AN INVESTIGATION OF THE USE OF INTERNET OF THINGS TO DEVELOP SUSTAINABLE AGRICULTURE IN KISUMU COUNTY

CHARLES OTIENO OJWANG
School of Informatics and Innovative systems

Jaramogi Oginga Odinga University of Science and Technology.
Email: ojwangcharles@yahoo.com

DR. COLLINS ODUOR ONDIEK
School of Science and Technology, United States International University -Africa
Nairobi Kenya.Email: coduor@usiu.ac.ke

Abstract

The use of Internet Of Things is rapidly developing in various industries and the application of this technology to agricultural sector can significantly reduce the wastages associated with farming, right from land preparation, harvesting and post harvesting management. The aim of the research was to investigate how the farmers in Kisumu County embrace and use the Internet of Things to improve their agricultural practice. The research design applied for this study was mixed method. A total of 150 Farmers in Kisumu County and 10 Field Extension Officers were sampled for this research. The study found out that 65.79% of the farmers are not aware of the smart farming technology and its application in agriculture. Most farmers in Kisumu County use websites and Farm Apps to get information related to agriculture and the percentages stand at 25% and 10.53% respectively. Farmers still have negative attitude towards introduction of technology to their farming practices. Some of the farmers view this as a way to introduce the genetically modifies organism to their farms others view it as a way of displacing them from their jobs in the farms. Interestingly, many farmers have embraced the use of mobile phones to do sales transactions, 19.74% of farmers have used mobile phones to transact.

1.0 Introduction

The human population continues to grow and the demand for food increases each and every day. Land as a resource for growing food is facing unprecedented fragmentation to pivot the increasing population pressure. For this reason, new innovative ways of growing and increasing agricultural produce need to be looked at. Our traditional ways of doing agriculture can no longer feed the ever growing masses.

Internet of Things is a promising new technology that can help the world grow more food to feed it's ever increasing population.By the IoT, objects recognize themselves and obtain intelligence behavior by making or enabling related decisions thinks to the fact that they can communicate information about themselves(www.nxp.com, 2012). This can be applied in agriculture to collect relevant information that can help farmers to efficiently use the available land and optimally increase the yields by specifically cultivating the right crop at the right conditions.

1.1 Background of the Study

Agriculture is an economic backbone to many nations and every contribution towards making it more efficient should be the first priority to any forward looking government. Kenya being one of the rapidly developing nations and given that it is economically dependent on agriculture, requires more efficiency in the agricultural produce and value chain. The application of IoT can significantly increase the efficiency given the need to share important information which the IoT can achieve by use of various sensors.

The use of IoT in agriculture comes with numerous advantages which include; efficient water management, increased productivity, improved Soil management such as PH level and Moisture content. IoT can also increase the crop sales in global market because farmer can easily be connected to the global market without restriction of any geographical area.

The data retrieved by the sensors has to be stored and processed intelligently in order to derive useful inferences from it(Sethi & Smruti , 2017). This useful information in agriculture application could be the need to know what time to apply fertilizer, and what specific deficiency which can likely affect the growth of crop in future is supposed to be addressed. The up-to-date information is the key to address a potential problem with crops and other agricultural produce. In other application areas, Internet connectivity of everyday objects can be used to remotely determine their state so that information systems can collect updated information on physical objects and processes(Friedemann & Floerkemeier, 2010).

Environmental sensors are used to get parameters in the physical environment such as temperature, humidity, pressure, water pollution, and air pollution(Sethi & Smruti , 2017). These parameters are the key to up-to-date information required to alleviate potential problemin agriculture. The agricultural practice that integrate the use of IoT can be crafted a new name “Smart Farming”. "Smart" applications can comprise cars, cities, homes, appliances, tags, building, grid etc(Machado & Kartik, 2014). The power to virtually inhabit two places at once, mediated by Internet-connected mobile devices, has become commonplace to billions of people(Sanders, 2016). When this power is achieved in Kenya, then it means a business professional can still be able to be actively involved in agricultural development while still efficiently working in an office. The increasing number of applications for sensors in everyday life has occurred at the same time as the development of wireless technology standards such as Bluetooth and Near Field Communication (NFC)(Sanders, 2016). These technologies are the once which can be effectively used to exploit the power of virtually inhabiting two places at once.This document will provide guideline and suggestions on how Kenya can benefit from this emerging technology to improve its agricultural output.

