# Review of Cloud Computing in Low-Income Countries (LICs): Prospects and Challenges

**Mr. Ugonna Udunwa[1], Ing. Solomon Nsor-Anabiah[2], Prof. Govind R. Kadambi[3] and Dr. Sathish Malathi[4]**

[1,2]*Ph.D. Scholar, Faculty of Engineering and Technology, Ramaiah University of Applied Sciences, Bangalore-560 054, India.*

[3]*Ph.D. Supervisor, Faculty of Engineering and Technology, Ramaiah University of Applied Sciences, Bangalore-560 054, India.*

[4]*Ph.D. Supervisor, Faculty of Engineering and Technology, Ramaiah University of Applied Sciences, Bangalore-560 054, India.*

*Corresponding Author*: Solomon Nsor-Anabiah

## Abstract

**Background:** The term cloud computing refers to the process of receiving computer power including; network speeds, RAM, operating system (OS) and CPU as a service over the internet instead of hosting these computing resources physically within the premises of the company. It is believed that cloud computing has some challenges before, during and after migration but once these inhibitions are removed, the spectrum of benefits is wide. Developing countries are feared to be plagued with all the technological issues and the lack of adequate budget, security and infrastructure further frustrates efforts to adopt cloud computing

**Objective:** The objective of this research is to review the extent of adoption of cloud computing in the Low-Income Countries (LICs) and determine the prospects and challenges involved in its implementation.

**Methods:** To achieve the objective, we conducted a qualitative and systematic review. Sites such as Google Scholar, ITU, most cloud computing sites, Web of Science and Scopus were searched for publications with contents of cloud computing. Selection criteria for articles were based first on global trends in cloud computing, followed by cloud computing in LICs, the prospects and challenges for cloud migration. A well-structured mechanism was applied to extract data and qualitative methods used to analyze them.

**Results:** Searches retrieved over 100 citations which were subjected to rigorous screening to determine the inclusion list. At least a quarter of the records were eliminated as junk URLs and duplicates, leaving 75 articles. Further scrutiny in terms of their titles and abstracts produced 25 directly related to the main topic of research. The cloud computing technology was seen as a major IT breakthrough to provide organizations with cost cutting strategies for running their businesses. The results from the review revealed several benefits of cloud computing but could only be enjoyed when the few challenges are resolved.

**Conclusion:** The study determined that there several benefits involve in migrating to cloud computing and the LICs are finding best ways to adopt. It helps to run businesses more efficiently without worries of physical infrastructure within the premises. Large storage, easy management, backup and recovery operational cost cuts are major benefits, but can be enjoyed when the hindrances are removed.

