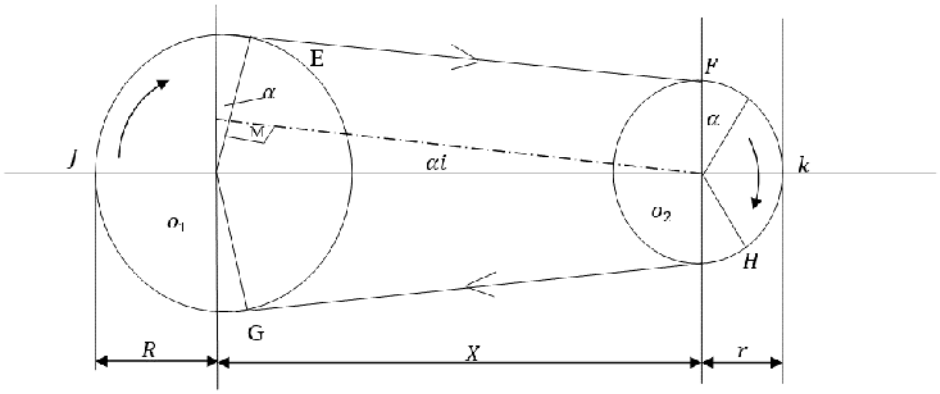

Figure 1: Open belt drive **(Source: Khurmi and Gupta, 2013)**

Where,

R = Radius of the larger pulley,

r = Radius of the smaller pulley,

x = Distance between the centers of two pulleys (i.e. 0_1, 0_2) and

L = Total length of the belt.

2.3.6 Distance between pulley centers

The distance between pulley centers according to Khurmi and Gupta, (1992) is given by:

$$X = Max\ (2R: 3r + R)$$

Where; R= radius of big (driven) pulley,

r= radius of small (motor) pulley.

The larger of the two values of X is usually chosen.

$$R = \frac{d_2}{2}$$

$$r = \frac{d_1}{2}$$

2.3.7 Belt length

The belt length L_1 will be determined using equation 2 (Khurmi and Gupta (2013).

$$L_1 = \frac{\pi}{2}(d_1 + d_2) + 2x_1 + \frac{(d_2 - d_1)^2}{4x_1} \quad 2$$

Where;

x_1 = Distance between pulley centers mm

d_1= Driver (electric motor) pulley diameter mm

d_2 = Driven pulley diameter mm

2.3.8 Bearing selection

This was done base on ASAE (1979) standard. The factors considered are:

i. Speed of the shaft
ii. Size of the shaft
Bearing allows motion between mechanical elements and lower the friction between them. (James, 2017).

A single row deep groove ball bearing was selected with inner diameter of 10mm and external diameter of 20mm which are four in number and have the same size. That is for the main shaft and the lower shaft.

2.3.9 Power requirement

The belt torsion would be determined using the equation given by Khurmi and Gupta, (2013).

$P = T_1 - T_2$

$$\frac{T_1}{T_2} = e^{u\theta}$$

$$V = \frac{\pi dN}{60}$$

Where;

P = Power from the prime mover (W)

T_1& T_2 = tension on the slack and tight side of the belt respectively (N)

N = Speed of prime mover (rpm)

D = Diameter of pulley (m)

θ = Angle of the lab (rad)

μ = Co-efficient of friction between the belt and the pulley

V = Velocity of belt (m/s).

2.3.10. Design of shaft

The required diameter for a solid shaft having combined bending and torsional loads is obtained from two basic theories of failure namely,

i. Maximum Shear Stress Theory or Guest's theory used for ductile materials such as mild steel,
ii. Maximum Normal Stress Theory or Rankin's theory used for brittle materials such as cast iron (Hannah, 1984).

Since mild steel is used for the shaft, maximum shear stress theory was used for the design of the shaft diameter and it is given in the equation 5 (Khurmi and Gupta, 2013).

$$d^3 = \frac{16}{\pi Ss}\sqrt{(K_b M_b)^2 + (K_t M_t)^2}$$

Where;

S_S = Maximum permissible shear stress,

$$Ss = \frac{Ultimate\ Strength\ in\ Shear}{Factor\ of\ Safety, FS} \qquad 6$$

K_b = Combined shock and fatigue factor applied to bending moment,

K_t = Combined shock and fatigue factor applied to torsional moment,

M_b = Maximum bending moment, Nm,

M_t = Torsional moment, Nm.

2.4 INSTRUMENTATION

The instruments used include;

i. **Protemeter**: It is a digital instrument used to measure content of grains. The grain master is protemeter moisture meter used was manufactured by Martin Linshman Ltd and has a range of 0 – 100%.
ii. **Tachometer**: This is used to measure the speed of shaft in revolution per minute.
iii. **Stop watch**: This is used to obtained time for each experiment in second. The stop watch model KK – 1045, and manufactured by Kenko it had a range of 0.00 – 9.59.59.
iv. **Lysimeter**: This is use to measure the weight in kilograms of materials. The Lysimeter was manufactured by Norwood instruments Ltd and has a range of 30kg maximum weight.

2.5 PERFORMANCE EVALUATION

The formulae for evaluating the different parameters for the performance of the machine were obtained from Ndirika (1993).

i. **Slicing efficiency Se (%)**: This is defined as the ratio of the weight of the fruits collected to the weight of total fruits.

$$S_e = \frac{W_{cs}}{W_t}$$

Where; W_t = total weight of fruits put into the hopper.

W_{cs} = weights of fruits collected at the outlet.

ii. **Scatter loss, SCL (%)**: This is the loss acquired due fruits scattering around the slicer during slicing operation.

$$scl = \frac{Q_l}{Q_t} \times 100\%$$

Where: Q_l = quantity of okra scattered around the machine

Q_t = total quantity of okra introduced into the machine

iii. **Throughput capacity, T_C (kg/h):** This is the total material quantity that pass through the machine in a given time.

$$\text{Through-put-capacity} = \frac{Q_s}{T}$$

Where: Qs = Quantity of sliced okra

T = time taken to sliced the okra

3. RESULT AND DISCUSSION

3.1 RESULTS

The machine was designed, constructed and tested by slicing the okra. The experiment was carried out on the machine using the okra of different quantity up to four times and it is as follows in table below.

Table 1: results of the Okra slicing machine

S/N	**Mass of okra(kg)**	**mass of scattered okra(kg)**	**mass of sliced okra(kg)**	**Time take(s)**	**S_e (%)**	**T_C (kg/h)**	**SCL (%)**
1	0.70	0.092	0.595	40s	85	53.5	13.14
2	1.00	0.103	0.880	60s	88	52.6	10.33
3	1.50	0.1012	1.38	75s	92.5	66.0	6.75
4	2.00	0.0614	1.92	90s	96	76.8	3.07
mean					**90.37**	**62.2**	**8.32**

From the results on the table above, the average slicing efficiency, throughput capacity and scattered losses are 90.37%, 6.22kg/hr and 8.32% respectfully. The result shows that the slicing efficiency and throughput capacity increases with increase in mass of okra introduced into the machine but the scatter losses decreases with increase in mass of okra introduced into the machine.

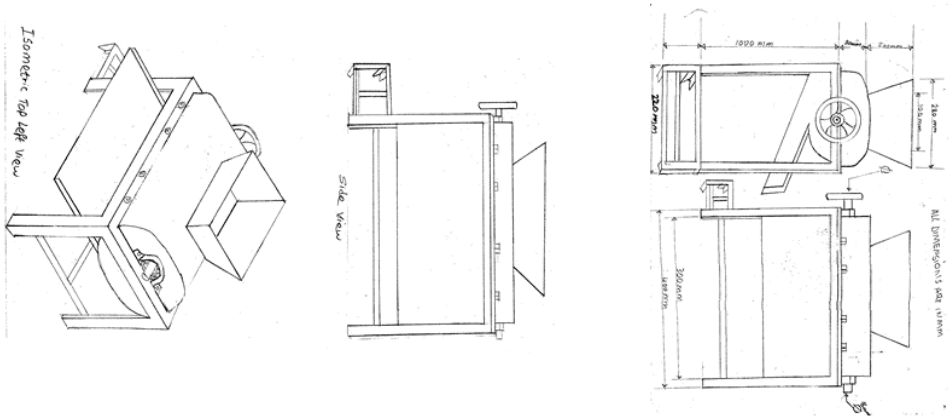

Figure 2: Developed Okra Slicing Machine.

4. CONCLUSION AND RECOMMENDATIONS

4.1 CONCLUSION

The design and fabrication of a okra slicing machine was successfully done. The machine can also be used to process other agricultural materials that have similar physical rheology and mechanical properties. The machine was designed to replace the traditional method of slicing okra which is very laborious.

4.2 RECOMMENDATIONS

As a result of some bottlenecks encountered during the construction and testing of the machine, the following are recommended for further improvement on the machine.

i. The size of the hopper should be increased and a means of pressing the okra inside the hopper should be provided.
ii. The outlet chute should be encased for safety and hygiene.

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Modern Microeconomics Renewable Energy

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Abstract: *Renewable energy is widely regarded as future substitute to fossil fuels mostly because it is self-replenishing and environmental-friendly. However, its use in the electricity industry is presently limited because it is about four to eight times more expensive than fossil fuels. This paper examines the global macroeconomics of renewable energy in electricity utilization from the perspective of a developing country such as Nigeria and the rest of Africa. The energy macroeconomic variables examined are access to energy, cost-competitiveness, electricity demand supply curve, net energy ratio, entropy, capital intensity, environmental externalities, energy efficiency and dispatchability. The implications of each of these macroeconomic variables projected future outlook of the energy industry with particular reference to electricity utilization and recommended strategies for developing countries are also examined.*

Key words: *Electricity, Energy, Fossil fuels, Macroeconomics, Renewable Energy.*

1. INTRODUCTION

The world is an energy economy. All forms of existence on earth and in the universe, both living and non-living things, contain energy in different forms and quantities. The total amount of energy in the universe is fixed because according to Isaac Newton's Law of Motion, energy can neither be created nor destroyed. The survival of mankind through the ages has revolved around the transformation of energy from one form to another. The greatest challenges to man's energy transformation activities are cost and energy losses associated with the transformation processes and technologies, Renewable energy in the form of wood was the first major global source of energy before it was displaced by coal during the Industrial Revolution of the 18th century. The discovery and exploitation of petroleum oil and gas led to its dominance as a global source of energy during the Second World War and it has remained the dominant source of energy till today. The Middle East Oil Embargo of the1970's which led to global shortage in the supply of crude oil and huge upsurge in the international price of crude oil and spiraling inflation in Europe and the United States served as a catalyst for the western countries' drive for improved energy security through the reduction of dependence on imported fossil fuels for electricity generation, heating and mass transportation (Faninger 2012), This is the reason for

tremendous increase by western countries in research budget to develop alternative energy sources to fossil fuels that will be commercially competitive and readily available. This is contrary to the perception today that the main driver for the developed countries' interest in renewable energy development is carbon footprint reduction and concerns about externalities associated with environmental pollution (Stokes 2015),.

An understanding of the most important and distinguishing characteristics of electricity is crucial to understanding its economics. These characteristics are unstorability (due to the high cost of doing so), society and government perception of electricity (as a merit good or a social good) and the inelastic nature of demand-supply curve of electricity. These features are examined in detail below.

2. Macroeconomics of Renewable Energy Development

The macroeconomics of renewable energy will be examined from the following perspectives:

a) Self-replenishing and uncontrolled access of renewable energy resources
b) Cost-competitiveness of renewable energy resources
c) Inelastic demand-supply curve of electricity
d) Net Energy Ratio, Net Energy Gain (NEG) and Entropy
e) Capital Intensity
f) Environmental externalities
g) Energy efficiency and energy subsidies
h) Dispatchability

a. Self-replenishing and uncontrolled access of renewable energy resources. Renewable energy resources can be regarded as public goods or quasi-public goods because they are inexhaustible and access to them is almost uncontrollable. While renewable energy resources have value in use, they do not have value in exchange since they are available to all and their consumption does not diminish the amount that is available for others to consume (characteristic of public goods). These characteristics exposes renewable energy resources to the Tragedy of the Commons whereby their uncontrolled consumption can as a result of destructive self-interest, lead to damaging exploitation behavior. This is because the utilization of renewable energy resource provides no incentive for individuals or the users to preserve the resource. This can have a future military application through the transformation of uncontrolled access to renewable energy resources especially as solar energy, to deliberately limited access to energy sources.

b. Cost-competitiveness of renewable energy resources. There are two major sources of energy for electricity generation namely fossil fuels and renewable energy sources. Fossil fuel power technology has a well-established global supply chain network and has become acceptable, available and affordable to people all over the world. In contrast, renewable energy technology is more recent, less well researched and developed, relatively more expensive and does not yet have established global supply chain infrastructure. Some countries in recognition of the commercial shortcomings of renewable energy technology when compared to fossil fuel power generation technology, have introduced various schemes that makes the former more cost-competitive, e.g., UK's Renewable Obligation (RO) certificates. On the other hand some other countries such as Nigeria are yet to develop policies that will make renewable energy competitive with the dominant fossil fuels. With the

pace of progress being made in renewable energy development, it is projected that in the next few decades, the unit cost of renewable power generation may be as cheap as that of fossil fuel power generation.

c. **Inelastic demand-supply curve of electricity.** Electricity is inelastic in many countries because it plays a central role in the everyday lives of people and there is yet no viable and competitive alternative to the roles that it plays in the society. Irrespective of the price of electricity or the quantity in supply, its demand will barely be affected. Consequently, in many developing countries where there is a strong societal perception of electricity as a social good, governments impose a price ceiling on electricity tariff in order to make it affordable for the citizens. Even in the developed countries where electricity is perceived as a merit good with emphasis on its efficient supply, social welfare schemes are put in place in order to make the lower segments of the society are able to pay for electricity - a further recognition that there is yet no commercially competitive alternative to electricity and hence the reason why electricity has inelastic demand-supply curve. Debates still persist concerning whether electricity markets should be free-floating or government controlled via price ceiling and other control mechanisms.

d. **Net Energy Ratio. Net Energy Gain (NEG) and Entropy.** Net energy ratio or Energy Return on Energy Invested (EROI) is the energy available for final consumption divided by the expended in producing it. A related expression is Net Energy Gain (NEG) which is the difference between energy that can be usefully consumed and the energy that is spent to make it available for consumption. Fossil fuels contain energy in concentrated form and have low entropy and more energy available for useful work/consumption compared to renewable energy resources which are characterized by energy in dispersed form and higher entropies. This is illustrated in Table 1 which shows that renewable energy resources have lower net energy ratios than fossil fuels. From an energy management perspective, this makes renewable energy resources more expensive to process for final consumption.