1.2 **Problem ofResearch**

Agriculture being the backbone of the Kenyan economy has been lagging behind in the ICT integration. This could be attributed majorly to the players in the industry, majority of which are semi-illiterate and disregard technology or are not aware what the technology can do to improve their value chain process. There is need to create awareness and innovate tools that are attractive to the major players in this field. IoT is well placed to fill this gap and bring agriculture to compete at the level with the leading industries in Kenya. The ability to react to events in the physical world in an automatic, rapid and informed manner not only opens up new ways for dealing with complex or critical situations, but also enables a wide variety of business processes to be optimized(Friedemann & Floerkemeier, 2010). This optimization is what we need to boost our agricultural produce to reach the market at the right time and state.

IoT represents the next evolution of the Internet, taking a huge leap in its ability to gather, analyze, and distribute data that we can turn into information, knowledge, and ultimately wisdom(Machado & Kartik, 2014). The problems which face most agricultural practices e.g. when to apply fertilizer, when to irrigate effectively without wasting water and also not starving crops can be addressed by the actuators and sensors found in IoT. Sensors, actuators, compute servers, and the communication network form the core building blocks of an IoTframework(Sethi & Smruti , 2017).

1.3 **Value of the study**

The result of this study will be a valuable source of information to the government agencies involved in agricultural promotion. Farmers and general public interested in farming will find this document valuable to enhance their knowledge and improve the production and add value to the agricultural produce.

1.4 **Objectives of the study**

a) To investigate the current ICT tools used by farmers.
b) To determine the benefit of IoT in agriculture.
c) To establish the strategies to deploy IoT in agriculture.

2.0 Literature Review

The IoT is a megatrend in cutting edge innovations that can affect the whole business range and can be considered as the interconnection of exceptionally identifiable smart items and gadgets with in today's web framework with expanded advantages(Priyanka, et al., 2017). The concept of IoT was firstly proposed by Kevin Ashton in 1999(Mirza , Qureshi, Habib, & Saleem, 2017). It is viewed as the next big thing that can be employed in virtually every area of field to improve

our way of life. It has the potential to transform everyday life in all sectors of society, including schools(Sanders, 2016). The "Internet of Things" connotes the next step in the evolution of smart objects-interconnected things in which the line between the physical object and digital information about that object is blurred(Sanders, 2016).Sethi& Smruti (2017)defineIoT as a paradigm in which objects equipped with sensors, actuators, and processors communicate with each other to serve a meaningful purpose. Machado & Kartik (2014) futher defines the internet of things (IoT) as a network of objects equipped with radio frequency identification chips and similar technologies so that the objects could communicate and interact with each other. Connectivity over the internet of not only people but also devices (such as sensors, appliances, machines, robots, and vehicles) is leading to a paradigm shift in manufacturing(Kamigaki, 2017). Along with data connectivity, sensor technology can potentially enhance otherwise ordinary objects such that they can automatically gather information to share over data networks(Sanders, 2016).

The World of IoT includes a huge variety of devices that include smart phones, personal computers, PDAs, laptops, tablets, and other hand-held embedded devices(Mirza , Qureshi, Habib, & Saleem, 2017). Smartphone can thus provide displays for physical objects and act as browsers for the Internet of Things – with the added benefit that the phone knows something about the current situation (such as the current location or the user's profile)(Friedemann & Floerkemeier, 2010). In the current IoT vision, sensors give more and more things in our daily lives a "voice"; by capturing data, sensors enable things to become context-aware, providing more experiential information to help people and machines make relevant and valuable decisions(Sanders, 2016). Larger and more visionary application scenarios are increasingly moving into the realm of what is possible(Friedemann & Floerkemeier, 2010).Friedemann& Floerkemeier (2010)argue that the IoT vision is grounded in the belief that the steady advances in microelectronics, communications and information technology we have witnessed in recent years will continue into the foreseeable future. Industry master, for example, Gartner anticipate that by 2020 more than 25 billion gadgets will be associated through IoT(Priyanka, et al., 2017).

Kamigaki (2017)reiterates the fact that radio frequency identification (RFID) is a well-known ICT technology that can automatically identify physical objects and people much like a barcode system. By reacting in time to relevant physical events, companies can optimize their processes, as typically illustrated by the use of RFID in logistics applications(Friedemann & Floerkemeier, 2010).

3.0 Research Design and methodology

3.1 Research design

The research design that is suitable for this research is a mixed method research. Mixed method research is a growing area of methodological choice for many academics and researchers from across a variety of discipline areas(Cameron, 2012). The blending of qualitative and quantitative methods in this study neutralizes the bias that can be intentionally or unintentionally realized on either sideand produces final product which highlights the significant contribution of both approaches.

