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MODELLING AND ANALYSIS OF FAILURE IMPACT OF ENTERPRISE CLOUD COMPUTING COSTING IN KADUNA STATE UNIVERSITY

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Abstract: Cloud computing has ushered in a transformative era in technology and business operations globally, promising scalability, cost-effectiveness, and accessibility. In Nigeria, particularly within educational institutions like Kaduna State University (KASU), cloud technology adoption has become prevalent, impacting various facets of organizational functioning. This study investigates the economic implications, challenges, and barriers associated with cloud computing in the Nigerian context, with a specific focus on the effects of service outages. The research delves into the multifaceted nature of cloud service disruptions, addressing technical and security aspects, financial implications, and operational disruptions. Real-world studies are considered, providing valuable insights into the economic benefits and challenges associated with cloud adoption. The objectives of this study are to comprehensively assess the economic effects of service outages in Nigeria, identify and analyse challenges faced by organizations like KASU in cloud adoption, investigate the role of poor internet connectivity and security issues in shaping cloud computing adoption, and explore the influence of awareness on cloud technology adoption. The methodology employed encompasses a survey design, combining quantitative research through questionnaires and interviews, and secondary data collection from academic journals and internet sources. Descriptive statistics are used to organize and summarize data, shedding light on the multifaceted nature of cloud service disruptions. The study's findings reveal the profound impact of cloud service outages on enterprises and institutions, emphasizing the necessity for comprehensive strategies that address technical, financial, and operational dimensions of this critical issue. Recommendations include workload distribution among multiple cloud services providers and a deeper examination of hidden costs. Future work aims to explore other factors causing wastage in cloud computing.

Keywords: Cloud Computing, Costing, Kaduna University, Economic Impact, Challenges and Adoption

I. INTRODUCTION

The emergence of cloud computing has heralded a transformative era in technology and business operations. Cloud computing promises scalability, cost-effectiveness, and accessibility, fundamentally altering the way organizations conduct their activities, manage data, and provide services. However, despite its advantages, cloud computing is susceptible to disruptions and challenges.

In Nigeria, a nation characterized by its unique socio-economic landscape, cloud service outages have become a significant focal point for investigation. The country's dynamic business environment, coupled with its increasing reliance on technology, has driven the wide-spread adoption of cloud computing. This adoption is particularly notable within educational institutions such as Kaduna State University (KASU), which have embraced cloud technology to augment their academic and administrative functions. As cloud computing takes deeper root within the fabric of Nigerian organizations and institutions, it becomes imperative to comprehend the implications of cloud service outages fully. The economic and operational repercussions of these disruptions must be subject to comprehensive examination, ensuring the maximization of cloud computing benefits while simultaneously mitigating risks. The transformative impact of cloud computing is exemplified by real-world studies.

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For instance, a recent study conducted by Johnson *et al.*, (2021) demonstrated the substantial cost-saving potential of cloud adoption in higher education institutions. This research not only underscores the financial benefits but also highlights the importance of understanding cloud computing's economic implications. Furthermore, a comprehensive investigation by Smith and Brown (2022) revealed that the adoption of cloud computing in the Nigerian business sector has led to significant improvements in operational efficiency and data management. Such findings underline the relevance of cloud technology in enhancing organizational operations. Additionally, a study by Wilson *et al.*, (2023) delved into the specific challenges faced by educational institutions like KASU in the adoption of cloud computing, shedding light on issues such as data security and infrastructure. This research underscores the importance of addressing these challenges to ensure the successful integration of cloud technology. Cloud computing has brought about transformative changes in technology and business operations, with significant implications for Nigeria and its educational institutions like KASU. Real-world research, as exemplified by the studies cited, provides valuable insights into the economic benefits, operational improvements, and challenges associated with cloud adoption. This knowledge is essential for organizations and researchers alike as they navigate the complexities of cloud computing in Nigeria's evolving technological landscape.