Energy source	Energy category	Net energy ratio
Shale oil	Fossil fuel	5
Natural gas		10
Oil (global)		35
Coal		80
Ethanol (sugarcane)	Renewable energy	0.8-1.0
Ethanol (corn-based)		0.8-1.0
Biodiesel		1.3
Photovoltaic cells		6.8
Wind		18
Hydropower		>100

Table 1: Net Energy Ratios for Fossil Fuels and Renewable Energy Sources (Source: Timmons, Harris and Roach 2014a),

e. **Capital intensity.** Accordingly to IRENA (2016), in terms of capital intensity, renewable energies have considerably higher capital costs per kW compared to

fossil fuels and thus are more capital intensive - refer to Table 2. However, renewable energy resources have much lower operation and maintenance cost compared to fossil fuels. Total Cost of Electricity Produced (TCOE), also called Levelized Cost of Electricity (LCOE) or Levelized Energy Cost (LEG) is used to calculate the net

Energy source	Energy category	Capital cost($)/kW
Natural gas (combined cycle)	Fossil fuel	1,019
Coal (advanced pulverized fuel)		3,607
Hydropower	Renewable energy	3,915
Wind (onshore)		8,852
Biomass		9,089
Wind (offshore)		17,800
Solar (photovoltaic)		19,365
Solar (thermal electric)		25,335

Table 2: Capital Intensity of Renewable Energy and Fossil Fuel Sources (Source: Timmons, Harris and Roach 2014b)

Present value of the unit cost of electricity throughout the life time of the plants that produce the electricity (Dyesol 2017), An ideal energy source should have low capita! intensity. It is expected that sustained research and development will continue to reduce the capital intensity of fossil fuels and renewable energy resources for power generation.

f. **Environmental externalities.** Externalities are the costs of benefits that affect a person or party without their consent or input and which usually does not reflect in the cost of the activity that produces that cost or benefit. Environmental externalities are the costs or benefits that affect the environment as a result of the execution of an economic activity. Generally speaking, renewable energy utilization generally produces lesser negative environmental externalities such as pollution compared to fossil fuels that generate a lot of it. Externalities whether positive or negative should ideally be completely internalized in order to fully capture the total cost of electricity generation, moderate producer and consumer behaviour and promote efficiency (Borenstein 2012), The full integration of the cost the of the of all environment externalities into levelized energy cost (LEC) for power generation will significantly increase the unit cost of power generation from fossil fuels and thus enhance the cost-competitiveness of renewable energy power generation. Most developing countries such as Nigeria have very low recognition of the economic cost of environmental externalities associated with power generation activities.

g. **Energy efficiency and energy subsidies.** Renewable energy suffers from resource intermittencies (mainly solar and wind) and have lower dispatchability compared to fossil fuels especially natural gas.

3. Implications of Macroeconomics of Renewable Energy Development

Fossil fuels, as finite and exhaustible energy sources, have a limited period within which

they can be relied upon to supply global energy needs, unless a form of technology leads to changes that will make this inapplicable. Unless another form of available energy source is presented, renewable energy resources will remain the most potentially viable alternative energy source to fossil fuels. This makes it imperative that people, the society and governments to have a more active interest in the activities of scientists involved renewable energy research and development. Economic cost, defined by affordability in energy security 4 A's, is the most important criterion that determines the viability of any alternative to fossil fuels.

Different countries attach different weights to the economic indices enumerated above that affect renewable energy development. In developing economies with low per capita income, inadequate power generation capacity, low level of infrastructural development and numerous competing socio-economic challenges such as Nigeria, capital intensity (capital cost of development) is probably, the most important economic index to consider in making an investment in renewable energy development. The internalization of environmental externalities is the least important factor. On the other hand, in developed countries of United States and Europe with already well developed physical and socio-economic infrastructure, sufficient power generation capacity, high per capita income and high standard of living, relative cost-competitiveness and environmental externalities will likely be the most important criteria for renewable energy investment decisions. These factors apply to both public and private sector investment decisions in renewable energy projects. While taking cognition of these factors that influence today's investment decisions, it is also important to develop adaptive strategies for the economic variables that will affect renewable energy investment decisions in future.

One major index that can significantly affect renewable energy decisions in the future is the International Seabed currently managed by the International Seabed Authority (ISA). It is estimated that there abounds in the international seabed, a vast amount of fossil fuels (coal, oil and gas) deposits and renewable energy (wind and wave energies) resources. The fossil fuels deposits in the international seabed are reputed to be more than the presently known proven fossil fuels reserves added together. Similarly, the whole energy of the vast oceans and open seas in the international seabed is also known to be enormous. However, the geographically fluid and non-restrictive nature of renewable energy resources brings into perspective ownership and rights over them. For example, in the absence of international delineation over the International Sea Bed (ISB) which is reputed to contain the largest amounts of fossil fuels as well as tidal and wave resources, and since the economic value of any commodity is derived as a function of its limited supply viz-a-viz demand and the existence of ownership rights over it to a finite number of persons, it becomes challenging and important to determine the true economic value of the resources abundant in the ISB by the time technology development makes commercial exploitation of the ISB resources possible and competitive. The determination of the economic value of a commodity is fundamental to the assignment of a basis of exchange in a market between suppliers (supply side) and consumers (demand side).

CONCLUSION

Majority of perspectives of macroeconomics of renewable energy are from the developed countries. Their main economic objective for investing in renewable energy development is to increase their energy security through reduction and ultimately elimination of dependence on imported fossil fuels for their energy needs. Africa and other developing regions of the world need to formulate and implement their own macroeconomic strategy for energy management by developing the appropriate fossil fuel and renewable energy mix that is favourable to their energy interests. Ultimately, the global energy community has to agree on an energy mix that satisfies the energy needs of the world both now and in the future.

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Reforms in the Nigeria Energy Sector with Solar Energy in Focus

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Abstract: *Nigeria having biggest growing economy among African countries, the sustainable and balanced growth is focused considering environmental and socio economic factors. This can be meet by development of renewable technologies and the initiatives by government. In this proposal, the potential of electricity supply through solar energy are presented considering its technical feasibility with available resources and integrating in to present energy infrastructure. Environmental impact and economic factors were also highlighted with the initiative by government for development of this technologies and also suitable policies for balance growth,*

Key words: *Energy, Solar, Reforms, & Renewable.*

INTRODUCTION

Generations of energy through renewable energy sources are the present focused for the world energy requirement. The energy demand is the key element for the socio economic development and nation's economic growth, which is very important for fastest growing country like Nigeria. The conventional resources of energy are diminishing with the increasing demand hence, increase its cost Mustapha (2019). The problems with environment unbalance due to emission of greenhouse gases with the use of conventional energy sources are the real challenge. Development of renewable energy can help in minimising the environmental impacts by lowering carbon emission, and energy security and balanced regional development.

Nigeria is the biggest economy in sub-Saharan Africa, however the country's growth is constrain as a result of the poor power sector. Nigeria is rich in oil, gas, hydro and solar resource that is capable of generating 12,522 megawatts (MW) however only 4,000 MW, is generated which is inadequate for maximum energy demand of the country (Tallapragada & Adebusuyi, 2008). The Nigerian government has taken steps to try and address the challenges faces across the power generation value chain. They include the introduction of a power regulatory body the Nigerian Electricity Regulatory Commission (NERC) in 2005 - the unbundling of power assets and the implementation of the National Integrated Power Project (NIPP) formed to address issues of insufficient electricity generation. In 2018, Meter Assets Provider (MAP) was introduced by NERC to encourage the development of independent and competitive meter services and eliminate estimated billing practices. Finally, the Electricity Theft and Prohibition Bill was submitted to the

Senate committee in an effort to tackle the 35% energy losses due to theft and sabotage. This report reviews the performance of the power sector since 2018 and maintains that power must be realistically priced in order to attract the investments required to provide electricity to parts of the nation without power. With about 60% of the country's population without access to electricity supply, the enforcement of a cost-reflective tariff system could offer an opportunity to reach more customers and provide a more sustainable solution to the distribution problems currently affecting the industry. In addition, policies that promote the adoption of alternative sources of power must be properly implemented so as to meet the rising electricity demand (Adebowale *et al*, 2017).

Table.7 Nigeria's energy mix

Energy ource	Percent of generation
Fossil	81.72
Wind	0.01
Solar	0.08
Hydro	18.19
Nuclear	0
Geothermal	0

Source: Global petrolprice.com

ROLE OF RENEWABLEENERGY SOURCES

The persistent depletion of fossil fuel sources and the quest to combat greenhouse emissions and its environmental impact has led to exploration of other renewable energy sources (Mekontso *et al*., 2019). In 2018, transition to renewable energy in the power sector, a significant impact was achieved on Carbon Dioxide (CO_2) emission, by evading 215 Mt of emissions (International Energy Agency, 2018). This success story from renewable was driven by China and Europe, together contributing 66% to the worldwide aggregate. Without this change to low-carbon energy sources in 2018, emission could have hit 50% higher. Power generation from sustainable sources expanded 7% in 2018, infusing an extra 450 TWh into worldwide power systems (International Energy Agency, 2018) . The power sector has seen significant transition lately regardless of growth in emissions. Today it is estimated that electricity generation contribute 475g CO_2/kWh, a 10% enhancement in reduction from the 2010 intensity records. Without this, worldwide CO_2 emissions would have been 1.5 Gt higher, or 11% of current power sector emissions. This success over the year has been achieved as a result of huge investment in Photovoltaic (PV) plant, Wind, Bioenergy, Geothermal, and other renewables sources. Residential households including commercial building consumes about 40% of world's total energy contributing one-third of the greenhouse emissions globally(Isa *et al*., 2018).

The irradiance level and duration of sunshine in most West African countries makes harnessing of solar as the main source of her future energy.

In Nigeria, electricity access rate was nearly 60% in 2015 (according to the World Bank), with 86% of urban areas and 41% of rural areas with access, while access to non-solid fuels reached only

4%. Nigeria has huge sun oriented energy potential, with genuinely conveyed sun based radiation averaging 19.8 MJm2/day and normal daylight long periods of 6h/day. The expected potential for concentrated sunlight based power and photovoltaic age is around 427,000 MW.

Moreover, it is essential to harness energy that are sustainable, economical and are less risky to nature while simultaneously fulfils the rising need for power (Isa *et al*., 2018). This need has driven the idea of inexhaustible and sustainable energy to the first of ecological maintainability discuss. In target to use the sustainable source to satisfy the power need, sun oriented photovoltaic power has been seen as the best accessible alternative that can bolster this strategic in enormous capacity to create power. Photovoltaic technology has several benefit including small size of sun powered plant that can take points of interest of unused space available on top of household and existing buildings. The PV modules are quiet and clean since they operate on incidence radiation emitted from the sun other than traditional fossil fuel (Isa *et al*., 2018). Many rural communities in these subregions are small and far away from the national grid or transmission infrastructure, supplying electricity via the traditional infrastructure will not be cost-effective (Shenawy *et al*., 2017). The deplorable nature of road networks linking this long-distance communities makes it impossible to install generator and transport fuel to produce electricity in such environs.

The optimization results over the years show that the use of batteries in conjunction with the renewable sources is economic and ecological friendly(Isa *et al*., 2018). In addition, a power supply system consisting of the aforementioned technologies are capable meeting the maximum power demand in rural communities or the installation they supply. Telecommunication networks or media transmission systems base stations are regularly provided with regards to standalone energy systems since they are every now and again installed at remote areas without simple access to the distribution system (Merei *et al*., 2013). Off - grid PV system is eventually considered as the future of the world's energy sector and has significant role of electricity generation. Off grid PV energy system usually includes energy storage battery system. The idea of Stand-alone PV system is well established for both distributed and centralized systems in Nigeria and major part of the world. Photovoltaic systems can be considered as the most far-reaching arrangement with huge edges of progress while guaranteeing the age of energy with low ecological effect (Askarzadeh & Askarzadeh, 2017).

However there are assortment of optimization issues that are non-direct and non-arched in nature such as uncertainties associated with the renewable power sources, load demand and the non- linear attributes of certain parts.

Optimization algorithms are significant methodologies for resolving complex optimization issues. optimization is characterized as the strategy of revelation that gives the base or most extreme estimation of a function *f(x)* [8]. There are numerous reasons that make these problems hard to unravel. To start with, we cannot play out a complete inquiry if the domain space is excessively enormous. Secondly,the evaluation function is uproarious or shifts with time, producing a progression of arrangements rather than a solitary arrangement. Thirdly, in some cases the imperatives forestall landing at a potential arrangement with the end goal that the optimization approach is the main outcome.

The complex nature of optimization problems is due to nonlinearities and the implicit nature of PV modules, critical computational exertion is required to get everyone of the parameters, consequently, in this setting distinctive metaheuristic algorithms has been proposed and used over the years. This is because of the improved precision and diminished execution time of this artificial intelligence techniques. Besides, the capacity of metaheuristic algorithms, for example, Genetic

Algorithms (GA) particle swarm optimization (PSO), artificial bee colony, firefly algorithm (FL) to adapt up to missing meteorological information, is a noteworthy advantage.

SOLAR ENERGY POTENTIAL IN NIGERIA

Solar power is developed its huge potential in the last decades with total installed capacity of 12,493 MW. The Renewable Energy Master Plan (REMP) seeks to increase the supply of renewable electricity from 13% of total electricity generation in 2015 to 23% in 2025 and 36% by 2030. Renewable electricity would then account for 10% of Nigerian total energy consumption by 2025.The mission has accelerated the development in this sector considering grid satisfaction and stand competition in market with an targeted vale of 12,493 MW of grid and 3,904 MW of off grid connected plants (Cecily *et al*, 2019).

AVAILABILITY OF ENERGY THROUGH SUN

Solar energy is a very clean sour of energy resources available freely an in abundant. Nigeria is blessed with abundant solar energy. The country has an annual average sunshine of about 6.25 h, ranging from 3.5 h at the coastal regions to 9.0 h at the north. Similarly, the mean daily solar radiation is about 5.25 kWh/m 2 /day, ranging from 3.5 kW/m 2 /day at coastal zones to 7.0 kWh/m 2 /day at the north. This extra ordinary local put Nigeria in very good advantages. It divides the country into two half due to which almost 300 sunny days are available annually because of location advantage. The average available solar irradiance is of 4-7KWh per sq. Thus, a day which can produce 5000 trillion kilowatts of energy.it is also estimated that potential of energy can be harnessed on 12.5% of the land mass. Also scope of adoption of building integrated approach helps in enhancing capacity. In addition the scope of distributed generation with mini and micro grids can solve the problem of rural figure 1 and figure 2.