**Keywords:** Cloud computing, prospects, challenges, Low-Income Countries, models, infrastructure.

## 1.  INTRODUCTION

Cloud computing is a technology that provides IT services in the form of storage and computing power at an offsite location from the organization's premises. The cloud simply means hosting a data center in virtual location instead of administering IT systems locally. It is becoming common for individual persons to use cloud services to store family materials and wealth such as pictures and files. This forms backup for such items when the residence or office is completely burnt fire. Cloud computing in other words means a process of acquiring computer services like operating system (OS), random access memory (RAM), network speed, computer processing unit (CPU) over the internet. In this case, most of the computing resources are not physically located at the offices of the company.
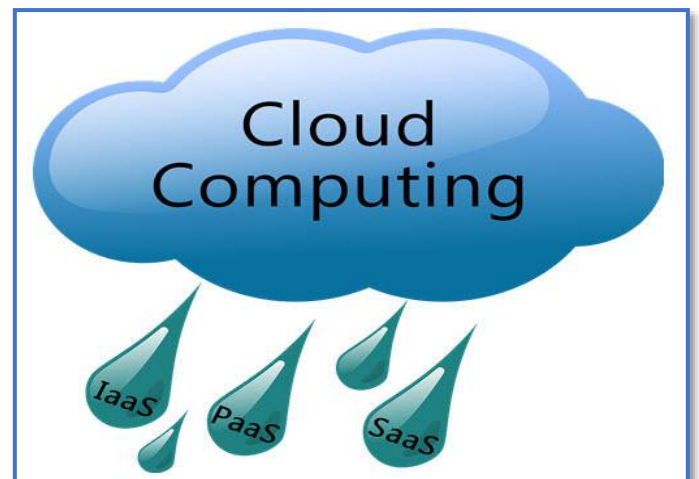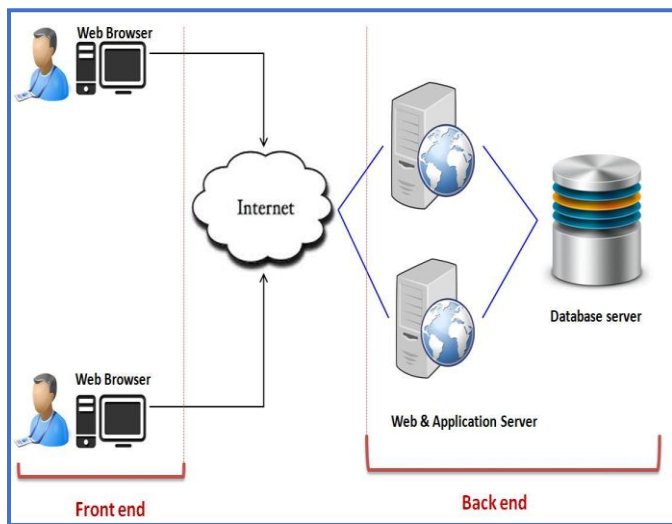


**Figure 1.1: Symbol for the Cloud Computing Technology**

Figure 1.1 shows the symbol used for the cloud computing technology, where the cloud represents storage for the services and rain or water droplets stand for the services such as IaaS, PaaS and SaaS which stand for Infrastructure as a Service, Platform as a Service and Software as a Service respectively.
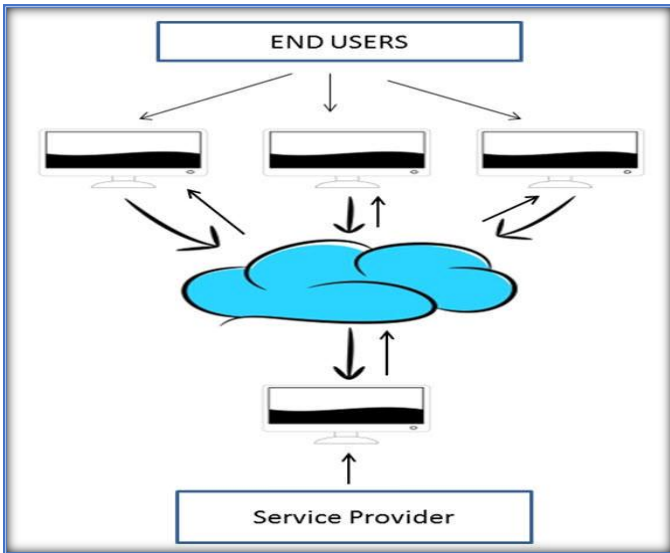
**Figure 1.2: Architecture of the Cloud Computing Technology**

The cloud computing technology architecture is demonstrated in Figure 1.2 in which the service provider is sitting in front the cloud with the users behind the cloud. As mentioned in the last section, the cloud represents the internet, so the cloud service sets up the system in a remote location, reachable only by connectivity through the power of the internet. The end user subscribes to the various services per requirement and via some standard protocols; services are extended to the customer after the signing of a possible contract. One of the most challenging issues is data security which every customer needs to authenticate before accepting to hire online services.