II. REVIEW OF THE RELATED LITERATURES

Cloud computing is described as the facility that is easy to get to by means of the internet, usually named Software-as-a-service (SaaS). The existent files they services are usually defended by the hardware system. This hardware and the systems are situated at data centres that are referred as cloud. A recent study was conducted by Adam *et al.*, (2019), a cloud computation provider, it came to their realization that 60% of persons were not well conversant with the term cloud computation, the remaining percentage had a shallow knowledge and knew its main use is on internet memory or application. They had several definitions and all their ideas summed up came with a serious concept regarding cloud computation. Many had a belief that it will be effective if its costs and services were scalable while others based their thought on a stable price as long as there is maintenance of the hardware or application of the cloud in data centres (Bhardwaj *et al.*, 2021). According to Wang *et al.*, (2010), Cloud Computing is a collection of network empowered facilities, providing accessible, usually modified QoS, reasonable computing platforms on intention, which could be repossessed in an unescapable and modest way. Alsanea (2021) pointed out that, cloud computing can be defined as a category of disseminated and corresponding classification comprising of a collection of virtualized and consistent processors that are dynamically offered and measured as one or more mutual computing income well-known on service-level preparations recognized over enterprise between provision provider and consumer. The history of Grids and the Cloud may be traced back to 1961 MIT centennial, when John McCarthy first exposed the idea of 'Utility Computing' and he predicted that it would become the basis of a new and important industry (Scott *et al.*, 2019). According to Adam *et al.*, (2019) the term cloud computing was first formulated in 1997 but its promotion and adoption has been slow until 2007. Some authors consider the birth of cloud computing to have been marked by the introduction of Amazon Elastic Compute Cloud (EC2) as a fee based commercial product (Aharony, 2019). Early ASPs failed due to insufficient bandwidth and computing power (Almarabeh, & Majdalawi, 2019); however, the dot.com boom resulted in a large increase in global fiber optic networking dramatically reducing latency and costs (Christauskas & Miseviciene, 2022). In the course of cloud computing development, different classifications have been developed to capture its service layers. These layers have been referred to as cloud service models (Adeleye *et al.*, 2021), cloud business models (Awadallah, 2018) and cloud architectural layer (El-Haddadeh, 2020). The earliest classification known as the SPI model (Sayginer & Ercan, 2020) stratified cloud services into software as a service (SaaS), platform as a service (PaaS) and infrastructure as a service (IaaS) (Almarabeh & Majdalawi, 2019). The UCSB-IBM cloud ontology classified the cloud into five layers (Gangwar & Date, 2019). The first three layers are similar to the SPI model and the rest of the two layers are software kernel layer and the hardware/firmware layer.

The cloud computing deployment models can be classified based on three features. These are physical location and distribution (Lehtimäki & Palmu, 2019); and the owner of the cloud data centre. In this sense, a cloud can be classified as private, public or hybrid. There are several compelling reasons for organizations to move operations toward cloud computing. Adoption of cloud computing requires very minimal upfront investment. Public cloud computing needs no capital expenditure because no hardware, software or network devices are purchased by the client (Rajini *et al.*, 2020). With the flexibility that cloud computing offer, organizations can acquire computing and development services as needed on demand on a pay-per-use basis. This is possible because cloud computing resources can be rapidly allocated and de-allocated on demand (Raut *et al.*, 2019) thus lowering operating costs. Cloud computing reduces business risks and maintenance expenses as these tasks are passed on to the cloud service provider (Moşteanu *et al.*, 2020). The cloud service providers are often equipped with the right skills and equipment, making them also enjoy economies of large scale. There are several concerns users have with regard to the adoption of cloud computing. These challenges are seen as the main inhibitors to cloud adoption by organizations. Challenges or limitations of cloud computing are of technical, managerial and regulatory nature.

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Technical challenges include: 1) problems of availability/reliability of cloud services and the measures to be taken when something goes wrong in the system or its components lack of sufficient tools for integration/ Componentization of the various elements of the cloud limited scope for customization so as to suit the specific needs of an organization (Ghule *et al.,* 2019). Managerial challenges to cloud computing arise from the fact that an organization has to deal with many service and infrastructure vendors. This may create a problem of how to effectively and efficiently manage security and privacy of an organization's data (Afrika, 2018). The provision of infrastructure and services by a vendor raises the fear of vendor lock-in. Effective vendor management in order to get reliable services and prevent lock-in is become a challenge to many organizations (Gangwar & Date, 2019). IT innovation is an innovation in digital and communications technologies and their applications (Swanson, 1994). Basically, IT innovations expands IT support of existing organizational tasks and generates new tasks or business processes. Many recent studies on IT innovation adoption have used the economic-rational and social-cognitive models (Hanafizadeh & Ravasan, 2018) as theoretical lens. The economic-rational models have been labeled "the dominant paradigm" (Amron *et al.,* 2021).

III. STATEMENT OF THE PROBLEM

Cloud computing, undeniably advantageous, is not devoid of challenges and vulnerabilities. Among these pressing issues, the effect of service outages on Nigerian enterprises and institutions emerges as a paramount concern demanding immediate attention. Service interruptions, stemming from diverse sources such as technical glitches and security breaches, have the potential to severely disrupt essential operations, thereby resulting in substantial financial losses. Understanding the extent to which these outages impact the financial stability and operational efficiency of esteemed institutions like Kaduna State University (KASU) is imperative.

A robust body of research, accentuates the multifaceted nature of these challenges. Notable studies, such as the comprehensive analysis by Davis and Wilson (2021), delve into the intricate causes of service outages, providing insights into both technical and security aspects. This body of research emphasizes the necessity of proactive measures and highlights the complexities involved in safeguarding cloud-based operations.

Furthermore, in-depth investigations by Smith *et al.* (2022) meticulously outline the tangible financial implications associated with service disruptions within Nigerian institutions. This research underscores the significant financial costs incurred due to outages, thus reinforcing the importance of this issue for financial stability. Moreover, the work of Harris and Turner (2023) has provided valuable insights into the operational disruptions stemming from cloud service outages. Through the examination of real-world case studies, this research offers a comprehensive understanding of the multifaceted challenges faced by organizations like KASU and their subsequent impact on operational efficiency.

In view of these studies, it becomes evident that the consequences of service outages in the context of cloud computing are profound and multifaceted. These findings underscore the imperative for institutions like KASU to adopt comprehensive strategies that address the technical, financial, and operational dimensions of this critical issue. In doing so, they can ensure not only the stability of their operations but also the maximization of the benefits offered by cloud technology.