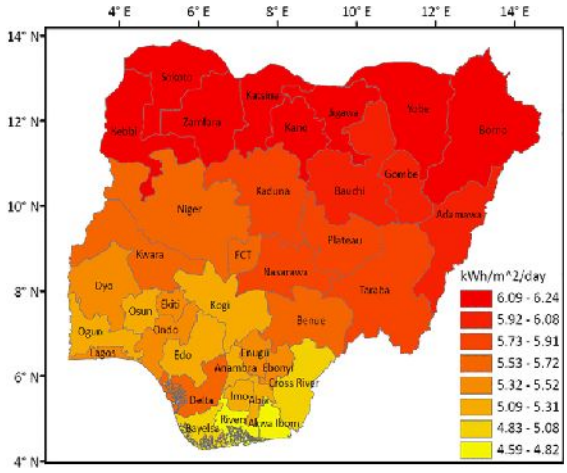

Figure1: Map of Nigeria showing global solar Irradiation (kWh/m 2 /day, from 1985 to 2004) on optimally inclined plane at the various locations (Cecily *et al*, 2018)

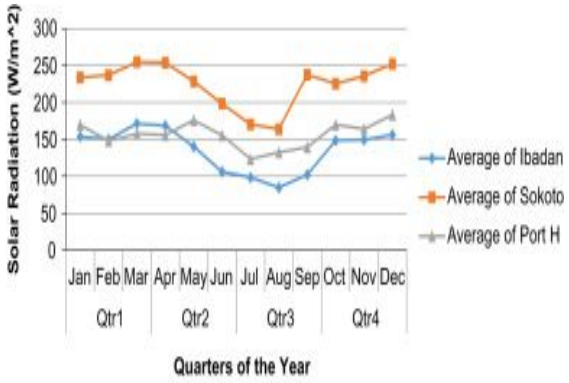

Figure 2: Exploration of solar radiation data from three geo-political zones in Nigeria (Cecily *et al*, 2018)

TECHNICAL CHARACTERISTICS OF SOLAR ENERGY

In Nigeria the global solar insolation is between 4 to 5.5. Electricity generated by solar cells is proportional to the area exposed and the intensity of global insolation received. Its conversion efficiency is defined by= Po/Pi where Po is the maximum power output and Pi is the power input at Standard Test Conditions (STC) of 1000 W/m2global insolation, 25 ◦C module temperature and 1.5 air–mass (AM). Solar cell, the change in efficiency with temperature is found to be±0.5% ◦C−1.For long term power generation; this inverse variation of efficiency with temperature is more or less compensated by season's changes. Solar based power generation depends on component selection, global insolation, seasonal variation, elevation angle, and temperature and battery capacity. The output of solar generation is maximum at noon and again it reduces to zero at night. For Nigeria, the Solar based system may able to give 67% efficiency without battery backup if the sky is clear.

INTEGRATION OF ELECTRICITY THROUGH SOLAR ENERGY IN SUPPLY SYSTEM

Nigeria's off-grid market has huge potential, especially in the areas such as rural electrification, power irrigation pump sets, back-up power generation for the expanding network of cellular towers across the country, captive power generation, urban applications, highway lighting etc. In addition to the government's initiatives such as Feed-in-Tariffs/Generation Based Incentive(GBI) as part of the NSM, the incentives under the semiconductor policy, and other expected incentives for the industry make the long-term prospects for this industry much brighter (Dada *et al*, 2017; Adenji *et al*, 2019). These targets and plans have potential to attract a variety of businesses in Nigeria, belonging to diverse segments - manufacturing, installation, operation and maintenance, training and engineering, procurement & construction (EPC) businesses, and more. The Nigeria energy resource master plan proposal (2020-2025) for new and renewable energy to rationalizes strategies for the development and Deployment of these sources. Thus, going forward, the market for photovoltaics in Nigeria is likely to be shaped by the following priorities

- Grid interactive solar power projects:
- Remote village solar lighting program:
- Retailing of solar energy products:

ECONMICS

The main object of Renewable Energy Association of Nigeria (REAN) and other agencies is to make a global leader in solar energy by boosting development into sector with appropriate policy conditions. The strategy is administered through

Nigeria Energies with Nigerian government, Energy development agencies in the various States for generation based incentives for grid connected solar plants with an extended scheme for central /state/ public / private PV power projects (Aondoyila *et al*, 2019) .

Nigeria's solar PV market is growing with tremendous rate. Currently, the Nigeria Solar PV manufacturing sector is export-led, and is much larger than the country's total installed capacity. In addition, the National Solar Mission's target to achieve 20 GW by 2030, of which 50% will be solar PV, and its plan to produce modules and cells domestically increases module production capacity. Many states in Nigeria are also devising the ambitious policies for solar PV power generation. Thus, there exists a huge manufacturing opportunity not only for the export market but also to fulfil the Nigeria federation and state targets.

CONCLUSIONS

Nigeria is a fastest developing country in which, its economic growth is measured with the power consumption. Various renewable technologies are contributing for supplying demand power and solar energy is promising technology measured considering geographical location of country with abundant energy sources. Solar technology is most dominating player in renewable energy scenarios with its advance in technology and support to grid with highest generation capacity which is most suitable. Considering scopes, initiatives and resources it quite feasible to be explored. Moreover, solar is also growing at faster rate for grid contribution and support wit with development of technology and reduction of cost. Solar energy has played a vital role in the overall electrification of rural areas and various off grids installations and applications, Hence currently powering as a major contributor in some agriculture sectors and in near feature with various policy and initiatives by government.

The authors believe that beginning to tackle our renewable energy issues by taking pragmatic steps towards implementing developed plans such as the one presented in this paper will take Nigeria out of the circle of a consuming economy to a creating one.

Development of Nigerian energy sector which will contribute to the Nations GDP. Since these energy could be exported for foreign exchange that will revamp the Nigeria's economy. Providing electricity would not only solve rural urban migration but would also ensure good educational outcomes in the rural communities where children find it difficult to learn in the evening.

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Infrastructure Efficiency and Effectiveness: The Urban Planner's Perspective

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Abstract: Infrastructure which is the live line of any settlement plays an important role in the existence of both plant and animal's lack of infrastructural faculties in any settlement leads to problems ranging from heath and sanitation poverty and unemployment etc. the role of urban planner in ensuring infrastructure, utility, efficiency and effectiveness is broken into three categories which are the role in new settlement, existing settlement and regional settlement. In ensuring infrastructure utility efficiency and effectiveness specific planning standard using either population or distance criteria are used. Some of the problems associated with efficiency and effectiveness of infrastructure in the developing nation are planning, finance, and implementation. The solution to these problems are privatization, participatory planning and the use of appropriate technology. No doubt the difference between the developed nation and the developing nation is infrastructure, utility efficiency and effectiveness.

Key words: Efficiency, Effectiveness, Infrastructure, Urban Planner.

1.0 INTRODUCTION

Infrastructure which is the life line of any settlement, it plays a very vital role both in existing and new settlements. Settlements lacking infrastructure have the likely hood of having diversified problems which hindrance the existence of both plants and animals. Some of the problems associated with lack of infrastructure can lead to poor health and high mortality. Where there are no clinic or hospital available, or where lack roads or bridges makes them inaccessible people cannot access the medical service that they require to be healthy and productive. Lack of infrastructure also leads to lack of employment by acting as disincentives to investment. Companies who struggle to produce and sell goods in an area with inadequate roads, electricity or water supply do not want to set up the factories or business that could potentially generate employment, improve living

standard and reduce poverty. Lack of adequate infrastructure perpetuates poverty because it denies possibilities. Hunger one of the most obvious systems of distance from food. When people live far away from food source, food security depends on infrastructure that ensures food can be transported in an efficient and cost effective way (Alan, 2008).

Infrastructure provides access to water and sanitation facilities are also key to good health, tube well or piped water are needed for people to drink , cook and bath. Sanitary toilet facilities are required to prevent the spread of bacteria and disease. (A villager in Mozambique explains "the most dangerous thing is that cholera has always appeared during the raining season and it is then that the river is in spate and boats cannot cross." The answer to treating cholera in this case is not medicine or doctor, it is a bridge. That is going by the villager, but to the urban planner who is pursing infrastructure efficiency the answer will be clean and safe drinking water as well as sanitation.

The distinction between the developed nation and the under developed ones is the efficiency and effectiveness of the infrastructural facilities and service in the two nations. Development is always associated with availability and functionally of infrastructural facilities in place. In the developed countries/ nations efficiency and effectiveness in service provided have gone or been linked to every nooks and crannies of the countries so much that the citizen of these nations feel that it is part and parcel of their community which is not in the developing nations where citizens and governments are still trying to put in place these infrastructural facilities not talking of its efficiency and effectiveness. A good examples of developed nations where urban planning is been practised for long is the Great Britain and no doubt that the role of the urban planners in pursing infrastructure efficiency and effectiveness in the country has been felted for a very many years. An example of the urban planners work in ensuring infrastructure efficiency and effectiveness is the city gate project where more sophisticated infrastructure such as the subway system of mass transportation is been.

The aim of the seminar is to identify the role of urban planners in ensuring infrastructure efficiency and effectiveness. It will be achieved through identifying the problems associated with lack of efficient and effective infrastructure, identifying the roles played by urban planners in ensuring the efficiency and effectiveness of infrastructural facilities, identifying the problems associated with making infrastructure efficient and effective and finding solution to the problems.

2.0 ROLES OF URBAN AND REGIONAL PLANNING IN INFRASTRUCTURE AND UTILITY EFFICENCY/ EFFECTIVENESS.

Urban planners are usually hired by developer's private property owner's private planning firms and local, regional government to assist in the large- scale planning of communal and commercial developments as well as public facilities and transportation system. Urban planner in the public role often assist the public and serve as valued technical advisor in the myriad web of the community political environment related discipline include regional ,city, environmental, transportation, housing community and cultural planning. The roles of the urban planner in infrastructure, utility efficiency and effectiveness are broken into the following types of levels this are the: (i) New settlements

(ii) Existing settlements

(iii) Regional settlement.

(i) **New settlements:** The pursuit of urban and regional planner in infrastructure, utilities efficiency and effectiveness in new settlements starts from the division of large parcel of land into plots this process is usually known as layout design (residential, commercial, industrial etc). The principal infrastructure used in dividing this parcel of land into segments is the road network in trying to ensure efficiency and effectiveness in the volume of traffic these roads carries the urban planner has different categories of road network ranging from primary, secondary district access/path with size such as 12m, 18m 24m 50m etc see table 1. The urban planner takes into consideration the anticipated volume of traffic to be generated by the threshold population he is planning for in the new town or settlements. These networks of roads are not just put in place but rather certain criteria which ensure it efficient use are also considered such as avoiding cross junctions sharp bends and long stretch of roads all in an attempt of reducing accidents to the lowest level. Just like the road network all other infrastructural facilities are computed having in mind the population of the proposed settlement and projection are made into the future with anticipated growth rate usually with a span of years gap given for example a ten year development plan of a proposed settlement can be computed with the threshold population as the base for the projection into the anticipated increase in the size of the settlement in the future.

Table1. **Standard for urban road system**

Types of road	Road reservation (meters)	Types of lanes (meters)	No. of lanes	Width of lanes	Divide width (metres)	Width (metres)
Express way	90	Dual	4-6	3.7	3.0-5.0	
Primary road	90	Dual	4-6	3.7	3.0-5.0	
Secondary road	40-60	Dual	2-4	3.7	1.8-2.5	3.0-5.0
Distributor road	18-25	Single	2	3.4-3.7	-	1.8-3.0
Access road	12-15	Single	2	3.4-3.7	-	1.8-3.0
Cul-de-sac	11	Single	2	3.1-3.4	-	1.5-1.8

Source: Obateru, (1986) Uloko and Agbonuga, (2005)

(ii) **Existing settlements:** In many communities, growth and development has brought problems related to infrastructure. Growth affects the cost of infrastructure, demand and efficiency. The role of urban planner in ensuring that infrastructural facilities are efficient and effective in communities cannot be over emphases. The role start in existing communities by identifying infrastructure in the settlement, under taking studies on the need assessment of communities with regards to infrastructure taking the population of the community comparing them with existing infrastructure facilities using specific planning

standards to ascertain whether the available infrastructures facilities tally with the population it serve, this way the urban planner can know the depicts of infrastructure facilities in communities. The role do not even stop at that , but rather goes be young to see how best this infrastructural facilities can be used to achieve the maximum output expected of it. For example, water is one important infrastructure that is required by any settlement or community, the urban planner in ensuring it availability , efficiency and effectiveness start by identify the source, the best method of harnessing it, how to connect every home/ building and computing even the total requirement of this essential infrastructure (i.e. consumption per capita). This applies to all the infrastructural facilities in the every community or settlement.

Table2 Site and access standard for neighbourhood facilities and services

Neighbourhood facilities and services	**Site area (hectare)**	**Maximum service radius (meter)**
Nursery school	0.8-1.6	400
Nursery primary school	1.6-3.2	400-800
Civic centre	0.8-1.6	800
Shopping centre or market	1.6-4.0	800
Retail shops	0.05-0.1	100-150
Neighbourhood playground	1.6-2.4	400-800
Neighbourhood park	0.8-2.4	400-800
Children's playground	0.2-0.5	100-150
Health centre	0.4-0.6	800
Place(s) of worship	0.3-04	800
Postal agency	0.1-0.2	800
Police post	0.2-0.4	800
Commercial bank	0.3-0.4	800
Petrol filling station	0.3-0.4	800
Refuse deport	0.2-0.4	400-800
Service industries	2.0-3.0	1,600
Cemetery	1.0-1.5	1,600

Source: Adapted from Obateru (1986, 2003) Uloko and Agbonuga (2005)

(iii) Regional settlement: The pursuit of urban planner in ensuring efficient and effective infrastructure and utility is not restricted to a single community or neighbourhood but rather to group of community/ settlements which is otherwise referred to as a regions here in ensuring that infrastructure and utility are effective and efficient certain facilities which require large population are proposed using the various regional planning concepts depending on the concept which suits the regions collective infrastructural facilities which link more than two or more settlements are proposed in a manner in which efficiency and effectiveness is achieved. Example of regional infrastructure includes the regional water supply from dams which serves more than one settlements. Planning for the efficient and effective utilization of this infrastructure is not only restricted to the primary purpose but

rather other uses such as irrigation agriculture, fishing etc which can go side by side with the primary purpose which is providing adequate safe drinking water to the communities.

Another regional infrastructural facility is the road which links communities in ensuring effective and efficient infrastructural facilities usage the urban planner identifies settlement with potential benefit in terms of either population, agricultural potentialities, mineral resources etc are link to consumption areas. Electricity which is another important infrastructural facility is transmitted from the generation stations to various settlements/communities using cables which span long distance branching in settlements all in an attempt to ensure that efficiency is achieved. The urban planner compute the electricity requirement of settlement, the size and amount of transformers required to make the supply effective and efficient. These are some of the few regional infrastructures, utility. All others not mention have planning standard of ensuring efficiency and effectiveness.