**Figure 1.3: Data Flow Diagram for Cloud Computing Technology**

The cloud computing technology is implemented with two main components, namely the front and back ends. The front end which also represents the client part of the system consists of the applications and interfaces needed to access the cloud platform. On the other hand, the back end which refers to the main cloud comprises of the resources that provide the needed services in the cloud technology. Servers, security

mechanism, virtual machines, data storage are some of the key resources controlled under the system. While back end refers to the cloud itself, it comprises of the resources that are required for cloud computing services. It consists of virtual machines, servers, data storage, security mechanism etc. It is under provider's control. Figure 1.3 identifies the flow of data involved in the cloud computing system with respect to the back end and front end. The database server containing the web and Application servers is situated at the back end and accessed by the front end or user through secured internet connectivity.
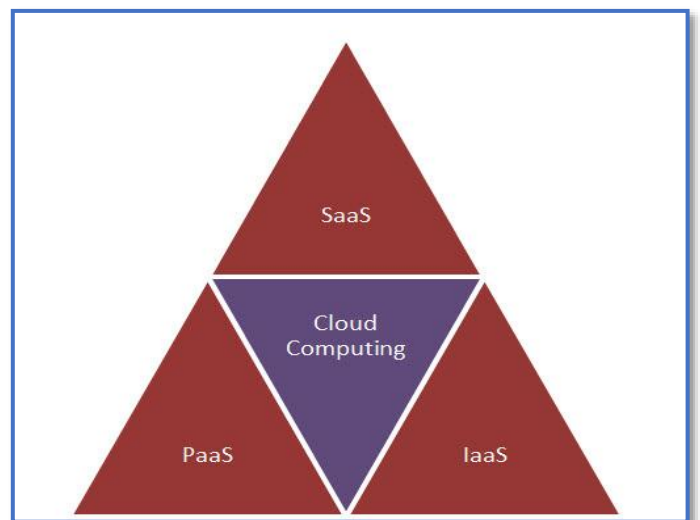
## 1.1  Types of Cloud Computing

The are four models of cloud defined according to the business requirements subcribed for. These are defined as follows:

1.  **Private Cloud:** This is a situation where reources from the cloud are channeled to the needs of a particular company. This category is used for internal business interractions, where the resources can be owned operated and governed by the same company.
2.  **Community Cloud:** Computing resources in this case are released for organizations and communities
3.  **Public Cloud:** This basically is a cloud type usually deployed for business to consumer (B2C) interactions, where the computing resources are mostly owned by the government, business organization or academic institution, it is also operated and governed by the same organization
4.  **Hybrid Cloud:** This cloud type have cloud resources bound together under different systems and can be used by business to business (B2B) and B2C.

There are three main cloud computing delivery services categorized according to the type of service provided. They are:

1. Software as a Service (SaaS)
2. Platform as a Service (PaaS)
3. Infrastructure as a Service (IaaS)



**Figure 1.4: Types of Cloud Computing Services**

Figure 1.4 describes the cloud service delivery triangle, where clouding computing is inside the inner triangle and the delivery services, SaaS, PaaS and IaaS on each edge. SaaS as per the name is a delivery model where a vendor distributes software services over the internet to the customer. SaaS is a pay-as-you-go model and supports basically service-oriented network architecture and web services. With advances in the accessibility in broadband connectivity and increased access to network information, companies such as Salesforce.Com and IBM Lotus Live are increasingly incorporating SaaS to their business operations. PaaS is a development-oriented service which sits directly on IaaS and delivers products such as operating systems and allied services to the subscribers via the internet instead of downloading or directly installing them on individual workstations by the company's staff. This operating environment delivers a variety of applications beyond the scope of the SaaS delivery model. Google's AppEngine, Amazon Web Services and Windows Azure Platform are examples of PaaS. On the other hand, IaaS is a model that provides the entirety of infrastructure enabled stack to deliver computer infrastructure and leverage on technology, data center capacity and services to provide high quality IT services to the customer. For instance, instead of software, IaaS delivers hardware such as CPUs, servers, disk space, memory and network connectivity. Some major players in this field include, Cisco Unified Service Delivery and Flexiscale.

## 1.2 Cloud Security

Security issues concerning cloud computing are very serious and have been a source of worry since the concept came into being. A survey was jointly conducted by Cloud Security Alliance and IEEE in 2010 and the results indicated that cloud computing would only thrive if security standards for cloud computing are urgently injected during implementation. The lack of business continuity was seen as another big hindrance to cloud success and until it is resolved growth would be stunted. The auditability and confidentiality of data was recognized as the third obstacle even though organizations outsource their sensitive operations such as payroll and email to providers outside [1]. In this case organizations, especially the small ones face serious business disruptions during privacy breach or data loss since they are unable to provide legacy systems to mitigate the failure.