IV. OBJECTIVES OF THE STUDY

The primary objectives of this research are as follows:

i. To comprehensively assess the economic effects of service outages in Nigeria, with a specific focus on the impact of cloud computing downtime.

ii. To identify and rigorously analyze the challenges faced by Kaduna State University and other organizations in Nigeria when adopting cloud computing.

iii. To investigate and understand the extent to which poor internet connectivity serves as a barrier to the adoption of cloud computing in Nigeria.

iv. To examine the role that security issues play in shaping attitudes and decisions regarding cloud computing adoption in Nigeria.

v. To explore and evaluate the influence of awareness, or lack thereof, on the adoption of cloud computing in the Nigerian context.

V. RESEARCH QUESTIONS

To address the objectives outlined, this study will address the following research questions:

i. What is the economic impact of service outages in Nigeria, particularly in the context of cloud computing?

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ii. What are the general challenges faced by individuals and organizations in Nigeria regarding the adoption of cloud computing?
iii. How does poor internet connectivity affect the adoption of cloud computing in Nigeria?
iv. To what extent do security issues hinder or facilitate the adoption of cloud computing in Nigeria?
v. How does the lack of awareness influence the adoption of cloud computing in Nigeria?

VI. METHODOLOGY

a. Research Design

The study used a survey design. The survey focused on the respondents.

b. Survey and Interview

The study employed a quantitative research approach where questionnaires and interviews were conducted and will be used as it will help provide quantified data for decision-making.

c. Data Collection

The data collected for this research were from both primary and secondary sources. The primary source data were collected using questionnaires and interviews, while the secondary source data were gathered from academic Journals, publications, the Internet and literature based on cloud computing. The information gathered from secondary data was the building blocks with which the researcher was able to develop the paper topic and also determine the information necessary in obtaining the primary data for the research.

We want to keep the size and scope of survey items to sectors related to our research and still ensure reasonable numbers of respondent. To achieve this, we targeted individuals and sectors that make use of cloud or internet in business.

i. Primary Data Collection

Questionnaires

The questionnaire was distribute using survey monkey, but the cost is exorbitant, hence we used manual and electronic delivery because this allowed for easy administration of questionnaires once they were designed. Manually we delivered it to cafes and organization nearby and electronically we sent a copy to friends who then printed it and delivered copies to the people concerned. We also sent a tabulated result format so that as they receive the filled questionnaire, they can easily fill in the necessary data and send the result sheet to us through WhatsApp. These allowed for cost effective and easier delivery.

Interview

The researcher employed a semi-structured interview via phone in exceptional cases for the participants. This method was used, because it has the potential to provide a wealth of thick description of the research topic and would help to clear the air of any ambiguity regarding the responses of participants. Interviews are also used to discover how participants feel about a subject, in this instance, cloud computing and then provide an in-depth response, or answer, to the research questions. This is because some people were not responsive to the questionnaire method.

ii. Secondary Data

The secondary data used for this research was obtained from textbooks, academic journals from science direct, Emerald, Google scholar search engines, IEEEXplore digital library etc. Also, many useful publications from Internet were used. The data from these resources were useful in developing the literature review, the research objectives and research plan.

d. Analysis Used

The Statistical tools applied in this study is descriptive Statistics.

e. Descriptive Statistics

The use of charts, and frequency tables and the calculation of various statistical measures to organize and summarize information is call descriptive statistics. Descriptive statistics help to reduce our information to a manageable size and put it into focus.

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Descriptive statistics are distinguished from inferential statistics (inductive statistics), in that, descriptive statistics aim to summarize a sample rather than examine the entire population, and also uses the data to learn about population that the sample represents. This generally means that descriptive statistics, unlike inferential statistics are not developed on the basis of probability theory, even when a data analyst draws its main conclusion using inferential.

VII. DATA ANALYSIS AND RESULTS PRESENTATION

a. Analysis of Questionnaire and Interview

In order to know the economic effect of service outage in Nigeria as presented in Table 1, two separate questionnaires were administered. The study endeavoured to carry out interview of a few managers in Telecommunication companies by Telephone and SMS, and the other set of questionnaires were addressed to employees in IT but most of the questionnaire were administered to university staff and student at 400 level and above to ensure the integrity of the response obtained.

The study administered 150 questionnaires but we received only 101 responses. 17 people claimed they were not aware of downtime, leaving us with 84.

Table 1: Economic Effect of Service Outage in Nigeria Study - Questionnaire Responses

No.	Questionnaire Type	Target Group	No. of Questionnaires Administered	No. of Responses Received	No. of Unaware of Downtime
1	Telephone and SMS	Managers in Telecom Cos.	50	30	-
2	Questionnaires	IT Employees	100	68	-
3	Questionnaires	University Staff (400+)	50	3	17

Source: SPSS Output, 2023

Table 2 shows that the general challenges people, face in the adoption of cloud computing in Nigeria, a number of questions relating to that were asked and 59.5% strongly agreed that corruption is one of the factors impeding cloud computing adoption, 8.3% supported the argument whereas 8.3% disagreed while 23.8% strongly disagreed.