Regional planning standards

s/no	Population	Facilities	number	Area in SQM
1	5,000	Dispensary	1	2,000
		Convenience shopping	1	1,000
		Parking area	1	5,000
		Postal agency	1	400
		Play ground	1	5,000
		Police post	1	400
		Bore hole	1	60
2	10,000	Comprehensive health centre	1	5,000
		Senior secondary school	1	6,000
		Religious building	2	400
		Electric substation 11kva	1	2,000
		Post office	1	400
		Community hall	1	2,000
		Local shopping	1	3,000
		Police station	1	400
		Service market	1	2,000
		Taxi stand	2	60
		Parks	1	10,000
		Play ground	1	10,000
		Water tank/ reservoir	1	2,000
		Waste collection/ treatment facility	1	2,000
3	1,000,000	Specialist hospital 200 bed	1	5,000
		Veterinary hospital	1	3,000
		Psychiatric hospital	1	2,000
		Electric substation 66kva	2	10,000
		Community park	1	50,000

		Bus terminal (car park)	1	1,000
		Waste water treatment	As per required	
		Multipurpose park/ ground	1	20,000
		Post office	1	400
		Police station	2	1,000
4	5,000,000	Teaching hospital 500bed	1	25,000
		Veterinary hospital	1	2,000
		University/ polytechnic/college	3	100,000
		Police station	3	1,000
		Fire station 5 to 7 km radius	3	10,000
		Adult education centre	1	1,000
		Electric substation 220kva	1	40,000
		Service market	1	60,000
		Bus terminal	1,	2,000
		District park	1	10,000
		Ceremonial ground	1	10,000
		Post office	2	5,000
5	Zonal / sub city	Medical college	1	As per required
		Nursing and paramedic institution	1	2,000
		Telephone exchange	1	2,500
		Sub city whole sale market	1	150,000
		Post office	1	2,500
		Multipurpose ground	1	80,000
		Divisional sport centre	1	300,000
		Bus deport	As per required	
			1	10,000

Adopted from Kadyali 2005 and Delhi urban area regional plan (2012)

3.0 Problems associated with ensuring infrastructure efficiency and effectiveness

3.1 Planning: planning is concerned with deliberately achieving some objectives, and it proceeds by assembling actions into some orderly sequence. In trying to ensure efficiency and effectiveness of infrastructure detailed analysis of situation must be made from what is obtained in the past to the present and possible into the future in terms of infrastructure requirement of settlement this is always a big problem especially in the especially in the developing countries where these series of activity in planning is difficult to achieve. Sometimes the activity may be in order but before the programme is implemented the projected period of development may be over so change in the target population will occur and hence not achieving the efficiency and effectiveness of the service to be provided by the infrastructural facilities.

3.2 Finance: provision and maintainers of infrastructure facilities is the responsibility of the government especially in the developing countries where the resource is limited or scares and these infrastructural facilities require huge capital to be place. Sometimes the infrastructures may be in place but resource to maintain them will be a problem which leads to inefficient and ineffective infrastructure service/facility delivery.

3.3 Implementation: Another hindrance to infrastructure efficiency and effectiveness is the implementation stage as project which have direct bearing to human development are not implemented either because of political reason or in some case the project may be on course by the previous government and abundant by the government of the day.

4.0 Solution to infrastructure efficiency and effectiveness

4.1 Privatisation: transferring ownership of public service from public sector (government) to private sector to operate for a profit or to non profit organisation. Some to be the solution to efficient and effective delivery of infrastructural service, this is more important in the developing nations where scares resource are competing for unlimited demands. A good example of privatisation is in the mobile telecommunication sector of Nigeria which has relatively succeeded.

4.2 Participatory planning: can result in programmes that are better and more efficient. By consulting the poor and giving voice to their concern and needs the resulting action are more likely to be relevant and appropriate to the conditions they face.

4.3 Use of appropriate technology: Taping local technology in the installation and maintainers of infrastructure, utility facilities and service will in no small way help in ensuring the efficiency and effectiveness solving the problem that way appropriate technology which are hard to find especially after installation i.e. for maintains of the infrastructural facilities.

5.0 Conclusion

The purists of the Urban and Regional Planner is mainly ensuring infrastructure, utility efficiency and effectiveness as all other roles are by extension linked to it, this because the efficiency and effectiveness of infrastructure leads to a liveable settlement, because water which is an example of an infrastructure is life as without it existence is not possible, it also leads to aesthetics in settlement road which is another examples of infrastructure is the first and gateway of archiving aesthetics quality of settlement especially when layout properly with interconnection within and among the various land uses in a settlement. The efficiency and effectiveness of infrastructure in a settlement enhances the security of the settlement with adequate lighting night crime can reduce to minimal; with layout road network surveillance is made easy. Another infrastructure aspect of infrastructure efficiency is in the provision of employment and reduction of poverty with infrastructure economy activities are made easy adequate energy for production of goods, efficient and effective road network makes transportation of goods and services. When infrastructure is access in every home then equality among the citizens of settlement is archived. When the low income earner pays for water/electricity bill just as the higher income earner in the

community then social justices is archived. These are some among the connection between the other purists of urban planner and infrastructure efficiency and effectiveness.

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An Investigation of the Optimal Cutting Condition in Meranti (Shorea Leprosula) Wood in Turning Process using Taguchi Method

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Abstract: *Problem statement: In wood machining operation, the quality of surface finished is an important requirement for many turned work pieces. Thus, the choice of optimized cutting parameters is very important for controlling the required surface quality. Approach: The focus of present experimental study is to optimize the cutting parameters using a single performance measure which is the surface roughness. Optimal cutting parameters for the surface roughness measure were obtained employing Taguchi techniques. The orthogonal array, signal to noise ratio and analysis of variance were employed to study the performance characteristics in turning operation.Results:The experimental results showed that feed rate had no effect on surface roughness.Moreover,it was found from the experiment that the factors affecting a surface roughness were cutting speed and depth of cut, with having tendency for reduction of roughness value at higher depth of cut and greater cutting speed.Conclusion:Thus,it is possible to increase machine utilization and decrease production cost in automated manufacturing environment.*

Key words: *Surface roughness, Taguchi parameter design, turning, Meranti wood*

INTRODUCTION

In the past few years, wood machining has often been treated as the last factor on improving productivity as an integrated part in furniture manufacturing; nevertheless, with growing concern on the future supply of wood resources, it becomes significant for researchers to gain a better understanding of wood machining process nowadays. Currently, Meranti (Shorea Leprosula) wood becomes more popular as an important raw material in Malaysia furniture and wooden tools manufacturing industry due to unique properties of Meranti such as excellent light red wood texture and color like high quality hardwoods. In addition, Meranti wood can be generally obtained from Meranti tree plants which are mostly found in Southeast Asian countries. Consequently, in order to improve the productivity of using Meranti wood for furniture manufacturing industry,

more understanding of the wood machining process and its optimal cutting condition are needed to acquire high quality wood products and to reduce production time with less tooling cost and less waste materials.

Wood machining is normally performed under very high cutting speed with the extremely sharp cutting edges. It is a predominantly abrasive process; therefore the erosion of the cutting tool material is the main wear mechanism. Low wedge angles are necessary for machining massive wood which generally give a better surface quality; however, the lower the angle the higher the wear (Endler, 1999). The amount of wear generally decreases with the increase in hardness, the decrease in grain size and the decrease in binder content of the cutting tool material. Several wear mechanisms may contribute to the overall wear of the cutting tool. Among these wear mechanisms are gross fracture or chipping, abrasion, erosion, micro fracture, chemical and electrochemical corrosion as well as oxidation. Corrosion can be easily removed from the cutting edge by abrasion depending on the cutting condition e.g., moisture content, composition, etc. (Sheikh-Ahmad and Bailey, 1999). Some wears could occur through tool edge chipping when wood products which have low moisture content (dry) are machined. Tool life and tool performance in a given operation improve considerably when the Cemented Tungsten Carbides are used in place of either high carbon steel or high speed steels (Bailey, 1983).

In general, most research has focused on primary wood production processes needed to produce materials with specific characteristics. There are many different methods to cut materials; routing process is often used to compare different material wear on the cutting tool. There are distinct characteristics in tool wear and surface roughness among different wood fiber plastic products. Differences also exist when these materials are compared to solid wood. A better understanding of the necessary process parameters to cut these materials will lead to the improved results with respect to tool wear and surface roughness (Buehlmann, 2001). Researchers have attempted to gain more understanding in wood machining process. The relationship between the cutting process parameters such as feed rate, cutting speed and wood machining productivity was developed (Diei and Dornfeld, 1987). The effects of tool wear, cutting direction, spindle speed on edge chipping of wood board using a Pinacho S90/200 lathe machine was studied. The relationship of work piece quality, tool wear and machining conditions was also verified with the empirical monitoring indices (Rodkwan, 2000).

Taguchi and Analysis Of Variance (ANOVA) can conveniently optimize the cutting parameters with several experimental runs well designed. Taguchi parameter design can optimize the performance characteristics through the settings of design parameters and reduce the sensitivity of the system performance to source of variation (Berger and Maurer, 2002; Ryan, 2000). On the other hand, Analysis Of Variance ANOVA used to identify the most significant variables and interaction effects (Henderson, 2006; Ryan, 2000).

The mechanics of machining was investigated for other materials, besides metals and wood, such as elastomers were also performed (Rodkwan and Strenkowski, 2002, 2003). In their research, the effects of various machining parameters on chip morphology, surface roughness and the associated machining force were examined using the orthogonal cutting test of elastomers. The feed rate and cutting speed were found to have significant effect on the type of chips generated during orthogonal cutting (Rodkwan, 2002).

The objective of this work is to investigate the effect of various machining parameters such as spindle speed, feed rate, and depth of cut on product quality through machining process on a manual lathe machine PinachoS-90/200 Model. Additionally, optimal cutting conditions on Meranti wood machining are determined using a statistical procedure.

MATERIALS AND METHODS

Experimental procedures and conditions: In this study, Meranti (Shorea Leprosula) wood of 2 inch diameter and 2-3 feet long for each of the sample which 9 samples are used as work material for experimentation using a lathe turning machine. The density at 13.82% moisture content is 710kg/m^3.High speed steel Plansee Tizit Model DGGT Grade H10T with 6.0% carbon was used throughout the experiment as the cutting tool. All tests were performed dry.

Cutting speed, feed rate and depth of cut were selected as the machining parameters to analyze their effect on surface roughness. A total of 9 experiments based on Taguchi's L9 (3^4) orthogonal array were carried out with different combinations of the levels of the input parameters. Among them, the settings of cutting speed include 950, 1150 and 1400 rpm; those of feed rate include 0.05, 0.1, 0.15 mm/rev; the depth of cut is set at 0.5, 1.0 and 1.5 mm. Experimental planning was prepared by using cutting parameters and test conditions that were advised for a couple of tool-work piece by tool manufacturers and the information available in the literature. A schematic diagram of the experimental set-up is shown in Figure 1.

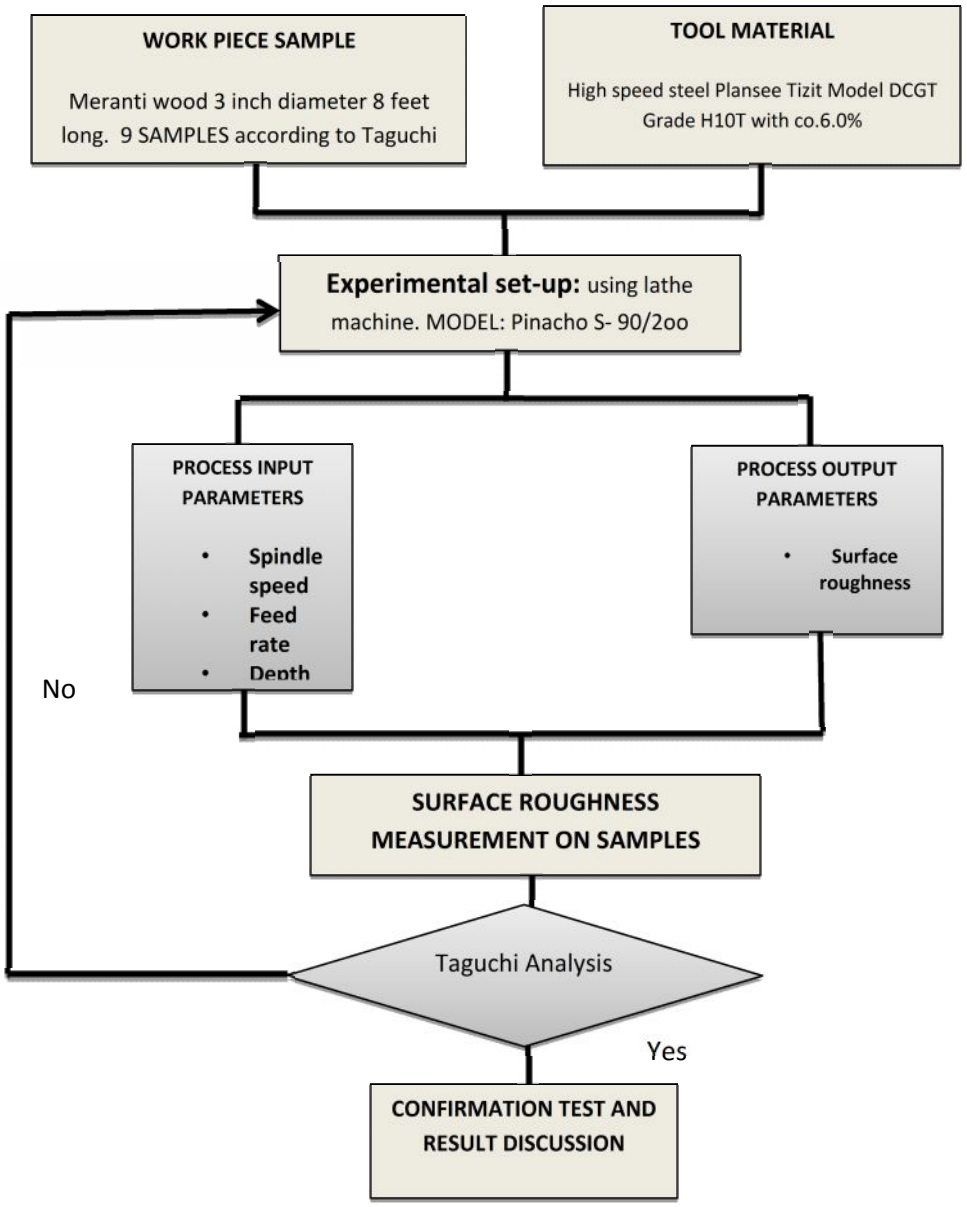

Figure 3 Methodology Flow chart.

The amount of standard surface roughness parameter (Arithmetic average deviation from the mean line Ra) is carried out using surface roughness tester model Mahr S2 Perthometer (produced by Mahr GMbH, Germany). Three measurements for work piece surface roughness were made and averaged for each test. This set-up was connected to computer using necessary hardware and software for data acquisition.

Taguchi method is being applied in to select the control factors levels (Cutting speed, Feed rate and depth of cut) that minimize the effect of noise factors on the response (surface roughness) and to come up with the optimal surface roughness value.

The goal of the experimental work was to investigate the effect of cutting parameters on surface roughness and to establish a correlation between them to determine which one has the most effect on the surface roughness. Experiment were planned according to Taguchi's L9(3^4) orthogonal array, which has 9 rows corresponding to the number of test with 3 columns at three levels, as shown in Table 1.The factors and interactions are assigned to the columns.