3.3 Target population

The sample size for this study therefore comprised of150 Farmers in Kisumu County and 10 Field Extension Officers.Table 1.0 shows the sample picked for the purposes of this survey.

Table 1.0 Target population selection

Population	Sample Size
Famers	**150**
Field Officers	**10**
Total	**160**

3.4 Sample size and Sampling procedure.

Sample size is an important consideration in for a researcher. Reasons to accurately calculate the required sample size include achieving both a clinically and statistically significant result and ensuring research resources are used efficiently and ethically(Burmeiste, Elizabeth, Aitken, & Leanne, 2012). In addition to the purpose of the study and population size, three criteria usually will need to be specified to determine the appropriate sample size: the level of precision, the level of

confidence or risk, and the degree of variability in the attributes being measured (Michener. & Miaoulis, 1976). In this particular study 30 % of the registered population was used.

3.5 Research instruments

The data collection instruments included questionnaires, observation and interview scheduled with farmers and extension field officers. The questionnaire items comprised of both close ended and open- ended questions, as well as matrix items that give the advantage of collecting both qualitative and quantitative data, in addition to generating maximum information.

3.6 Validity of the instruments

According to Mugenda&Mugenda (2008), validity answers whether the data collected are accurate enough to reflect the true happenings in a study. For the purposes of this study, pilot study was used to validate research instruments to determine accuracy, clarity and sustainability of the instruments. The analysis of the pilot study results was used to rectify the research instruments with the help of the supervisors to assess the concepts the instruments was to measure in order to determine whether the set of items accurately represents the items under study.

3.7 Reliability of the instruments

Reliability of the instruments was tested based on a correlation coefficient. The estimate of reliability was based on the scores which were correlated using Pearson's product moment co-efficient. If a co-efficient of 0.5 or more was attained, the instruments would be adopted for use in the study otherwise necessary adjustments would be made to research instruments and process repeated until an acceptable co-efficient is attained(Best & Kahn, 2006).

4.0 Research findings and analysis

4.1 The level of sensitization to farmers by the field extension officers on the use of technology.

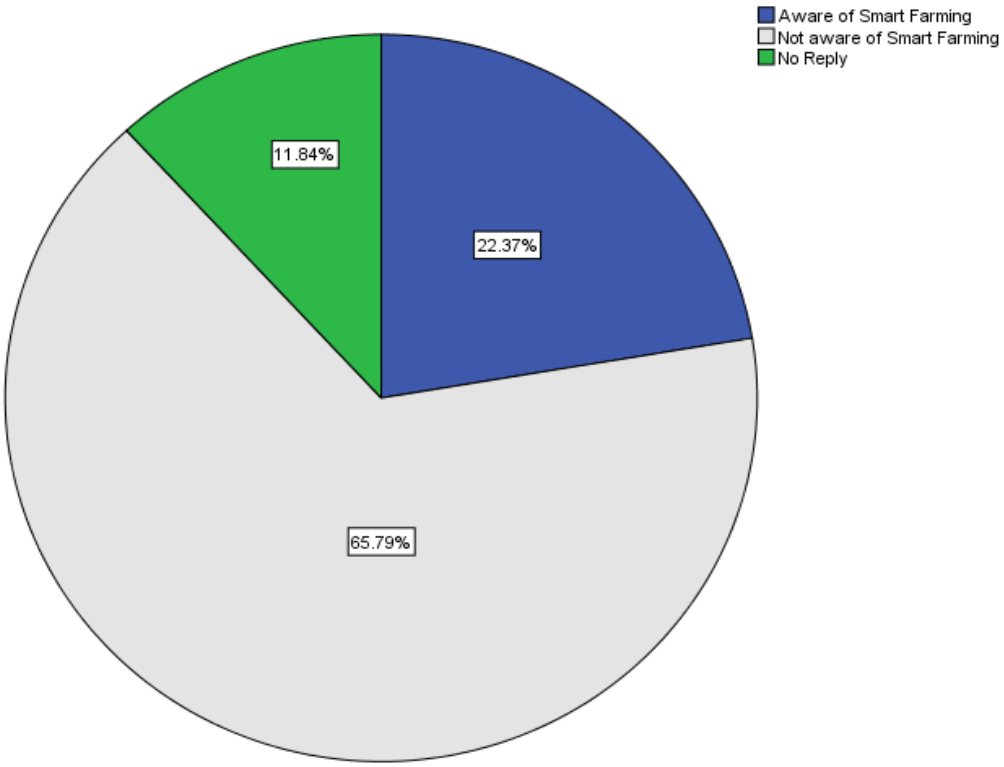

Figure 1: Pie Chart representation of sensitization level.