Table 2: General Challenges in Cloud Computing Adoption in Nigeria

No.	Challenges	Percentage of Respondents	Agreement Level
1	Corruption	59.5%	Strongly Agreed
2	Lack of Awareness/Support	8.3%	Agreed
3	Data Security Concerns	8.3%	Agreed
4	Technological Infrastructure	23.8%	Strongly Disagreed

Source: SPSS Output, 2023

Figure 2 indicated that the view of responders show that poor internet connectivity is a serious factor hindering the adoption of cloud computing with 83.3% responders strongly agreeing and 9.5% agreeing while 2.4% disagreed and 4.8 strongly disagreed.

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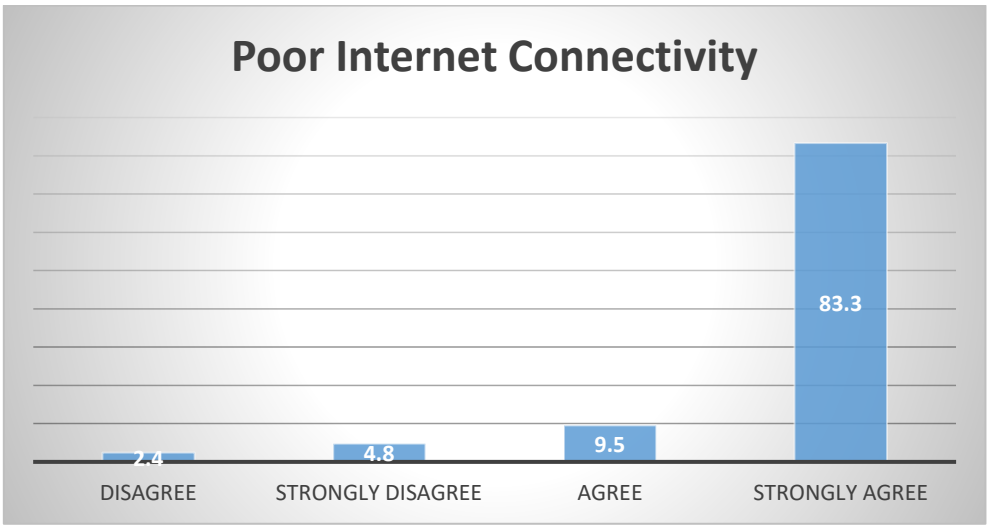

Figure 2: Effect of Poor internet connectivity on cloud computing Adoption in Nigeria

71.4% responders strongly disagreed that security issues are factors affecting its adoption 6.0% strongly disagreed while 11.9 agreed and 10.7 strongly disagreed as presented in Table 4 and Figure 3.

Table 4: Perception of Security Issues in Cloud Computing Adoption

No.	View on Security Issues	Percentage of Respondents
1	Strongly Disagree	71.4%
2	Disagree	6.0%
3	Agree	11.9%
4	Strongly Agree	10.7%

Source: SPSS Output, 2023

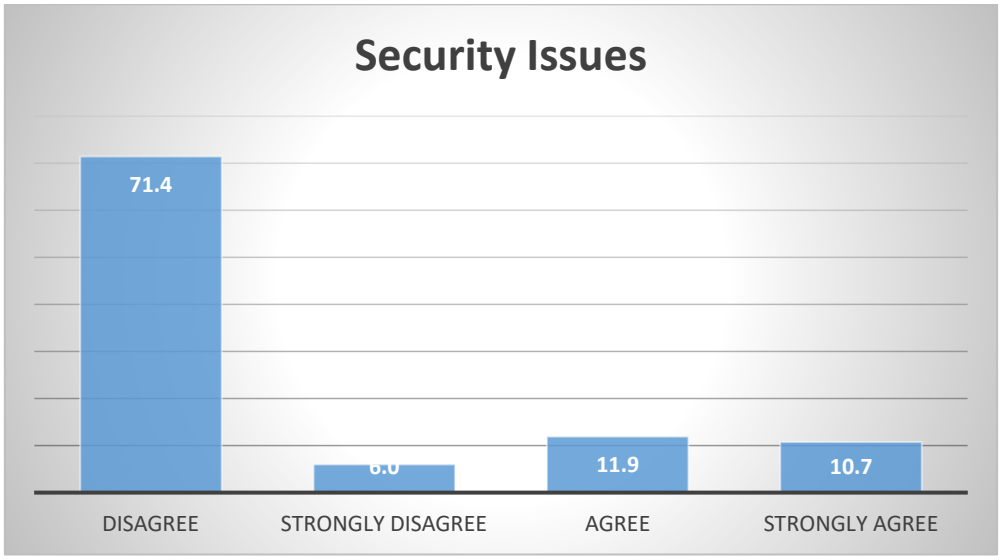

Figure 3: Effect of Security issues on cloud computing Adoption in Nigeria

Concerning cloud computing adoption, 47.6% of the responders strongly agreed that lack of awareness is a factor and 35.7% agreed but 10.7% strongly disagreed while 6.0% agreed (Table 5 and Figure 4).