Table 1: Orthogonal array L9 (3^4) of Taguchi

Experiment No	Cutting Parameter Level		
	A (Cuttings peed)	B (Feed rate)	C (Depth of cut)
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

It means a total of 9 experimental numbers must be conducted using the combination of levels for each independent factor (cutting speed (A), feed rate (B), and depth of cut (C)),as shown in Table 1.The orthogonal array is chosen due to its capability to check the interaction among factors.

The procedure for these test were to measure each work piece surface roughness and transformed into a Signal to Noise (S/N) ratio.

There are three categories of quality characteristic in the analysis of the S/N ratio, (i) the-lower-the-better, (ii) the-higher-the-better and (iii) the-nominal-the- better. Regardless of the category of

the quality characteristic, process parameter settings with the highest S/N ratio always yield the optimum quality with minimum variance. The category the-lower-the-better was used to calculate the S/N ratio for both quality characteristics surface roughness and work piece surface temperature, according to the equation:

$$\eta = -10\log_{10}\left(\frac{1}{n}\sum_{i=1}^{n} y_i^2\right)$$

Where:
η = Signal to noise ratio
n = Number of repetitions of experiment
y_i = Measured value of quality characteristic

In addition, a statistical Analysis Of Variance (ANOVA) is performed to see which process parameters are significantly affecting the responses (surface roughness, Ra).

RESULTS

The measured values of surface roughness for the machined surfaces corresponding to all the experimental runs are given in Table 2.

Signal to noise ratio: Analysis of the influence of each control factor (S, F and D) on the surface roughness (Ra average) has been performed with a so-called signal to noise ratio response table. Response table of S/N ratio for surface roughness are shown in Table 3.It show the S/N ratio at each level of control factor and how it is changed when settings of each control factor are changed from one level to other.

The influence of each control factor can be more clearly presented with response graph. Response graph for the control factors are shown in figure 2,the slope of the line which connects between the levels can be clearly show the power of the influence of each control factor.

Table 2.Experimental result for Ra (average) from three different readings

S	F	D	Ra_1	Ra_2	Ra_3	Average
950	0.05	0.5	1.657	1.012	1.464	377667
950	0.1	1	1.26	1.284	1.227	1.257
950	0.15	1.5	1.249	1.261	1.294	1.268
1150	0.05	1	1.378	1.359	1.362	366333
1150	0.1	1.5	0.902	0.903	0.998	934333

1150	0.15	0.5	1.1789	1.179	1.148	168633
1400	0.05	1.5	0.808	0.85	0.883	0.847
1400	0.1	0.5	1.006	1.063	1.482	183667
1400	0.15	1	1.171	1.244	1.858	424333

S: Cutting speed; F: Feed rate; D: Depth of cut: Ra average; Average experimental surface roughness

Table 3: Response table for S/N ratio (smaller is better) for Ra

Level	S	F	D
1	-2.27732	-1.35056	-1.86701
2	-1.15825	-0.95378	-2.59002
3	-1.03150	-2.16273	-0.01003
Delta	1.24583	1.20895	2.57999
Rank	2	3	1

Analysis of variance ANOVA: The experimental results were analyzed with analysis of variance (ANOVA) using one-way ANOVA analysis, which is used for identify each individual factors significantly affecting the performance measures. The results of ANOVA with Signal to noise ratio are shown in Table 4, 5 and 6 respectively. This analysis was carried out for significance level of α = 0.05, i.e. for a confidence level of 95%.

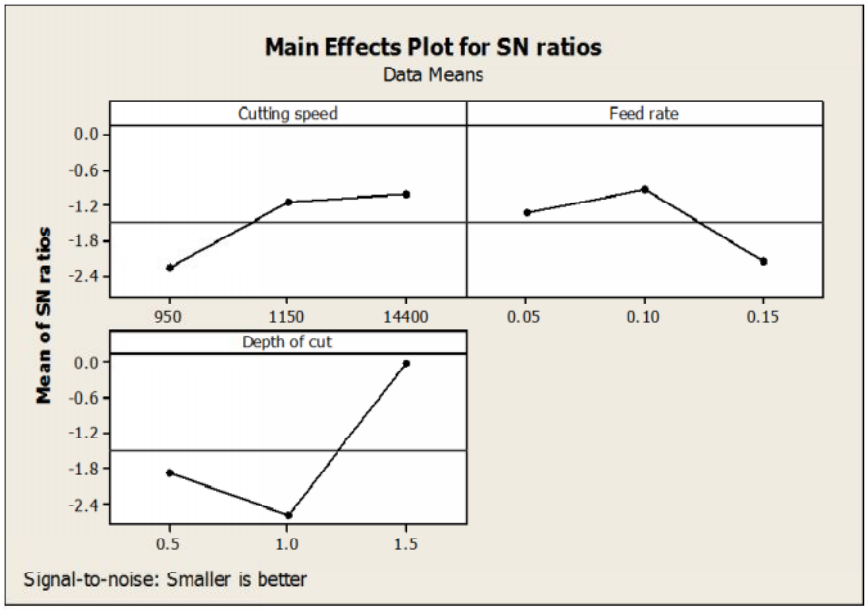

Figure 2. Main effect plot for S/N ratio for surface roughness (Ra)

Table 4: One-way ANOVA: Signal to noise ratio versus S

Source	DF	SS	MS	F	P-value
S	2	2.82	1.41	0.52	0.621
Error	6	16.36	2.73		
Total	8	19.18			
S= 1.651		R-Sq = 14.70%		R-Sq (adj) = 0.00%	

Table 5: One –way ANOVA: Signal to noise ratio versus F

Source	DF	SS	F	P
F	2	2.28	1.14	0.40
Error	6	16.91	2.82	0.684
Total	8	19.18		
S=1.679		R=Sq=11.88%		R-Sq(adj)=0.00%

Table 6:One-way ANOVA: Signal to noise ratio versus D

Source	DF	SS	MS	F	P
D	2	10.68	5.31	3.73	0.089
Error	6	8.56			
Total	8	19.18			
S=1.194		R-Sq=55.40%		R-Sq(adj)=40.53	

DISCUSSION

It can be seen from table 3 and according to the rank value for each control factor that the depth of cut had the strongest influence on surface roughness followed by cutting speed and last by feed rate.

From the main effects plot for S/N ratio for surface roughness Figure 2, the surface roughness appear to be an almost linear increasing function of depth of cut (D) and decreasing function of cutting speed (S).Thus, in order to reduce the level of surface roughness, depth of cut (D) should be set at its highest level (1.5mm) and the cutting speed (S) as well to its highest level (1400rpm) too. Also, high level (0.15rev/mm) or low level (0.05rev/mm) of feed rate (F), may be preferred, while the effect of F has not been found statistically significant (p-value= 0.40).

From Table 4, 5, and 6, analysis of variance ANOVA for surface roughness. It can be found that depth of cut has the slightest significant cutting parameters for affecting surface roughness. The change of the feed rate in Table 2 has an insignificant effect on surface roughness.

Therefore, based on the S/N ratio and ANOVA analysis, the optimal cutting parameters for surface roughness are the depth of cut at level 3, the cutting speed at level 3 and feed rate at level 2.

CONCLUSION

This study discussed an application of the Taguchi method for optimizing the cutting parameters in turning operations using single performance measure which is the surface roughness (Ra). From this study, the following conclusions could be reached with a fair amount of confidence: Regardless of the category of the quality characteristic, the-lower-the better for surface roughness the lowest feed rate (F = 0.05 mm rev? 1), the highest cutting speed (S = 1400 rpm) and highest depth of cut (D = 1.5 mm) lead to optimal surface roughness value. Finally the experimental results show that better surface quality in Meranti wood can be achieved by controlling the cutting parameters for better optimization.

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An Exclusive Assessment on the Effect of Parboiling on Rice Paddy: A Review

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Abstract: *Rice is a staple food accepted as the most important cereals in the world. But before it is consumed, it will undergo different stages of processing to remove the hull, bran and germ from the rough rice kernel which is either parboiled or not. This paper review and analyzes the effects of parboiling on different varieties of rice from different countries. The results show a significant improvement from the new methods in used now. For all the varieties study/experiment conducted shows soaking and steaming affected the physico-chemical properties while steaming completely gelatinized the rice starch during parboiling process. Parboiling reduced the breakage, fat, protein and amylose content of the rice while cooking time, water uptake and thiamine content were increased. This paper suggested an improved method without wasting too much soaking time and temperature during the process. It can therefore be inferred that parboiling which has been the means of processing rice can be a way of improving vitamin content and milling properties of rice and should attract the interest of food technologist and food processing industries to keep on improving in order to produce good quality parboiled rice that meets consumer need and satisfaction.*

Key words: *Paddy, Oryza sativa japonica, Oryza sativa indica.*

1. INTRODUCTION:

Rice (Oryza Sativa) is one of the leading crops in the world. In 2010, the global rice production was 696 million tons. More than 90% of the world's rice is grown and consumed in Asia by 60% of the world's population on about 11% of the world cultivated land (FAO, 2010).

Rice, like barely and oat, is harvested as a covered grain, which is called rough rice (also referred to as paddy).Rough rice, consists of a white, starchy endosperms surrounded by tightly and having bran and germ within a hull. The hull surrounds, but is not bound to the grain and constitutes about 20-25% of the rough rice mass (Champagne,2004: Delcour and Hoseney, 2010).

Several investigation has shown that about 20% of the rice produced worldwide is parboiled, i.e. "partially boiled". This three step hydrothermal treatment involves; soaking, heating and drying of rice and is performed either on rough or on brown rice. Parboiling has a considerable impact on the texture and nutritional characteristics of cooked rice. In particular, cooked parboiled rice is firmer, less sticky and more nutritious than its cooked raw counterpart.It is also generally assumed that parboiling increase HRY.Parboiled rice has a darker color than raw rice and slightly different flavor (Bhattacharya, 2004; Delcour and Hoseney, 2010).

2. REVIEW OF PREVIOUS METHOD/TECHNOLOGY.

Raghavendra. (1970) ***effect of parboiling on some physicochemical properties of rice***: The experiment was conducted using seven varieties of rough rice and selection ranging from 2 to 27% of brown-rice amylose content was used to study the effect of parboiling on grain properties. They used samples of IR8,Acc.9800,Palawan,PI215936,Century Patna 231XSLO17,IR35-23-2,and IR253-16-1-2 rough rice which was obtained from the experimental farm in the institute(International Rice Research Institute,Los Banos,Laguna,Philippines).The experiment were conducted in a laboratory using different method to ascertain both the physical and chemical properties. The rice varied in age (storage time at 20^0c since harvesting) from 0.1 to 11 months at the time of parboiling while 2 to 3kg was soaked in water about 5^0c below the gelatinization temperature for 6 to 7 hours, drained, steamed for 14 minutes in an autoclave. They conducted the physical test on mean length and width of 20 kernels of rough, Brown, and milled rice were determined, while the hardness of brown rice was estimated from 10 Kernels using Kiya-type hardness tester (Vidal and Juliano, 1967).

Table II. Protein, Amylose, and Brown Rice Amylogram Data of Raw and Freshly Parboiled Rices of Seven Varieties and Selections

Variety/Selection	Treatment	Protein, %	Amylose, %	IBC, %	Gel. Temp., ° C.	Gel. Time, min.	Temp. at Peak Visc., ° C.	Viscosity, B.U.[a] Peak	Initial at 94° C.	After 20 min. at 94° C.	Cooled to 50° C.
R8	Raw (5.5)[c]	7.57	27.2	5.88	68.5	15	93	1010	1000	800	1570
	Soaked at 65° C.	7.78	27.5	5.83	67.5	16	94	1110	1110	980	1650
	Parboiled	7.45	27.4	6.12	71.5	23	94	350	120	350	530
R8[b]	Raw (0.5)[c]	10.2	28.9		63	15	88.5	950	885	790	1395
	Parboiled	10.0			82.5	18	94	705	400	695	1200
Acc. 9800	Raw (0.1)[c]	9.58	24.9	5.29	73.5	11	93	690	560	385	630
	Parboiled	9.44	23.4	5.43	79.5	17	94	330	225	325	605
Palawan	Raw (1.5)[c]	8.57	23.2	5.15	72	11	91	780	520	385	645
	Parboiled	8.20	22.9	5.05	76.5	13	94	600	540	535	960
PI 215936	Raw (1)[c]	9.61	18.8	3.26	66	17.5	93	420	410	230	380
	Parboiled	9.56	16.7	3.12	72	16	94	510	460	495	720
CP 231 × SLO 17	Raw (11)[c]	11.2	15.4	3.23	76.5	8.5	92	820	600	420	640
	Parboiled	11.1	14.6	3.10	78	8	93	850	700	525	765
CP 231 × SLO 17[b]	Raw (0.5)[c]	9.20	15.0		75	7	88	890	510	455	580
	Parboiled	9.06			75	10	94	940	935	680	950
R35-23-2	Raw (1)[c]	12.8	7.5	2.40	75.5	8	90	950	520	435	630
	Parboiled	12.7	7.7	2.44	57	20	91	690	615	570	790
R253-16-1-2	Raw (1)[c]	10.6	2.0	0.81	64	5.5	75.5	415	305	290	355
	Parboiled	10.6	2.0	1.02	32	33	84	410	375	340	415

[a] 11% paste. B.U. = Brabender units. [b] Additional samples. [c] Age of samples in months.

Table III. Amylose and Brown Rice Amylogram Data of Five Raw and Parboiled Rices after Storage for Eight Months

Variety/Selection	Treatment	Amylose, %	IBC, %	Gel. Temp., ° C.	Gel. Time, min.	Temp. at Peak Visc., ° C.	Viscosity, B.U.[a] Peak	Initial at 94° C.	After 20 min. at 94° C.	Cooled to 50° C.
Acc. 9800	Raw (8.1)[b]	21.4	4.09	82	5.5	93.5	960	820	620	790
	Parboiled	20.5	4.30	87	6.5	94	480	300	480	815
Palawan	Raw (9.5)[b]	20.5	4.22	73.5	10	92	955	860	580	660
	Parboiled	20.0	4.17	84	7	94	670	520	640	995
PI 215936	Raw (9)[b]		2.23	75	9	93	640	640	450	515
	Parboiled		3.06	79.5	20	94	460	240	450	720
IR35-23-2	Raw (9)[b]		2.38	76.5	7	90	1065	700	525	735
	Parboiled		2.03	85	11.5	94	550	420	560	725
IR253-16-1-2	Raw (9)[b]	3.3	0.39	66	4.5	75	660	550	520	490
	Parboiled	3.0	0.47	40.5	27	81	400	365	340	400

[a] 11% paste. B.U. = Brabender units. [b] Age of samples in months.