Only 22.3% of the farmers interviewed have heard of smart farming in their life. The majority of farmers are not aware of the smart farming, the figure 1 is a pie chart representation of the study and it shows that 65.79% of the farmers interviewed are not aware of smart farming.

4.2 The ICT tools employed in the farming currently by farmers and field officers.

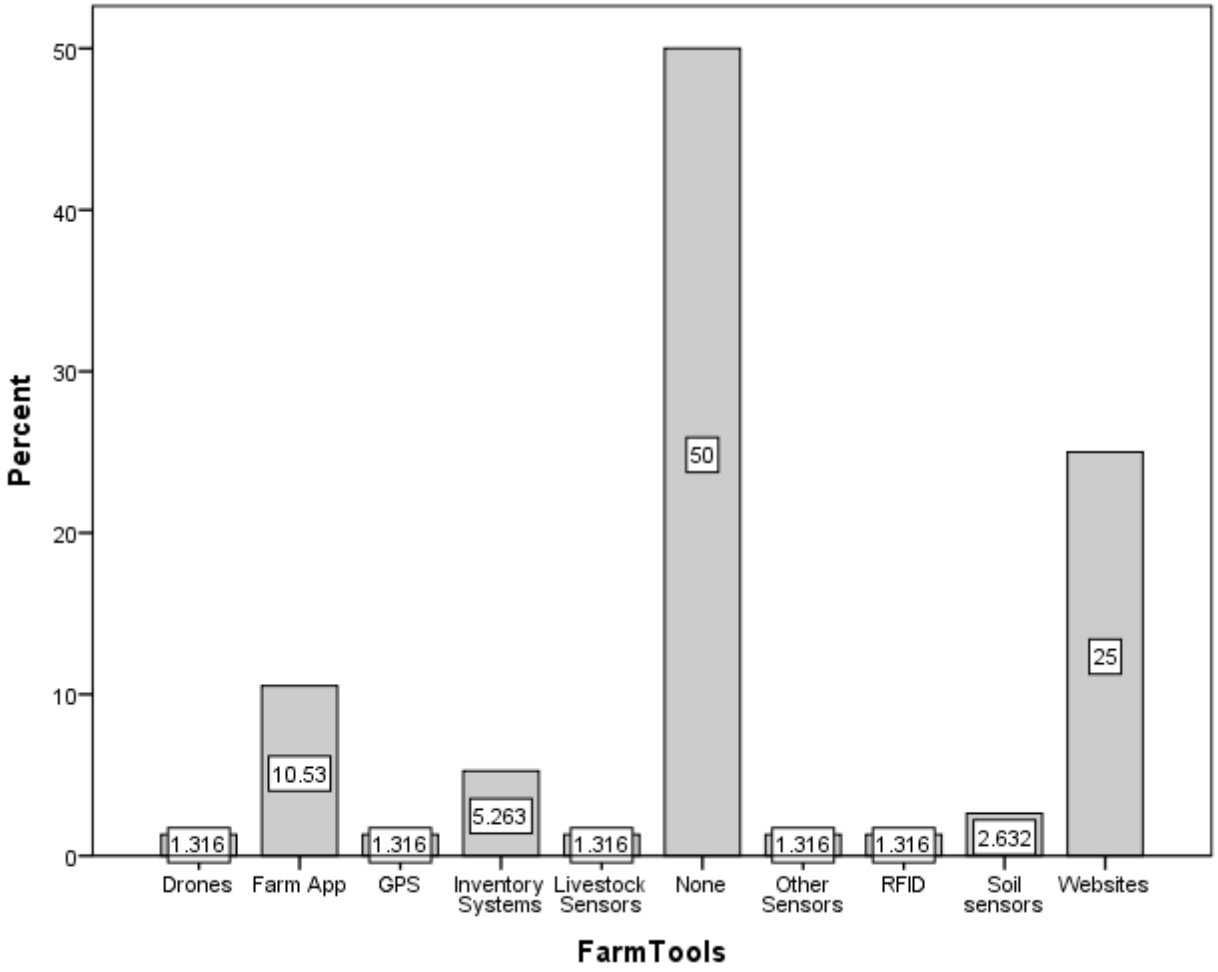

Figure 2:Bar chart representation of tool employed currently by farmers and field officers

From the figure 2 above, farmers who employ the use of technology in their farming would prefer websites and farm application where the tools score 25% and 10.53% respectively. Further investigation revealed that the use of farm app is a new concept and farmers are still acclimatizing with the technology.