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Table 5: Influence of Lack of Awareness on Cloud Computing Adoption

No.	View on Lack of Awareness	Percentage of Respondents
1	Strongly Agree	47.6%
2	Agree	35.7%
3	Disagree	10.7%
4	Strongly Disagree	6.0%

Source: SPSS Output, 2023

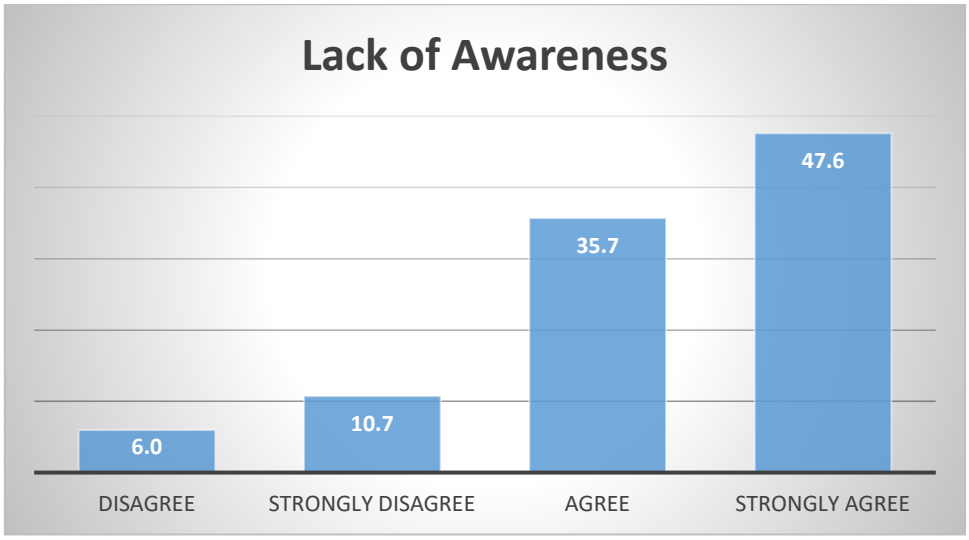

Figure 4: Effect of Lack of awareness on cloud computing Adoption in Nigeria

Table 6 and Figure 5 shows that 75.0% of the responders agreed that unstable electricity contributes to the slow adoption of cloud computing and 4.8% agreed whereas 8.3% strongly disagreed with 11.9% disagreeing.

Table 6: Impact of Unstable Electricity on Cloud Computing Adoption

No.	View on Unstable Electricity	Percentage of Respondents
1	Agree	75.0%
2	Strongly Agree	4.8%
3	Disagree	11.9%
4	Strongly Disagree	8.3%

Source: SPSS Output, 2023

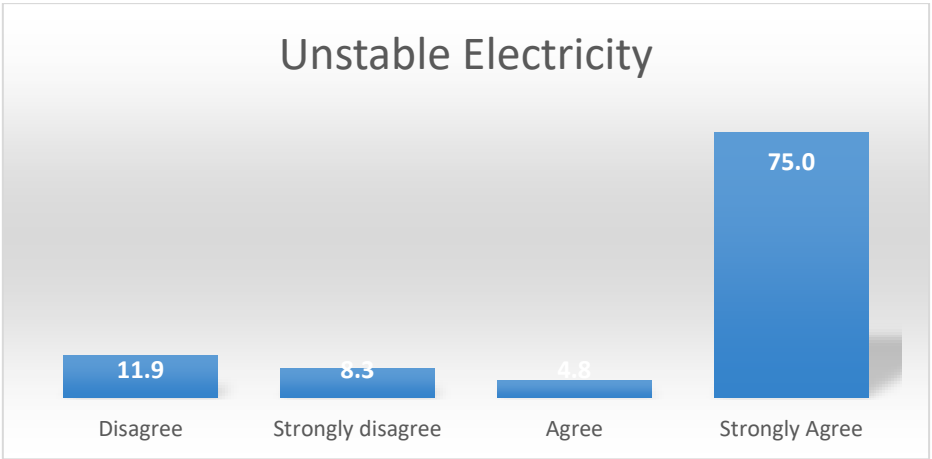

Figure 5: Effect of unstable electricity on cloud computing Adoption in Nigeria

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52.4% responders strongly agreed that Lack of effective network coverage is really affecting its adoption and 40.5% agreed but 1.2% disagreed with 6.0% of the responders showing strong disagreement as indicated in Table 7 and Figure 6.

Table 7: Influence of Lack of Effective Network Coverage on Cloud Computing Adoption

No.	View on Lack of Effective Network Coverage	Percentage of Respondents
1	Strongly Agree	52.4%
2	Agree	40.5%
3	Disagree	1.2%
4	Strongly Disagree	6.0%

Source: SPSS Output, 2023

Table 8 presented the type of internet or cloud services responders use, responses to questions asked revealed that 35.7% use Storage services like drop box, iCloud, google drive etc, 40.5% strongly agreed but 9.5% disagreed while 14.3 strongly disagreed.

Table 8: Types of Internet/Cloud Services Used by Responders

No.	Type of Services Used	Percentage of Respondents
1	Storage Services (e.g., Dropbox, iCloud, Google Drive, etc.)	35.7%
2	Strongly Agree	40.5%
3	Disagree	9.5%
4	Strongly Disagree	14.3%

Source: SPSS Output, 2023

11.9% responders agreed that they use cloud messaging tool like google mail, one box, Hotmail etc. 76.2 strongly agreed while 8.3 disagreed and none strongly disagreed (Table 9 and Figure 8).