Security for the SaaS model resides in the bosom of the vendor due to the high degree of abstraction and integrated functionality which leaves the customer with little control over the system. The business world is not too comfortable with this model due to the inability of customers to easily determine whether their data is securely stored. As such, the risk of losing data as well as privacy breach is very pronounced for organizations deploying the SaaS model. Key security challenges of the model are data locality, data access, data security, data segregation, network security and data integrity. In terms of security, the PaaS model gives greater control and extensibility to the customer but offers reduced high-level features. This means that, the customer has the opportunity build applications over the platform but the

security underlying it is still within the jurisdiction of the cloud service provider. IaaS brings more security to the customer because it has less degree of abstraction compared to the other two, and also due to the fact that the client possesses less control on the organizations IT infrastructure compared to the rest [1].

All the security challenges in the cloud computing landscape are generally influenced by the location of the CSP outside the domain of the organization. The absence of trust assurance and guarantees from the CSP prevents most of the organizations from adopting the phenomenon. The following are key security issues affecting small businesses in the least developed countries. They are:

- Service Availability
- Identity Management
- Data and Application Security
- Privacy
- Negotiation in Service Level Agreement

## 2 TRENDS IN CLOUD COMPUTING

Norah Trent conducted a study into the cloud computing market this year and the results reported as follows. The research was done in two different time periods; the first is referred to as the historic period covered five years, from 2014 to 2018. The second spanned between 2018 and 2022 and called the forecast period, and analysis indicate that the total value of cloud market on the global stage was $325.1 billion 2018. This represents a growth by 10.7% since 2014 at a CAGR, and is projected to further expand to almost $528.4 billion by 2022 at a CAGR of 12.9%. The cloud service market increased during the historic period because of growing preference for cloud network instead of the traditional in-house infrastructure, which observed as strategy to reduce cost of operations. Further, reduced interest rates, increased global internet penetration, advanced technology, favorable government regulations and initiatives and better cyber security environment were responsible for the market expansion within the historic period under discussion [2]. The cloud computing technology according to [3] has great benefits such as; system efficiency, scalability, business agility, does not require huge capital for initial investment, and more importantly provides a lot of cost savings in terms of operations. The author corroborates the position of [2] that the development of fast internet and advances in technology and the development of intelligent software have created an enormous opportunity for anyone to access technology from any corner of the globe with just a click on a button. He further explains that cloud computing is basically the virtualization of software and hardware, and the service architecture associated with it, as well as many more value-added services. As part of the emerging trends in cloud computing technology, most businesses irrespective of their size find the phenomenon as a viable option to increase efficiency and productivity. This is mainly due to its flexibility, easy deployment and cost saving effects, however, cloud infrastructure must be properly complemented with a solid security and backup regime.

Another global cloud computing market survey was performed by Adroit Market Research and reported by Globe Newswire on May 30 2019. The projections according to the report shows that the global market size will grow to a value of $696.25 billion by 2025, recording the fastest CAGR growth over the forecast period compared to that made by [3] for 2022. The study noted that the factors driving this trend are increased operational cost reduction, enhanced agility via automation and advanced customer experience. The report also indicates that the adoption of cloud computing by organizations has the propensity of reducing annual operational cost by as much as 35%, apart from the its functional capabilities which are leveraged by organizations to increase business performance and returns on investments [4]. The global market on cloud computing has been categorized under small, medium and large size organizations, as a result, the applications are also divided into Manufacturing, Healthcare (mHealth), IT & Telecom, Aerospace & Defense, Retail, Government and Utilities and Consumer Electronics. In a different market survey on cloud computing in Southeast Asia, the value of the market is expected to reach $40.32 billion by the end of 2015, which is largely driven by the upsurge of demand for the technology by most emerging small to medium business organization in the region. It is believed that cloud computing technology is the spring board for small businesses in small nations such as Indonesia, Myanmar and Thailand to gain better connectivity to the world stage to enable them competes favorably [5].