4.3 Any real-time feedback application applied in farming today.

The farmers don't' have real time information feed as at now but they use the farm app to give information about the weather and the best time to plant. Thesefarm apps in as much as they are not real time but the information they give the farmers are near real time and farmers can rely on them to make informed decision.

4.4 What the farmers use the IoT for

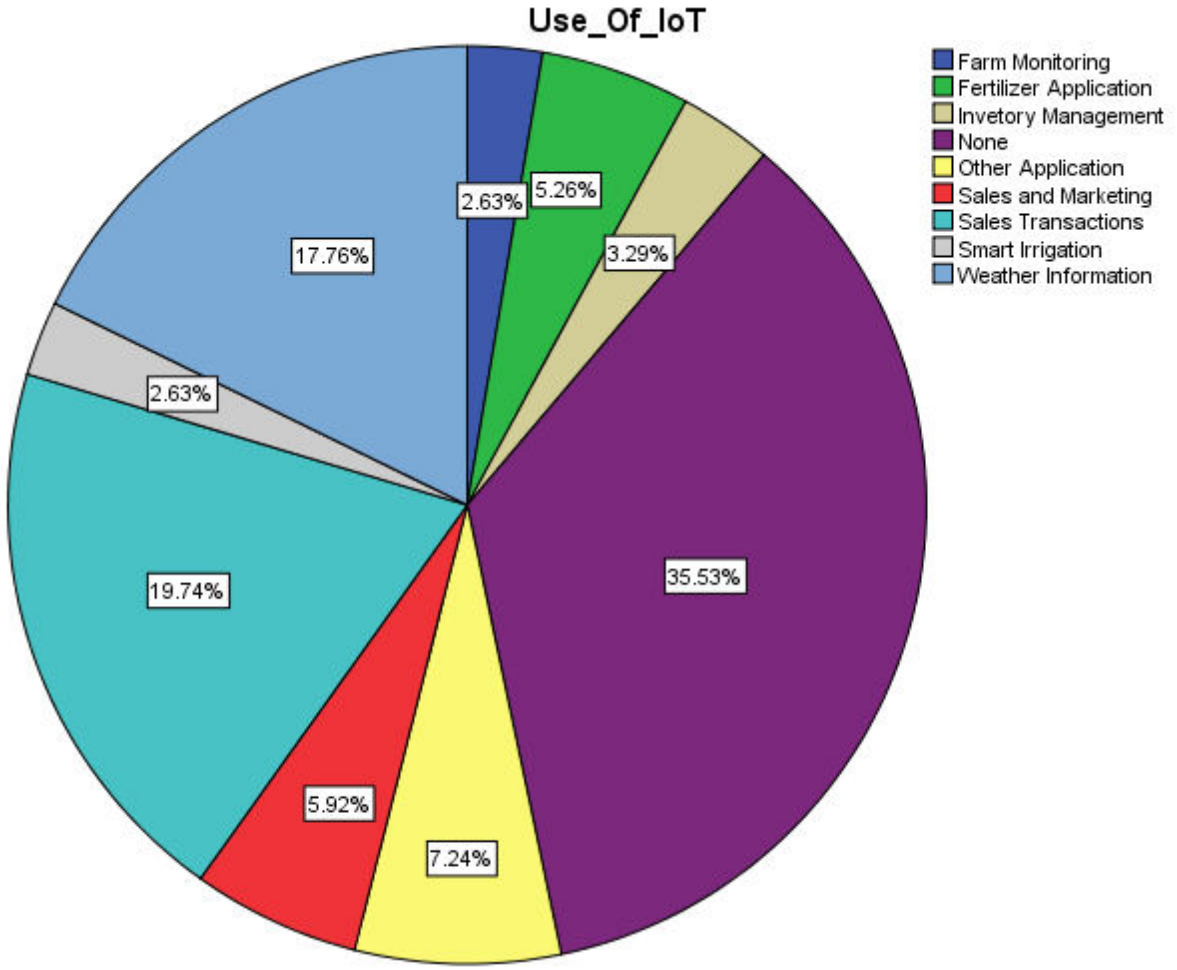

Figure 3. How farmers employ the use of IoT.