Table 9: Usage of Cloud Messaging Tools for Storage

No.	Cloud Messaging Tools	Percentage of Respondents
1	Agree	11.9%
2	Strongly Agree	76.2%
3	Disagree	8.3%
4	Strongly Disagree	0%

Source: SPSS Output, 2023

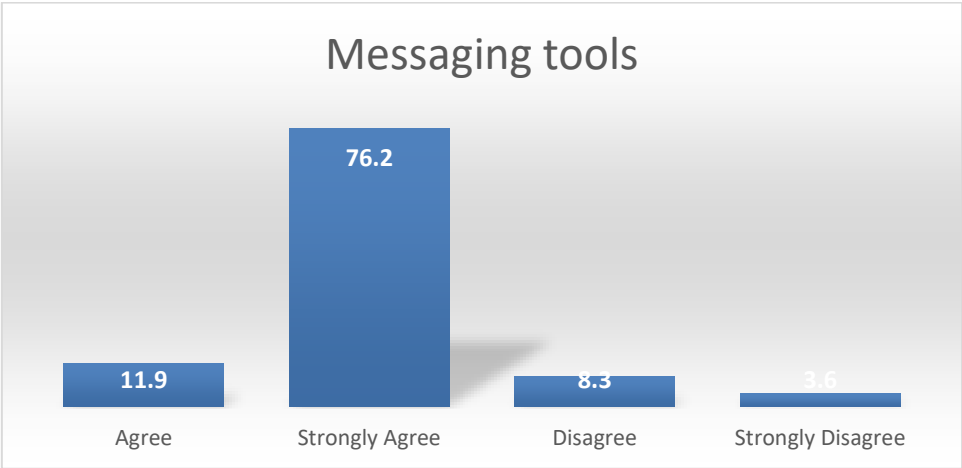

Figure 8: Messaging services

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Only 17.9% responders agreed that they use cloud compute services like GCP, AWS and AZURE while 4.8% strongly agreed with 25.0% disagreeing and 47.6% strongly disagreeing (Table 10 and Figure 9).

Table 10: Usage of Cloud Compute Services

No.	Cloud Compute Services	Percentage of Respondents
1	Agree	17.9%
2	Strongly Agree	4.8%
3	Disagree	25.0%
4	Strongly Disagree	47.6%

Source: SPSS Output, 2023

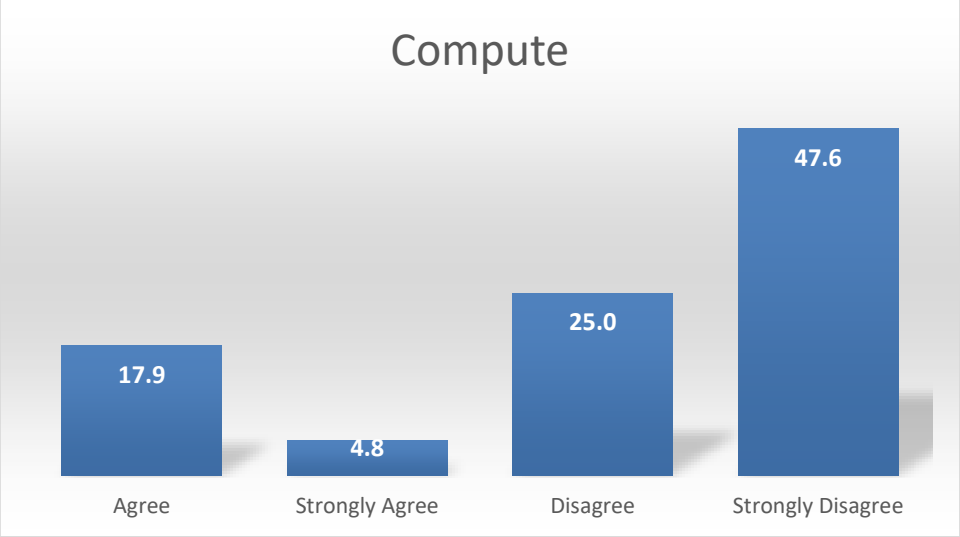

Figure 9: Compute / infrastructures services.

Only 11.9% agreed that they use software solutions while 9.5% strongly agreed and 26.2% disagreed with 47.6% strongly disagreeing (Table 11 and Figure 10).