Another hardness test consisted of disintegrating 10 Kernels of brown rice in Wig-L-Bug amalgamator for 40 seconds for determining the percentage by weight that passed through an 80-mesh sieve. They used Little. (1958) to determine the Alkali test on whole milled rice, while the cooking time was determined by the method of Ranghino (1966) after the rice has being milled. Batcher (1956) method was used for the cooking test for just 10 minutes. Pre-soaking minimized the difference in cooking time between raw and parboiled samples. Selection of raw and parboiled samples were prepared and stained according to Del Rosario (1968) method, while the brown rice was analyze for crude protein (Nx5.95).parboiled and raw rough rice were stored for 8 months in a sealed bin at an ambient temperature and bimonthly samples were drawn, dehulled, milled and tested for amylograph and cooking time values

The results of the experiment show that many physical properties of rice kernel were altered by parboiling treatment while the 100 kernel weight of the rice did not change. Three varieties including the waxy IR253 selection, has essentially the same dimensions for

both raw and parboiled. They agree that parboiling resulted in interesting changes in the amylograph curve of rice pastes. The changes in amylograph characteristics of the rice samples on parboiling may be partly ascribed to their difference in amylose content. They opined that aside from the loss of viability of rice, parboiling affected the physical more than the chemical properties of the grain. They recommended that various aspect of parboiling and aging requires further study to resolve conflicting results and to determine the cause or causes of the observed reduction in solubility of starch and protein.

Hiromichi. (1983) ***effect of parboiling on texture and flavor components of cooked rice*****:** The experiment was conducted using samples of Nakateshinsembon variety of rice (oryza sativa L. Japonica) and Bluebonnet variety of rice (oryza sativa L.indica) harvested in Hiroshima prefecture, Japan, and that of Koshihikari variety of rice (oryza sativa L. japonica) harvested in Niigata prefecture, Japan, were used. An experiment process line was used for parboiling of these samples. The samples were soaked in water for 50^0c under atmospheric pressure for 170min and steamed at 115^0c under 0.5kg/cm^2 for 15min.After the aerated at 45^0c for 7min until the moisture content had decrease to 29%,the steamed rice was dried in two steps; that is first at 50^0c for 10 hours to a 20% moisture content and second at 30^0c for 10 hours up to 15% moisture content, while the milling yield was 91-92% of the brown-rice samples for each samples using the test mill model TM05.other raw and parboiled brown-rice samples were milled with a satake two-in-one pass rice whitening and caking machine.

They discovered that the milled parboiled thus obtained had a pale amber and transparent appearance which indicated that it had been completely parboiled….while the milled rice samples were stored at 4^0c in polyethylene film bags. Other parameters consider were the physical measurement using the method of Tsugita (1983),extractability of protein by a modification of the percolation system described by Cagampang (1966), crude lipid was treated according to the method of Lee and Mattick(1964)to obtain the free fatty acid fraction. Fat by hydrolysis was extracted using Yasumatsu and Moritaka (1964) method using 20kg of milled flour rice with diethyl ether and petroleum ether successively for 30hours using a soxlet apparatus to obtained the unbound lipid fraction. Other parameters used include; Lipid Bound to Protein, Free Phenolic Acids, and Headspace Volatiles of cooked Rice, Steamed-Distilled Volatile concentrate of milled rice, GC and GC-MS Analysis. The results obtained by the their experiment shows that the milled parboiled brown-rice samples of Nakateshinsembon showed a significantly smaller expanded volume and water-uptake than the milled unparboiled rice.

While similar results have been reported by Raghavendra Rao and Juliano (1970) with the use of rough rice samples of indica rice. Cooked parboiled rice had a harder, more cohesive, and less sticky texture than cooked, unparboiled rice in the case of both Nakateshinsembon and Bluebonnet. Cooked parboiled and unparboiled Bluebonnet rice showed greater hardness and cohesiveness and less stickiness than in the case of Nakateshinsembon.

Also similar experiment was conducted by Okabe (1979) reported “texturogram” showing the relationship between the textural characteristics of cooked rice and acceptability, as judge by a trained panel of Japanese. According to Okabe (1979) cooked, unparboiled Nakateshinsembon rice was evaluated as being excellent for Japanese, and cooked

parboiled Nakateshinsembon rice was slightly poor but acceptable, and further both cooked, parboiled and unparboiled Bluebonnet rice were evaluated as being unacceptable for Japanese, though the latter was preferable to the former. These objective evaluations indicate the acceptability of parboiled japonica rice and the unacceptability of parboiled indica rice for Japanese.

These results also agree with the actual sensory evaluation by members of the laboratory team for respective cooked rice.

Otegbayo. (2001) ***effect of parboiling on physico-chemical Qualities of Two Local rice Varieties in Nigeria*****:** The experiment was conducted using two varieties of local rice in paddy form. The samples were collected from local farmers at Okemesi Ekiti in Ekiti state of Nigeria (western Nigeria) The rice samples were the type of varieties consumed in Nigeria (Oryza glabarrima steud), but is known to the locals as Offanda (white variety) and Alaso-osun (Brown variety).The rice varieties were stored for 180 days after harvesting.25kg of each of the local varieties in paddy were divided while half was parboiled. Cleaned paddy were soaked in water at room temperature (below the gelatinization temperature of rice to minimize the splitting of the grains), to hydrate the grains in a steeping tank for 5-8hours.parboiling was done in the laboratory by the pressure parboiling method of Iengar (1980),in this method the paddy rice was not saturated with water but briefly exposed to steam under high pressure using autoclave to gelatinize the starch for 15minutes at 15 p.s.i.g. pressure(121^0c).the parboiled paddy rice was then tempered for 30min to cool and air-dried in a cabinet dryer at 45^0c for 8hours.both the raw and the parboiled rice samples were milled in a grantex mill.

The results from the study shows that parboiling as a means of rice processing affects both the physical and the chemical properties of the grain, it improves milling and cooking qualities of the rice grains in a positive manner which has been found to influence consumers demand and acceptability. The increase in thiamine content of the parboiled rice can also serve as an effective means of improving the thiamine intake in people's diet thereby enhancing their nutritional status. They opined that parboiling which has been the means of processing rice in Nigeria can be a way of improving vitamin content and milling properties of rice and should attract the interest of food technologist and food processors to develop the rice industry because the two rice varieties used in the experiment shows high content of protein between 6.86-8.75%, this therefore means that the rice could be a major source of protein and diet for Nigerians if consumption is adequate.

Bhattacharya. (1966) ***effect of processing conditions on Quality of parboiled Rice*****:** The experiment was conducted using two varieties of rice in India popularly known to the locals as Bagara sanna(BS)and Ratna Chudi(RC) in semi parboiled paddy(rough rice).Only whole grains handpicked from the well mixed and cleaned samples were used for this experiment. The parameters obtained throughout the methods includes; coking quality of rice, cooking of rice in water and color of rice. However the results obtained shows that soaking above 60^0c affected the quality of rice, it shows that the greater the severity of heat treatment during soaking and steaming the lower the water uptake and the darker the color of rice. When it was soaked above 70^0c and above it will have a relatively effect on the color, while steaming above 60^0c will have effect on the processing conditions on quality.it

was observed that beside nonenzymatic browning, the husk pigment and the bran also appeared to contribute to the color of parboiling rice. Parboiled rice specification was determined from the characteristics of its reflectance.

They opined that the cooking quality and color of rice were affected by the severity of heat-treatment during soaking and steaming. Quick cooling after parboiling may be the most important factor in industrial-scale operations. They discovered two factors which are the chief contributors to the quality of parboiled rice; the first being the discoloration during parboiling which is due to nonenzymatic browning of the maillard type inhibited by bisulfie, while the other factor is the husk pigment which also contribute by diffusing into the endosperm or by being absorbed on splitting of the grain during soaking.

Previous studies conducted were conducted on different varieties of rice. Roberts. (1954) studied the effect of certain conditions on the color, expanded volume, and soluble starch content of parboiled rice.Quarat (1962) observed certain dimensional changes in the grain after parboiling and alterations in its starch grannules.Kurien (1964) noted similar grain-dimension changes and studied the effect of steaming on the cooking of quality of the rice. A more comprehensive investigation covering wide processing conditions was desirable

3. REVIEW OF CURRENT METHOD/TECHNOLOGY

Graham. (2015) ***effect of soaking and steaming Regimes on the quality of Artisanal parboiled Rice*****:** The experiment was conducted using an improved high yielding aromatic upland variety of rice in Benin Republic. The sample used was grown in August-December 2012 planting season by the Africa Rice Center (Africa Rice) in Lokossa (Kinwedji) in Benin. The sample was dried to a moisture content of 13% before use. A CRCD of the experiment was set up using Statgraphics centurion XVII software(Standpoint Technologies inc;Warrenton VA)with two factors(K=2) namely IST(30-90^{0}c)and STM(5-20min).Fourteen treatment combination (table 1) were performed on the sample. The responses measured were water absorption during parboiling (WAP), milling (brown rice, total milled rice and head rice) recoveries, appearance (chalkiness and color), cooking properties (cooking time, water uptake, volume expansion, texture (hardness and stickiness) of food grains and pasting properties (PV, Tr, BD, FV and SB).

They agree that parboiling, a hydrothermal behavior has been identified as a key method used to improve the quality and effectiveness of locally produced rice. The process of parboiling seals internal fissures in the rice grain initiating in higher HRY during milling (Manful. 2009). Milled parboiled rice has also been reported to have lower glycemic indices, higher resistant starch content and higher contents of B vitamins than milled non-parboiled rice (Jenkins. (1988). Luh and Mickus (1991); Newton.(2011); Odenigbo.(2013). In addition to the improved milling and nutritional properties, parboiled rice has also been touted with a set of unique cooking, flavor and textural characteristics that are appealing to certain groups of consumers.

An extra of specific methods exist for producing parboiled rice, however, the central processes remain the same and comprise soaking paddy rice in water for a number of hours until kernels are fully hydrated, draining the water, steaming the rice, drying and

milling. Although the exact processes of most commercial parboiling units in developed countries are commercial secrets (Bhattacharya.1985), it is generally known that paddy is soaked at a constant temperature between 60 and 65^0c up to 3 hours and pressure steamed for up to 20 min (Manful. 2009). The equipment and procedures used for parboiling in industrial plants have been standardized to give consistently high- quality parboiled rice.

In many sub-Saharan African (SSA) countries, artisanal methods of parboiling using diverse rudimentary equipment and procedures are the mainstays. In artisanal parboiling, all operations are carried out under atmospheric pressure. The paddy is soaked in water with initial temperatures ranging from ambient to over 90^0c and allowed to cool for up to 16 hours until the grains are fully hydrated before steaming. Steaming techniques employed in artisanal parboiling include the use of steel drums with a false bottom on which the paddy is directly steamed or the paddy is put in a jute bag before being placed on sticks in the steaming container (Behrens and Heinemann (2007); Fofana. (2011)). The importance of proper pre-processing steps such as paddy cleaning is being addressed while several new parboiling vessels and stoves are also being developed and tested (Houssou and Amonsou (2004); Houssou (2005); Ndindeng. (2015). Variations in parboiling processes have been noted to produce rice with different characteristics Oli. (2014).

The experimental results show that Artisanal parboiling can be successfully applied to improve the quality of rice particularly the milling recoveries and appearance especially if the quality of the starting paddy is poor. However, treatment combinations (IST and STM) ought to be carefully chosen in order to achieve the desired effect. Varying parboiling treatments alter other physico- chemical properties of rice such as cooking properties, cooked rice texture, pasting properties and nutritional com- position of rice. This could be exploited to produce rice with cooking properties and texture that meet demands of target consumers. Given the effects on pasting properties, parboiling could also be optimized to alter the functional properties of rice in food formulations. Artisanal parboiled rice with good HRY and uniform translucent appearance can be produced when soaked at initial temperatures beyond 80^0C, cooled to ambient temperature and steamed for 15–20 min. TABLE

1. Treatment Combinations Generated From Response Surface Central Rotatable Composite Design.

Treatment	IST		STM	
	Coded unit	Uncoded unit(^{0}C)	Coded unit	Uncoded unit(min)
1	0	60.0	0	12.5
2	-1	30.6	-1	5.0
3	+1	90.0	-1	5.0
4	0	60.0	0	12.5
5	-1	30.0	+1	20.0
6	+1	90.0	+1	20.0
7	0	60.0	0	12.5

8	0	60.0	0	12.5
9	0	60.0	+1.414	23.1
10	-1.414	17.6	0	12.5
11	0	60.0	0	12.5
12	+1.414	100.0	0	12.5
13	0	60.0	-1.414	1.9
14	0	60.0	0	12.5

Chijioke. (2015) ***effect of steaming on physical and Thermal properties of parboiled Rice*****:** The experiment was conducted using Samples of five improved rice paddy varieties (FARO 44, FARO 52, FARO 60, FARO 61) used in this study were harvested in December, 2012 by the Breeding Unit of Rice Research Program, National Cereal Research Institute (NCRI) Badeggi Niger State, Nigeria and one local variety (Bisalayi) also harvested in the same period was obtained from Crop Improvement Unit of Kano State Agriculture and Rural Development Agency (KNARDA). They were packed in nylon jute bags and transported in February, 2013 to Bioresource Engineering Department, McGill University of Montreal, Canada and stored at room temperature. Prior to experiments, the unparboiled paddy samples were taken out, thoroughly cleaned and flawed grains removed. The moisture contents of the samples were determined by the fixed air-oven method drying at 120^{o}C for 24 h in duplicates and found to be 0.0713 + 0.0023 g/g d.b. Their experiment include; studying the effect of steaming time on physical properties(translucency, hardness, lightness, and color intensity)of parboiled rice, evaluation effect on steaming time on thermal properties(degree of gelatinization)of parboiled rice varieties and determine the optimum steaming condition required to obtained optimum quality of parboiled rice. The main purpose of this process is to pre-gelatinize the starch granules, transforming the crystalline structure of the starch into an amorphous one.

Previous studies shows that starch gelatinization imparts additional hardness to the rice grains and allows them to withstand harsher milling (Rao & Juliano, 1970; Bhattacharya, 1985; Islam, 2002) It is reported that parboiled rice also has better organoleptic properties, retains more nutrients and cooks better than non-parboiled rice (Rao & Juliano,(1970); Sareepuang .(2008); Lamberts.(2008). In generally, parboiling process consists of three stages namely: soaking of paddy to saturation moisture content (SMC), steam heat treatment of the soaked paddy to partially gelatinize the rice starch, thereby eliminating white portions and cementing crack developed in rice during harvesting and/or threshing and finally drying the steamed product to moisture content adequate for milling. Parboiling brings about modifications in rice during which vitamins and minerals are transferred from the aleurone and germ into the starchy endosperm. These transformations are accompanied by reduction in white portion, and give milled rice more translucent appearance (Juliano and Bechtel, 1985). A common problem with parboiling, especially by employing high temperature and pressure and longer processing time, is darkening of the grain (Bhattacharya, 1995). Also, steaming operation, which bring about the gelatinization of starch, requires a lot of energy to produce steam for the process, it is therefore necessary to establish optimum processing conditions required to obtain better qualities of the finished product while saving energy and time. Marshall. (1993) studied the relationship

between percentage of gelatinization and head yield (the primary parameter used to quantify rice milling quality given by the ratio of weight of rice grains that are three-quarters intact to the total weight of milled parboiled rice) of parboiled rice (Cooper and Siebenmorgen, 2005).