Sales transaction and weather information are the major application that the farmers exploit in the ICT in general. Most of the farmers use mobile money platform to do their daily transactions and the M-PESA service offered by Safaricom was the one majorly mentioned by many famers. From the figure 3 above, 19.74% of the farmers use the mobile to do sales transactions.

4.5 How farmers view smart farming.

There is a negative attitude towards introduction of ICT in general among the farmers. Some view this as a way of introducing genetically modified organism, while others view it as a way of displacing them from their job. Only a handful had a positive view towards introduction of ICT to the farming practice. The level of computer illiteracy is high among the farmers in the region and this could be a significant factor that contributes to the low level of technology acceptance.

4.5 How helpful the ICT is general.

Many farmers already using the ICT in one way or the other to manage their farm operation were happy with the use technology to do their day to day work. However majority of the farmers still don't use the technology in any way, so they were not in a position to give their view on the benefit of the technology. From my own observation the farmers still need a lot of training to embrace the use of technology to improve their farming operations.

5.0 Conclusions and Recommendations

5.1 Conclusions

From the study, lack of awareness in the use of smart farming which stands at 65.79% appears to be the greatest obstacle to the penetration of the technology. The farmers still lack real time information feed to assist them in making the right decision regarding when to prepare land and when to apply fertilizer and other farm activities. Farmers in Kisumu County don't use smart irrigation, only 2.63% of the interviewed farmers acknowledge the use of irrigation in their farming.Thisis a very small number given that with the smart irrigation" Water savings of 20-30% through improved water use efficiency in landscape and turf industries could offset the ever-increasing water demand"(Diganta, Adhikari, Zoldoske, & Goora, 2017).

5.2:Recommendations

Use of technology in agriculture is slowly picking up in many countries, Kenya needs to invest heavily on this technology given that its economy depends on agriculture so significantly. Sensitizations about the technology and the incentive to the farmers should be at the top of the agenda for the government. ICT application to agriculture should be taught as a common course at the university to enhance its acceptability and integration into the economy.

Bibliography

[1] (2012). Retrieved January 20, 2018, from www.nxp.com: http://www.nxp.com/assets/documents/data/en/white-papers/INTOTHNGSWP.pdf

[2] Best, J. W., & Kahn, J. (2006). *Research in Education.* New Delhi: Prentice Hall of India Pvt. Ltd.

[3] Burmeiste, Elizabeth, Aitken, & Leanne. (2012). Sample size: How many is enough? *Australian Critical Care* .

[4] Cameron, R. (2012). Mixed Methods Research: The Five Ps Framework. Gladstone, Australia: Central Queensland University,.

[5] Diganta, D., Adhikari, Zoldoske, & Goora, D. (2017). *Monitoring and Control of SMART Irrigation system.* Fresno,California.

[6] Friedemann, M., & Floerkemeier, C. (2010). From the Internet of Computers to Internet of things. *Informatik-Spektrum 33(2)* , 107–121.

[7] Kamigaki, T. (2017, February 8). *Object-Oriented RFID with IoT: A Design Concept of Information Systems in Manufacturing*. Retrieved February 23, 2018, from www.mdpi.com: http://www.mdpi.com/journal/electronics

[8] Machado, H., & Kartik, S. (2014). Internet of Things (IoT) impacts on Supply Chain.

[9] Michener., R. D., & Miaoulis, G. (1976). *An Introduction to Sampling.* Dubuque,Iowa: Kendall/Hunt Publishing Compan.

[10] Mirza , A. R., Qureshi, M. A., Habib, G. S., & Saleem, U. (2017). Security Issues in the Internet of Things (IoT): A Comprehensive Study. *(IJACSA) International Journal of Advanced Computer Science and Applications,Vol. 8, No. 6* .

[11] Mugenda, M. O., & Mugenda, A. (2008). *Research Methods: Qualitative and Quantitative Approaches, African Centre for Technology Studies.* Nairobi, Kenya.

[12] Priyanka, A., Parimala, M., Sudheer, K., Thippareddy, Kaluri, R., Lakshmanna, K., et al. (2017). BIG data based on healthcare analysis using IOT devices. *IOP Conf. Series: Materials Science and Engineering 263.*

[13] Sanders, J. (2016). *IoT*. Retrieved February 23, 2018, from https://www.clarity-innovations.com/: https://www.clarity-innovations.com/publications/iot-education-landscape-review

[14] Sethi, P., & Smruti , R. S. (2017). Internet of Things: Architectures, Protocols, and Applications. *Hindawi Publishing Corporation Journal of Electrical and Computer Engineering Volume 2017* , Article ID 9324035.