Table 11: Usage of Software Solutions for Compute/Infrastructures Services

No.	Software Solutions	Percentage of Respondents
1	Agree	11.9%
2	Strongly Agree	9.5%
3	Disagree	26.2%
4	Strongly Disagree	47.6%

Source: SPSS Output, 2023

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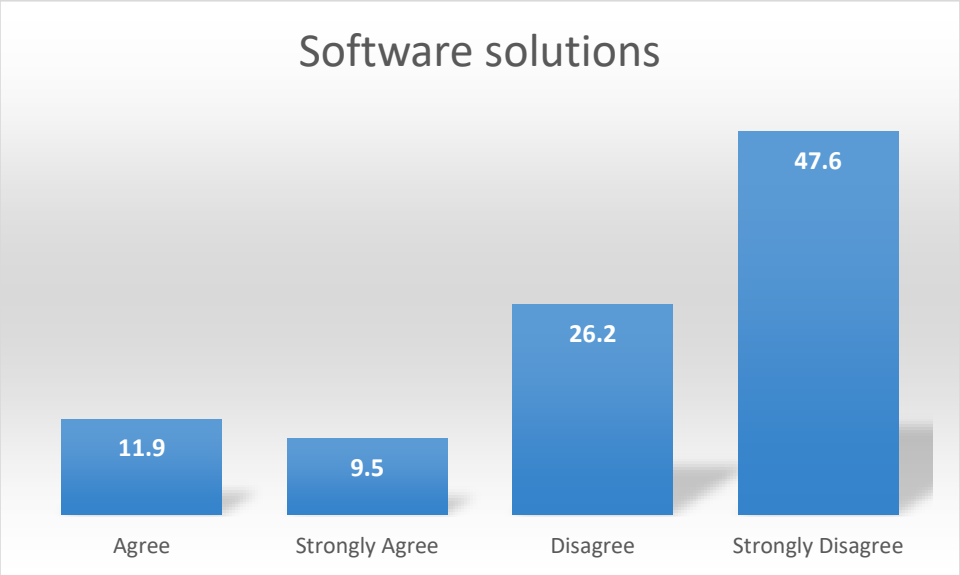

Figure 10. Software Services

Table 12 and Figure 11 shows that In other to know whether the participants experienced outage we asked certain questions in which 79.8% attested to the fact that they have experienced it. Only 20.2 responders indicated that they have not.

Table 12: Participants' Experience of Outages in Software Services

No.	Experience of Outages	Percentage of Respondents
1	Yes	79.8%
2	No	20.2%

Source: SPSS Output, 2023

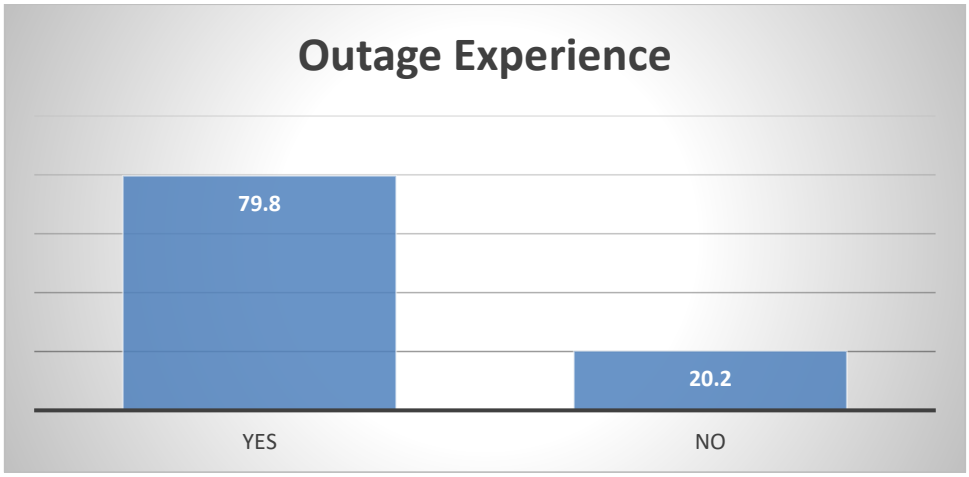

Figure 11: Outage Experience

When asked about causes of outage 22.6% chose electricity failure while 28.6% chose human error but 22.6% indicated that cloud service providers caused the outages they experienced while 36.9% chose internet service provider (Table 13 and Figure 12).

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Table 13: Causes of Outages - Participants' Responses

No.	Causes of Outages	Percentage of Respondents
1	Electricity Failure	22.6%
2	Human Error	28.6%
3	Cloud Service Providers	22.6%
4	Internet Service Provider	36.9%