The cloud computing technology in West Africa is still very young with a lot of prospects to grow, as the supply side of the equation is dominated by international brands. In the local scene, providers of ICT services are becoming the middlemen for the global players. Operators are however leveraging on their enhanced infrastructure to provide reliability on cloud services thereby increasing the competition among providers. A critical review of the study reveals that while the global market for cloud computing is well developed due to increased need for hybrid cloud, the narrative in West African market is that regulatory policies must be put in place to boost the deployment of cloud services. Key challenges identified for the low adoption include the absence of electricity and business policy to streamline operations [6]. The trending issues in this Region is it is busy developing IaaS while the advanced economies have shifted focus to SaaS. Even though the cloud subscribers are more interested in local service providers because of the familiarity to local data sovereignty, the lag in technology is a major setback to the industry.

## 2.1  Cloud Computing  in Low-Income Countries (LICs)

Cloud computing is the current trend in the IT industry and even though the advanced economies are far reaping the successes in this new concept, the developing economies are finding ways of enjoying such innovations. A study by V.S.Varnika sought to determine the advantages and challenges of cloud computing in low-incomes countries. The results of the study revealed a number of benefits in the implementation of the new technology. The benefits are that, customers get a simplified method for the maintenance of

their infrastructure including software and hardware. They get uninterrupted services from the CSP due to smaller downtimes and a better disaster management regime since there is an offsite backup. Furthermore, greenhouse computing is practiced because harmful emissions from extensive infrastructure with the organizations premises are cut out. Above of all these, cloud computing is the best operational cost reduction strategy for most SMEs [7]. Since drastic cost reduction is one of the benefits for cloud computing, then it is the best IT technology for emerging economies since they do not have large budgets to implement the traditional systems. E-governance is very important for every country if policies are to be communicated to the citizens in a most efficient, effective and fast manner. This can only get better and less expensive through the cloud computing technology where e-government architecture is clearly demonstrated to provide better services at lower economic cost. Hashemi et al [8], in their research, emphasized on the cost benefits of the phenomenon in the developing economies.

Mujinga and Chpangura [1] corroborate the findings of [7] in terms of the benefits gained for using cloud computing but were quick to reveal the challenges of this technology in developing countries. Their view is that small businesses located in these regions have enormous benefits but connectivity is an issue and since cloud computing is about having fast internet connections, it is difficult to operate. However, they are also quick to proffer a solution in the form of broadband access. Cloud security was also discussed in the study and the proposal was that each organization has a unique security issues and must iron it out during engagement. Sam Goundar opens a favorable argument for the developing countries in terms of mobile penetration. The author contends the narrative of mobile in these countries is quite a remarkable success and continues to grow, however, internet seems to have failed and IT requires a better way of helping to run businesses. The paper looked at the use of cloud computing coupled with mobile devices to offer new opportunities for developing nations. Existing mobile applications such m-Banking, m-Health, m-Education and m-Agriculture already exist but needs to harnessed using cost effective strategies such as the cloud [10]. Study determines that network and connectivity in a major setback to the development of cloud computing in the low-income countries. The lack of clear policies of various governments on the extension of network to remote areas and the provision of incentives and subsidies for network operators further erode the benefits.

To further buttress the importance of the cloud computing technology, Raphael Amposah conducted the importance of the concept in Kenya in relation to corrupt practices. He concluded that an Open Data Initiative based on cloud computing has the capacity to halve the corruption rate in the East African nation tagged as one of the most nations in that region within a decade [11]. Other researchers determined the following benefits of cloud computing.  It is Suggests by [12] that the concept is good for e-governance infrastructure, [13] says it helps to resolve inefficiencies in running businesses while [14] finds cloud computing as lowering cost computing power for SMEs. Others are, [15] which conclude that the

technology provides considerable savings for customers just as Mark Stieninger [16] recorded agility, affordability and scalability as the major benefits from study he conducted, while [17] identifies the huge cost benefits of cloud computing but also warn against the infrastructure issues. Finally, a research in reveals that cloud makes business operations in Botswana more flexible [18], and according to [19], there are indeed many benefits but adoption is low in Africa and other developing countries because of the challenges.