They reported that maximum head rice yield could be achieved when the rice starch is 40% gelatinized during parboiling of paddy and that extensive parboiling or extensive starch gelatinization is not required to obtain maximum head rice yields.

The results obtained from the different processes including the grain kernel translucency which was determined by adopting the method of Marshall. (1993) with slight modification. The hardness of 25 unfissured whole brown rice kernels was measured using a compression method (Introns 4502, Canton MA, USA). The average bio-yield point value (Mohsenin, 1980) of the 25 measurements was expressed as the hardness in newton's (N). Brown rice kernels were put on the base plate and the bio-yield point value measured in flat position (Islam. 2001). A 500 N load cell, a probe of 3.84 mm diameter and 5 mm/min compression rate were used. The probe was set to travel a distance of 2.25mm into the sample. For the lightness value a spectrophotometer (CM – 3500d, Minolta Co., Ltd., Japan) was used to measure the lightness and saturation of the color intensity value of the whole kernel milled rice utilizing the L*a*b* uniform color space procedure. The thermal (gelatinization) properties were determined with a Differential Scanning Calorimeter (DSC Q100, TA instruments, Wilmington, DE USA). Heat flow and temperature calibrations of the DSC were performed using pure indium with heat of fusion and a melting temperature of 28.41 J/g and 156.66^{o}C respectively.

The instrument was coupled with refrigerated cooling system. Nitrogen was used as a purge gas at a flow rate of 50 ml/min. Raw and parboiled rice were de-husked using an electric compact rice de- husker (TR 200, Kett Electric Laboratory, Tokyo) and polished using a test polisher (Pearlest, Kett Electric Laboratory, Tokyo). Rice flour was then prepared by grinding samples of the polished rice using a coffee grinder (SUMEET Multi Grind, India) and passed through 0.075 mm sieve (Fisher brand test sieve, Fisher scientific co., USA). This ratio accounts for more than 60% moisture, corresponding to the moisture content required for rice gelatinization and to obtain a single endotherm during DSC experiment (Billiaderis.1986). The pans were hermetically sealed with TA sample crimping device. The sealed samples were stored at room temperature for one hour to stabilize before thermal scanning. The pans were placed in the sample cells of the DSC while an empty pan was sealed and placed in the reference cell of the DSC. The data of the effect of dependent variables (steaming time and variety) on the dependent variables (percentage of translucency, hardness, lightness, gelatinization temperature and gelatinization enthalpy) were statistically analyzed using SAS software (version 9.2), and where there was significant effect, means were separated using the Duncan's multiple range test ($P<0.05$) The findings from this study show that steaming time significantly affects physical and thermal properties of parboiled rice.

The improved rice varieties used in this study show better hardness than the local variety which might be due to the difference in the structural arrangement of starch granules among rice varieties in addition to varying extent of bonding between gelatinized starch

and ruptured protein bodies. Hardness of rice was found to increase with steaming duration and ranged from 59.45 – 113.65 N, 79.39 – 158.17 N, 77.24 – 136.70 N, 73.59 – 136.65 N, and 73.14 – 126.20 N for Bisalayi, FARO 61, FARO 60, FARO 52 and FARO 44, respectively.

The optimum grain hardness was achieved at 20 min of steaming for Bisalayi and FARO 44 while for FARO 61, FARO 60 and FARO 52 it was attained at 15 min. Bisalayi (local variety) was found to be more discolored more than the FARO (improved) varieties. Lightness value decreased with increase in steaming period with values of 78.34 – 58.98 , 71.27 – 58.67 , 73.85 – 59.06 , 70.21 – 57.00 and 69.75 – 58.67 for Bisalayi, FARO 61, FARO 60, FARO 52 and FARO 44 respectively, corresponding to 0 – 20 min of steaming. The varietal difference in color change observed as observed could be due to a more rapid nonenzymatic browning of the Maillard reaction in the Bisalayi than in the FARO varieties in addition to genetic make-up among cultivars. Steaming completely gelatinized rice starch in samples, thus, there was no residual enthalpy of gelatinization after steaming of paddy.

Table 1: Gelatinization properties of non-parboiled paddy rice from Nigeria

Parameters	variety				
	Bisalayi	FARO 61	FARO 60	FARO 52	FARO 44
T_o °C	72.78±0.38^a	73.90±0.18^a	73.16±0.08^a	64.24±0.16^b	64.37±0.82^b
T_P, °C	76.61±0.16^a	77.03±0.08^a	76.07±0.06^a	68.79±0.28^b	75.26±0.47^b
T_c, -0C	83.78±1.03^a	82.55±0.85^a	80.98±0.08^a	77.70±10.0^b	75.26±0.47^b
ΔH, J/g	5.76±1.49^a	3.62±0.65^{ab}	3.15±0.37^b	1.55±0.74^b	2.35±0.08^b

Means with the same superscript along the lines are not significantly different at P < 0.05 To, Tp, and Tc is onset, peak and conclusion gelatinization temperatures, respectively; ΔH is the gelatinization enthalpy

They opined that steaming time significantly affected both physical and thermal properties of the selected varieties of parboiled rice from Nigeria. The improved rice varieties used in this study show better hardness than the local variety which might be due to the difference in the structural arrangement of starch granules among rice varieties in addition to varying extent of bonding between gelatinized starch and ruptured protein bodies. Hardness of rice was found to increase with steaming duration and ranged from 59.45 – 113.65 N, 79.39 – 158.17 N, 77.24 – 136.70 N, 73.59 – 136.65 N, and 73.14 – 126.20 N for Bisalayi, FARO 61, FARO 60, FARO 52 and FARO 44, respectively. The optimum grain hardness was achieved at 20 min of steaming for Bisalayi and FARO 44 while for FARO 61, FARO 60 and FARO 52 it was attained at 15 min Bisalayi (local variety) was found to be more discolored more than the FARO (improved) varieties. Lightness value decreased with increase in steaming period. Steaming completely gelatinized rice starch in samples, thus, there was no residual enthalpy of gelatinization after steaming of paddy.

4. PROPOSAL/SUGGESTION

Because of the inconsistence in the results of different method carried out on different rice varieties in many countries. Parboiling still remained and still in used in improving milling quality of rice. Several Authors and researches agreed on their findings that parboiling has significant effect on the physical as well as the chemical properties of rice. The main findings of this review paper detect that difference in soaking temperature and steaming time is responsible for giving out conflicting results. This review paper agreed with the latest research conducted by Ebrahim et al(2015)whose research work provide the most suitable soaking temperature of 65^0c and 4 min steaming time which gave the highest value of head rice yield, lightness and rupture force. This treatment was found to provide the most desirable quality of parboiled rice. The paper also suggested that future Research/studies should focus and pay more attention to the difference in soaking temperature and steaming time to improve the quality of rice.

5. CONCLUSION

It is evident that Parboiling still remained the alternative process of improving the quality of rice by increasing its vitamin content, amylose content, and thiamine content. The physical properties are more affected by parboiling than the chemical properties. However it is very important for researchers and food processing industries to look deep into the issues suggested by this paper.

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Evaluation of Rainwater Harvesting Potentials for One Thousand (1000) Housing Estate in Maiduguri, Nigeria

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Abstract: *Access to potable water (quantity and quality) is inadequate worldwide. In this study rainwater harvest as source of water supply in a selected housing estate (1000-housing estate) in Maiduguri, Nigeria was evaluated. Types of flats in the estate were identified and were counted. Average number of person per flat was obtained. Water demand of 120 l per capita per day (WHO standard) was used to compute water demand per each bedroom flat. Rainfall data were collected (1979-2013) from Nigerian meteorological agency (NIMET). The effective surface area of various flat (1-bedroom 2-bedrooms, 3-bedrooms and 4-bedrooms) were calculated using standard method. Water yield per flats were calculated using rainfall intensity and effective surface area (Rational method). The water yields (Rain harvest) per flats were used in design, collection transportation and storage facilities for the flats. The study revealed that the total flats in 1000-housing estate was 1000 housing unit consist of 120 1-bedroom flats, 680 2-bedroom flats, 110 3-bedroom flats and 90 4-bedroom flats. Averages of person per flats were 3, 5, 8 and 10 for 1-bedroom 2-bedrooms, 3-bedrooms and 4-bedrooms respectively. Annual rainfall in Maiduguri was found to be between 64.92 mm and 2869.03 mm with an average of 693.21mm. Effective surface areas for various flats were 72 m^2. 132 m^2, 233 m^2 and 287 m^2 for 1, 2, 3 and 4-bedroom flats respectively. Rainwater harvest or yield for 1, 2, 3, and 4-bedroom flats were 43 m^3/yr, 78 m^3/yr, 131 m^3/yr and 169 m^3/yr respectively. Government support by incorporating rainwater harvesting in building code, will help in reducing the cost and create enabling environment for the adoption of the technology.*

Key words: *Rainfall data, Roof catchment, water demand and water quality*

INTRODUCTION

The water supply systems and drinking water inaccessibility in the developing countries is a global concern which calls for immediate action. Providing quality drinking water to all citizens of the world who are deprived access to water will serve as the breaking point of poverty alleviation in most developing countries especially in Nigeria, where substantial amount of national budgets are used to treat preventable water borne diseases (Cobbina *et al*., 2013). The main source of water is precipitation in form of rain and when it rains, only a fraction of the water percolates, while the major part of the rainfall drains out as run-off and goes unused, finally into the ocean (Sivanappan, 2006). Among the various alternative technologies to augment freshwater resources, rainwater harvesting is a decentralized, environmentally sound solution, which can avoid many environmental problems, associated with centralized, conventional, large-scale project approaches (Akoto *et al*., 211). Rainwater harvesting is often overlooked by planners; engineers and builders because of lack of information; both technically and otherwise (Despins *et al*., 2009). Rainwater is the purest form of naturally occurring water. It is considered to be produced by a form of natural distillation. However, it

contains dissolved gases such as carbon dioxide, sulphur dioxide, nitrogen dioxide, ammonia, fine particulate materials or aerosols from the atmosphere that mix with it after formation (Nsi, 2007).

Rainwater harvesting is the capture, diversion, and storage of rainwater for a number of different purposes including landscape irrigation, drinking and domestic use, aquifer recharge, and storm water abatement. Rainwater harvesting has been used throughout history as a water conservation measure, particularly in regions where other water resources are scarce or difficult to access (Khan, 2012). Rainwater harvesting, in its broadest sense, is a technology used for collecting and storing rainwater for human use from rooftops, land surfaces or rock catchments using simple techniques such as jars and pots as well as engineered techniques (Dakua, 2013). The scope, method, technologies, system complexity, purpose, and end users vary from rain barrels for garden irrigation in urban areas, to large-scale collection of rainwater for all domestic uses. Rainwater is valued for its purity and softness, it has a nearly neutral pH, and is free from disinfection by-products, salts, minerals, and other natural and fabricated contaminants (Tabassum, 2013). The components of rainwater harvesting system differ between developed and developing countries, a typical rainwater harvesting system comprises of three basic elements: the catchment surface, the conveyance system; the storage and distribution systems (Morey *et al*., 2016). The catchment surfaces are commonly roofs, although runoff form precipitation (rainfall) can also be collected from other impermeable areas, such as roads, car parks and pavements (Fewke, 2006). The material of the catchment area affects the rainwater quality and quantity. After collection, rainwater goes through the conveyance system consists of gutters or pipes that deliver rainwater falling on the rooftop to storage vessels (Lee *et al*., 2002). Both drain pipes and roof surfaces should be constructed of chemically inert materials such as wood, plastic, aluminum, or fiber glass, in order to avoid adverse effects on water quality.

Governments typically do not include rainwater utilization in their water management policies, as extensive development of rainwater harvesting systems may reduce the income of public water systems. Rainwater harvesting systems are often not part of the building code and lack clear guidelines for users and developers to follow. In Maiduguri, rainwater harvesting is still at its primitive stage, as ground water is the main source of water supply system. Over exploitation of groundwater in the city with the increasing demand of water and natural absence of surface water has necessitated the need to consider new water source for future. The city is characterized with seasonal flood due to poor drainage systems and indescrimate dumping of refuse. The city also experience serious soil erosion due to the loose nature of the soil, and there was no any attempt to create a mitigation measures through harvesting and conserving the precipitation endowment received annually. To address the problem of flood, soil erosion and water scarcity, rainwater harvesting has been thought as one of the potential alternatives, where significant portion of water demand during rainy season could be met from the rainwater that would also reduce the pressure on vended water and city water supply. The aim of this research is to evaluate the potentials of rainwater-harvesting system for 1000 housing estate using available rainfall data in Maiduguri.

MATERIALS AND METHOD

Study Area

Maiduguri serves as a gateway to the Sahel region of West Africa. The city is the capital of Borno state located in North-Eastern Nigeria between latitude 11^0 5″ – 11^0 55″ N and longitude 13^0 02″ -13^0 16″ E. It lies on a vast open plain which is flat with gentle undulations at an average elevation of 345m above sea level. Maiduguri has a total land area of 187.13km^2, with build-up area of 102.62Km^2, undeveloped area of 78.19Km^2, Bare surface of 5.87Km^2 and water body of 0.4Km^2. Trading is the major occupation of the inhabitants with few agrarian practices. Maiduguri is estimated to have a population of about 1,197,497 in 2009 (NPC, 2006). More than 80% of this population depends on groundwater resources, with per capita water consumption of 10-40 litres of water per day (UN, 1988). The vegetation of the study area is Sahel Savannah. According to Hess *et al.* (1996), the climate of Maiduguri is semi-arid with three distinct seasons, cool-dry season (October to March), hot season (April to June) and a rainy season (July to September). The annual rainfall ranges from 560 to 600mm. The cold (harmattan) season runs from November to March when temperatures fall to about 20°C and a dry dusty wind blows from the Sahara desert (Jaekel, 1984). The area is fragile and highly susceptible to drought with average relative humidity of 13% in dry seasons and 65% in rainy seasons. The one thousand

(1000) housing estate (1 bedroom 2 bedrooms, 3 bedrooms and 4 bedrooms) was built in 2014 to reduce the problem of accommodation in the city and currently, the estate water supply system is inadequate.

Methodology

The 1000-housing estate was identified and selected at the out skirt of Maiduguri, Nigeria. Types of flats in the estate were identified and counted. Average number of person per flat was obtained. Rainfall data were collected (1979-2013) from Nigerian meteorological agency (NIMET). Effective surface area of various flat (1 bedroom 2 bedrooms, 3 bedrooms and 4 bedrooms) were calculated using standard method. Water yields per flat were calculated using annual mean rainfall and effective surface area (as recommended by rational method). The water yields (annual mean rainfall and effective surface area) from 1-bedroom, 2-bedrooms, 3-bedrooms and 4-bedrooms flats were used in the design, collection, transportation and storage facilities for each of these flats.

Design Calculations

Water demand

The average daily water demand per household was calculated using 120l/day/capita (WHO, 2004) as stated in Equation 1.

The daily water demand per household = Number of person/ house x Water demand/person (1)

1. Water demand per household for 1-bedroom flat

Average number of person per house for 1-bedroom flat = 3

Water demand per household = 3 x 120

= 360 l/day/household

Water demand per household/year for 1-bedroom flat = 360 x 365

= 131400 l/yr/ household

= 131.4 m^3/yr/household

2. Water demand per household for 2-bedroom flats

Average number of person per house for 2-bedroom flats = 5

Water demand per household = 5 x 120

= 600l/day/household

Water demand per household/year = 365 x 600

= 219000 l/yr/ household

= 219 m^3/yr/household

3. Water demand per household for 3-bedroom flats

Average number of person per house for 3-bedroom flats = 8

Water demand per household = 8 x 120

= 960 l/day/household

Water demand per household/year = 365 x 960

= 350400 l/yr/ household

= 350.4 m^3/yr/household

4. Water demand per household for 4-bedroom flats

Average number of person per house for 4-bedroom flats = 10

Water demand per household = 10 x 120

= 1200 l/day/household

Water demand per household/year = 365 x 1200

= 438000 l/yr/ household

= 438 m^3 /yr/household

Effective roof catchment area (A)

The effective roof catchment area (A) was calculated in accordance with BS EN 12056-3 (2000) using the horizontal span slope, height of roof pitch (Roof pitch of 30º) and the length of the roof as stated in Equation 2.

$$A = L \times (W + \frac{H}{2})$$ (BS EN 120563: 2000) (2)

Where, A = effective roof catchment area

W = Horizontal span slope

H = Height of the roof pitch
L = Length of the roof

1. Effective roof catchment area (A) for 1-bedroom flat using Equation 2

$$A = 8.15 \times (3.5 + \frac{1.5}{2}) = 36.13 m^2$$

Total effective roof catchment (A) = 36.13 x 2= 72.26 m²

2. Effective roof catchment area (A) for 2-bedroom flats using Equation 2

$$A = 12(4.5 + \frac{2}{2}) = 66 m^2$$

Total effective roof catchment (A) = 66 x 2=132m²

3. Effective roof catchment area (A) for 3-bedroom flats using Equation 2

$$A = 16.5(5.5 + \frac{2.5}{2}) = 111.38 m^2$$

Total effective roof catchment (A) = 111.38 x 2= 222.76m²

4. Effective roof catchment area (A) for 4-bedroom flat using Equation 2

$$A = 18.5(6.5 + \frac{3}{2}) = 143.38 m^2$$

Total effective roof catchment (A) = 143.38 x 2 = 286.76m²

Gutter and downpipe size

The factorized effective catchment area of the gutter and downpipe were calculated in accordance with BS EN 12056-3 (2000) using rainfall intensity (I) = 150 mm/hr, roof pitch of 30º as presented in Table 1 & 2 and effective catchment area (A) as stated in Equation 3.

Factorized effective catchment area = A x 1.5 x 1.2 (3)

1. The gutter and downpipe sizes for 1-bedroom flat using Equation 3

Factorized effective catchment area = 72.25 x1.5 x1.2
= 130 m²

External gutter cross-sectional area = 100 mm²x 130
= 13 000 mm²
= 125 mm (3/4 round) Table 3

Vertical downpipe cross-sectional area = 50 mm² x 130
= 6 500 mm²
Downpipe diameter = 100 mm (Table 3)

Horizontal downpipe cross-sectional area = 100 mm² x 130
= 13 000 mm²
Downpipe diameter = 125 mm (Table 3)

2. The gutter and downpipe sizes for 2-bedroom flat using Equation 3

Factorized effective catchment area = 132 x1.5 x1.2
= 238 m²

External gutter cross-sectional area = 100 mm² x 238
= 23 800 mm²
= 150 mm (Table 3)

Vertical downpipe cross-sectional area = 50 mm² x 238
= 11 900 mm²
Downpipe diameter = 125 mm (Table 4)

Horizontal downpipe cross-sectional area = 100 mm² x 238
= 23 800 mm²
Downpipe diameter = 150mm (Table 3)

3. The gutter and downpipe sizes for 3-bedroom flat using Equation 3

Factorized effective catchment area = 223 x1.5 x1.2
= 401 m²

External gutter cross-sectional area = 100 mm² x 401

= 40 100 mm^2
= 175 mm (Table 3)
Vertical downpipe cross-sectional area = 50 mm^2 x 401
= 20 050 mm^2
Downpipe diameter = 150 mm (Table 3)
Horizontal downpipe cross-sectional area = 100 mm^2 x 401
= 40 100 mm^2
Downpipe diameter = 175 mm (Table 4)
4. The gutter and downpipe sizes for 4-bedroom flat using Equation 3
Factorized effective catchment area = 287 x1.5 x1.2
= 512 m^2
External gutter cross-sectional area = 100 mm^2 x 512
= 51 200 mm^2
= 200 mm (Table 4)
Vertical downpipe cross-sectional area = 50 mm^2 x 512
= 25 600 mm^2
Downpipe diameter = 175 mm (Table 4)
Horizontal downpipe cross-sectional area = 100 mm^2 x 512
= 51 200 mm^2
Downpipe diameter = 200 mm (Table 4)

Table 1: Rainfall Intensity Factor

Rainfall	Factor
80 mm/hr multiply by a factor	0.8
100 mm/hrmultiply by a factor	1.0
150 mm/hr multiply by a factor	1.5
200 mm/hr multiply by a factor	2.0

Rainfall intensity>100mm/hr the catchment area must be factorised to allow for the increased rainfall

Table 2: Roof Pitch Factor

Pitches	Factor
10˚ – 25˚ multiply by a factor	1.1
25˚ – 35˚ multiply by a factor	1.2
35˚ – 45˚ multiply by a factor	1.3
45˚ – 55˚ multiply by a factor	1.4

Roof pitches >10˚ the catchment area must be increased to allow for the increased rate of run-off.

Table 3: Standard Gutter and Downpipes

Standard	gutter (mm^2)	Standard downpipes (mm^2)	
125mm 1/4 round	5,000	65mm	3,318
125mm x 75mm rectangular	9,375	80mm	5,027
175mm x 125mm rectangular	21,875	100mm	7,854
300mm x 125mm rectangular	37,500	125mm	12,272

Water yield (harvested rainwater)
The harvested rainwater per year was calculated using rational formulae, with mean annual rainfall for 34 years, effective roof catchment area for each flats and runoff coefficient as stated in Equations 4.
S = R x A x C (Adopted from Lee *et al*., 2000) (4)
Where: S = Mean harvested rainwater (m^3)
R = Mean annual rainfall
A = Effective roof catchment area
C = Runoff coefficient
1. Mean harvested rainwater (S) for 1-bedroom flat using Equation 4
S = 0.693 x 72.25 x 0.85
S = 42.56 m^3/yr/household

2. Mean harvested rainwater (S) for 2-bedroom flats using Equation 4
S = 0.693 x 132 x 0.85
S = 77.75 m^3/yr/household
3. Mean harvested rainwater (S) for 3-bedroom flats using equation 4
S = 0.693 x 222.75 x 0.85
S = 131.2 m^3/yr/household
4. Mean harvested rainwater (S) for 4-bedrooms flats using equation 4
S = 0.693 x 286.75 x 0.85
S = 168.9 m^3/yr/household

Storage tank

The sizes (diameter and height) of the storage tank for each flats was calculated using one-twelfths of the volume of harvested rainwater using the Equation 5 and 6

$$V = \frac{\lambda D^2}{4} h \quad (5)$$

$$D = 2\sqrt{\frac{V}{\lambda h}} \quad (6)$$

Where; V_r = Volume of harvested rainwater for each flat (m^3)
r = Number of bedrooms
D = Diameter of tank
h = Height of tank,
Π = 3.142

1. Storage tank diameter for 1-bedroom using Equation 6
Where; V_1 = 3.55 m^3 (one-twelfths of the volume of harvested rainwater)
h = 1.5 m (assumed)

$$D = 2\sqrt{\frac{3.55}{3.142x1.5}} = 1.74 \text{ m}$$

2. Storage tank diameter for 2-bedroom using Equation 6
Where; V_2 = 6.48 m^3 (one-twelfths of the volume of harvested rainwater)
h = 1.7 m (assumed)

$$D = 2\sqrt{\frac{6.48}{3.142x1,7}} = 2.2 \text{ m}$$

3. Storage tank diameter for 3-bedroom using equation 6
Where; V_3 = 11m^3 (one-twelfths of the volume of harvested rainwater)
h = 1.8 m (assumed)

$$D = 2\sqrt{\frac{11}{3.142x1.8}} = 2.82 \text{ m}$$

4. Storage tank diameter for 4-bedroom using equation 6
Where; V_4 = 14.08 m^3 (one-twelfths of the volume of harvested rainwater)
h = 2 m (assumed)

$$D = 2\sqrt{\frac{14.08}{3.142x2.2}} = 2.99 \text{ m}$$

RESULTS AND DISUSSION

Number of Flats in the 1000-Housing Estate

The 1000-housing estate is located at the out skirt of the city, along Maiduguri–Kano road and was fully occupied with majority civil servant because of government institutions along the road. The study revealed that the total number of flats in 1000-housing estate were 1000 housing units, which consist of 120, 680, 110 and 90 for 1-bedroom flat, 2-bedroom flats, 3-bedroom flats and 4-bedroom flats respectively. The 1-bedroom flat is for non-family members and newly married family members. The 2- bedroom flats, which account for 680 bedroom flats are for an average civil servant (between grade levels 8-12). The 3- bedroom flats and 4- bedroom flats for the executives, which has an alternative house in their institutions.

Number of People and Water Demand per Flats in the 1000-Housing Estate

The average numbers of person per flats were 3, 5, 8 and 10 for 1-bedroom, 2-bedrooms, 3- bedrooms and 4-bedrooms respectively. The computed water demand per flats per year were 129.6 m^3, 219 m^3, 350.4 m^3 and 438 m^3 for 1, 2, 3, and 4-bedroom flats respectively, using water demand of 120 l per capita per day (WHO, 2004) as presented in table 5. The people living in 1-bedroom flat's are mostly non family members and newly married couples, while for 2-bedroom flats are single family members with 2-4 children. The 3-bedroom and 4-bedroom flats are occupied by family members with 2-3 wives and children. The variations in water demand per flats per year was dependent on the size of the family, the water for 2-bedroom is twice that of 4-bedroom. The water demand of 120 l per capita per day was adopted in order to achieve water availability and good hygiene.

Water Yield (harvested rainwater)

The harvested rainwater was calculated using mean annual rainfall, effective roof catchment area and roughness coefficient of the catchment surface as presented in Table 4. The effective roof catchment area of 72.25 m^2, 132 m^2, .222.75 m^2 and 286.75 m^2 was calculated for 1-bedroom, 2-bedroom, and 3-bedroom and 4-bedroom flats respectively. The run off coefficient of 0.85 was adopted and the mean annual rainfall of 693.21mm was obtained from 35 years rainfall data. The harvested rainwater for each bedroom flats were 42.56m^3, 77.75m^3, 131.2m^3 and 168.9m^3 for 1-bedroom, 2-bedroom, 3-bedroom and 4-bedroom flats respectively as presented in Table 4. The mean rainwater harvested for 1-bedroom, 2-bedroom, 3-bedroom and 4-bedroom flats were able to canter for 33%, 36%, 37 and 39% water demand respectively for a household per year. This will reduce the cost spent on vended water during the rainy season.

Table 4: Design Parameters of Rainwater Harvesting System

	1BR	2BR	3BR	4BR	
Water demand (m^3/h/year)		131	219	350	438
Rainwater (m^3/year)	43	78	131	169	
Roof catchment area (m^2)		72	132	22	287
Percentage HRW to WD (%)	33	36	37	39	

Design of Rainwater Facilities

The design of rainwater harvesting facilities was carried out in accordance with BS EN-3 was used to obtained gutter cross-sectional area, gutter diameter, vertical downpipe cross-sectional area, vertical downpipe diameter, horizontal downpipe cross-sectional area, horizontal downpipe diameter and storage tank diameter and height as presented in Table 5. The gutter diameters for 1-bedroom, 2-bedroom, 3-bedroom and 4-bedroom flats are 125 mm, 150 mm, 175 mm and 2000 mm respectively. The vertical downpipe diameters are 100 mm, 125 mm, 150 mm and 175 mm for 1-bedroom, 2-bedroom, 3-bedroom and 4-bedroom flats respectively. While the horizontal downpipe diameters were the same with the gutter diameters for each bedroom flats. The storage tank diameters are 1.75 m, 2.2 m, 2.82 m and 2.99 m for 1-bedroom, 2-bedroom, 3-bedroom and 4-bedroom flats respectively. To ensure good quality of the harvested rainwater, the tanks were air tight, screened and collection of water from the tanks were either through pumping or taps fitted to the tanks. Maintenance of the household roof catchment systems was limited to regular cleaning of the tanks, inspection of the gutters and downpipes, including removal of dirt accumulated on the screen. Cleaning of the roof catchment surface was done by opening the first flush valves to wash the roof and allow the dirty water to flow out during the first major downpour.

Table 5: Rainwater Harvesting System Facilities

	1BR	2BR	3BR	4BR	
Gutter cross sectional area (mm^2)	13 000	23 800	40 100	51 200	
Gutter diameter (mm)	125	150	175	200	
Horizontal downpipe area (mm^2)	13 000	23 800	40 1001	51 200	
Horizontal downpipe diameter (mm)	125	150	175	200	
Vertical downpipe area (mm^2)	6 500	11 900	20 050	25 600	
Vertical downpipe diameter (mm)		100	125	150	175

Storage tank diameter (m)		1.75	2.2	2.82	2.99
Storage tank (m)	1.5	1.7	1.8	2	

Estimated Cost for 1- bedroom Flats

The cost of design facilities for 1-bedroom flat was estimated using present market price, the facilities includes gutter (PVC), PVC pipe, valve, T-joint, Elbow-joint, Stop cock, PVC filter, Storage tank as presented in Table 6. The initial total cost for the rainwater harvesting system was ₦165, 178.00. Harvesting technology seems capital intensive, but operating costs are negligible.

Table 6: Cost Analysis for Rainwater Harvesting System

Material	Quantity	Unit cost	Amount
Gutter (PVC)	4	3200	12 800
PVC pipe	2	2300	4600
Valve	2	250	500
T-joint	2	300	600
Elbow-joint	2	300	600
Stop cock	2	230	460
PVC filter	1		2500
Storage tank	1		105, 000
Labour and misc.			38, 118
Total cost			**165,178**

CONCLUSION

The study revealed that Maiduguri rainfall has seven months raining period with April, May, June and October have less than 50mm in a year. The mean rainwater harvested for one, two, three and four bedroom was able to canter for 33%, 36%, 37 and 39% water demand respectively for a household in a year. The advocacy for its adoption will reduces water-shortage or water related diseases and improve standard of living of the people. Government support by incorporating rainwater harvesting in building code, will help in reducing the cost and create enabling environment for the adoption of the technology.

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