## 3    PROSPECTS AND OPPORTUNITIES IN  CLOUD COMPUTING

Available literature and the discussion in the last chapter point to the fact that implementing the cloud computing technology in developing countries has a wide spectrum of benefits including:

1.  Increased storage capacity (greenhouse computing)

2.  Improved performance (uninterrupted services)

3.  Increase data safety

4.  Fewer Maintenance issues (easy management)

5.  Instant software updates

6.  Improved Operating systems compatibility

7.  Backup and recovery (disaster management)

8.  Performance and Scalability

9.  Lower computing power and  IT infrastructure costs for customers (cost reduction)

Other future prospects of using cloud completing are as follows:

- Entrepreneurial Applications
- Government Applications
- Access to IT  infrastructure
- Productivity Gain
- Health Applications (mHealth)

### 3.1  Challenges and Risks in the Implementation  Cloud Computing

The list of risks and challenges provided below directly affect the implementation of cloud computing, especially, in the developing countries of the world. These are caused basically by lack of sufficient budget to provide the basic IT network infrastructure by governments to support small business units.

- Data Security
- Privacy
- Economic Dependence
- Physical location of data
- Internet coverage
- Devices
- Infrastructure
- Lack of right IT skills to adequately manage the technology

## 4.   MATERIALS AND METHODS

To achieve the objective, we conducted a qualitative and systematic review. Sites such as Google Scholar, ITU, most cloud computing sites, Web of Science and Scopus were searched for publications with contents of  cloud computing. Selection criteria for articles were based first on global trends in cloud computing, followed by cloud computing in LICs, the prospects and challenges for cloud migration. A well-structured mechanism was applied to extract data and qualitative methods used to analyze them. Special attention was given to cloud computing studies conducted on SMMEs and LICs so that a direct correlation between cloud migration and cost effectiveness could be established.

## 5.   RESULTS AND DISCUSSIONS

Searches retrieved over 100 citations which were subjected to rigorous screening to determine the inclusion list. At least a quarter of the records were eliminated as junk URLs and duplicates, leaving 75 articles. Further scrutiny in terms of their titles and abstracts produced 25 directly related to the main topic of research. The cloud computing technology was seen as a major IT breakthrough to provide organizations with cost cutting strategies for running their businesses. The results from the review revealed several benefits of cloud computing including reduced operational cost for SMMEs and small initial cost for startups. However, these advantages can only be enjoyed when challenges underpinning cloud migration are resolved. The cloud phenomenon is not widely adopted in the LICs compared to the advanced economies due to lack of adequate ICT infrastructure backbone. Governments in Africa should therefore put ICT in the front burner of issues since this would help most small business to expand so that government can increase.

## 6.   CONCLUSION AND THE WAY FORWARD

The cloud computing technology offers many huge benefits despite some areas of difficulty posed to prospective clients. The fact still remains that small-to-medium scale enterprises across the world are beneficiaries of the concept. The literature reviewed, attest to the advantages of using the cloud computing technology, however, care must be taken to resolve the infrastructural challenges before embarking on this technological journey. Developing countries have a very large number of SMEs in the business sector contributing tremendously to the individual economies to grow the GDP. Governments stand to gain more through corporate and income taxes and therefore must prepare the grounds for easy adoption of clouding computing. Security has been the major bottleneck for cloud computing globally, the narrative is even worse when the subject is Africa or LICs. The inability of customers to control data, services and infrastructure when a cloud model is adopted is a major risk keeping prospective businesses away. The way forward is for CSPs to fully guarantee security, availability of service, performance and scalability, as well as provide a clause for responsibility in case of breaches, during the SLA signing.

## REFERENCES

[1]  Mathias Mujinga and Baldreck Chipangura. "CLOUD COMPUTING CONCERNS IN DEVELOPING ECONOMIES: the 9th Australian Information Security Management Conference, Edith Cowan University, Perth Western Australia, 5th -7th December 2011". http://ro.ecu.edu.au/ism/127. [Online]. (July 26, 2019).

[2]  Norah Trent. "Global Cloud Services Market 2019 Size, Trends, Industry Analysis, Leading Players & Future Forecast by 2022". https://www.wiseguyreports.com/sample-request/3928608-cloud-services-global-market-opportunities-and-strategies-to. [Online]. (July 26, 2019).

[3]  Vikash Kumar. "Cloud Architecture and Cloud Computing Trends in 2019". [Online]. (July 18, 2019).

[4]  Adroit Market Research. "Cloud Computing Market will grow at CAGR of 10.2% to hit $696.25 billion by 2025 - Global Analysis by Trends, Size, Share, Deployment, Product, Organization size, Application and Regions: Adroit Market Research".

     **https://www.adroitmarketresearch.com/contacts/request-sample/855** [Online]. (July 14, 2019).

[5]  Adroit Market Research. "Southeast Asia Cloud Computing Market 2018-2025" https://www.adroitmarketresearch.com/case-studies/challenges-faced-by-worldwide-flight-services-wfs-while-implementing- cloud-computing-services/ [Online]. (July 26, 2019).

[6]  Laura Wood. "The Cloud Market in West Africa, 2018-2019 - Broadband Infrastructure & SaaS Presents Growth Opportunities" https://www.researchandmarkets.com/research/h7zzkk/the_cloud_market?w=4 [Online]. (July 26, 2019).

[7]  V.S. Varnika. "Cloud Computing Advantages and Challenges for Developing Nations". International Journal of Scientific Research in Computer Science and Engineering Vol.6, Issue.3, pp.51-55, June 2018.

[8]  Hashemi et al (2013). "Using Cloud Computing for E-Government: Challenges and Benefits". World Academy of Science, Engineering and Technology International Journal of Computer, Electrical, Automation, Control and Information Engineering Vol: 7, No: 9, [Online]. (July 10, 2019).

[9]  Sam Goundar. "Cloud computing: Opportunities and issues for developing countries". https://www.researchgate.net/publication/265060137 [Online]. (July 26, 2019).

[10] Raphael Amponsah (2015). "Cloud computing: Revolutionizing the African Continent through open data. Using Kenya as a case study". https://www.researchgate.net/publication/277140912 [Online]. (July 26, 2019).

[11] Ban Salman et al. "An Analysis of Cloud Computing Adoption Framework for Iraqi e-Government"/ *(IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 9, No. 8, 2018.*

[12] Colin Ting Si Xue and Felicia Tiong Wee Xin (2017). "BENEFITS AND CHALLENGES OF THE ADOPTION OF CLOUD COMPUTING IN BUSINESS".  [Online]. (July 14, 2019).

[13] Senarathna, Wilkin, Warren, Yeoh and Salzman. "Factors That Influence Adoption of Cloud Computing: An Empirical Study of Australian SMEs". Australasian Journal of Information Systems, Vol 22, ishan.senarathna@deakin.edu.au [Online]. (July 26, 2019).

[14] The National University of Singapore and Microsoft (2017). "A Cloud for Doing Good: A Technology Revolution for All in ASEAN". https://creativecommons.org/licenses/by-nc/4.0/. [Online]. (July 16, 2019).

[15] Omar Al-Hujran, Princess Sumaya (2018) "Challenges of Cloud Computing Adoption from the TOE Framework Perspective". https://www.researchgate.net/publication/325951656 July 2018 DOI: 10.4018/IJEBR.2018070105. [Online]. (July 26, 2019).

[16] Mark Stieninger (2018). "Factors influencing the organizational adoption of cloud computing: a survey among cloud workers". International Journal of Information Systems and Project Management, Vol. 6, No. 1. [Online]. (July 26, 2019).

[17] John Denham-Smith and Pontus Harvidsson (2016). "DRIVERS AND BARRIERS CONCERNING ADOPTION OF CLOUD COMPUTING – FOCUS ON STRATEGIC DECISION MAKING".  [Online]. (July 16, 2019).

[18] Malebogo Khand (2018). "SME Cloud Adoption in Botswana: Its Challenges and Successes". (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 9, No. 1. [Online]. (July 26, 2019).