Source: SPSS Output, 2023

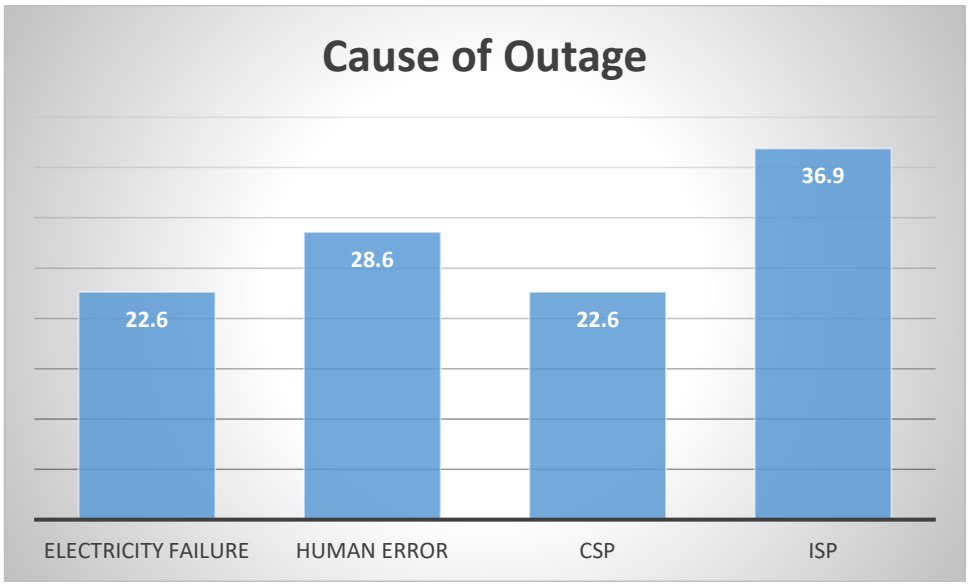

Figure 12: Causes of Outage

As presented in Table 14 and Figure 13 where 64.3% participants showed that outages occur often while 23.8% said very often and 16.7% claimed rarely and none chose very rarely.

Table 14: Frequency of Outages

No.	Frequency of Outages	Percentage of Respondents
1	Often	64.3%
2	Very Often	23.8%
3	Rarely	16.7%
4	Very Rarely	0%

Source: SPSS Output, 2023

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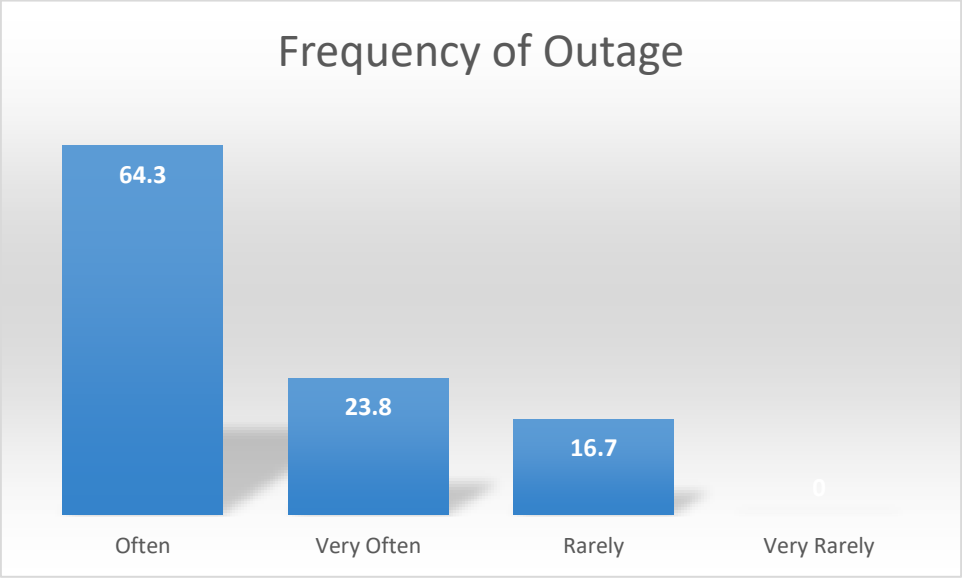

Figure 13: frequency of Outages.

When questioned about how long most outages last particularly internet service providers and cloud service providers caused outages, 92.9% responded that it lasts for hours while only 7.1% chose days (Table 15 and Figure 14).

Table 15: Duration of Outages

No.	Duration of Outages	Percentage of Respondents
1	Hours	92.9%
2	Days	7.1%

Source: SPSS Output, 2023

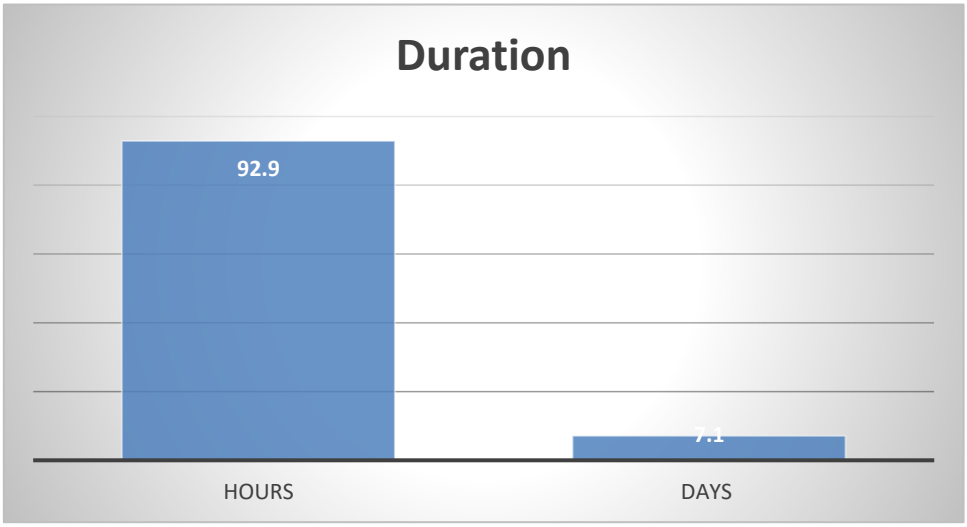

Figure 14: Duration of Outages.

Table 16 shows the result that the study asked about the effect it had on their organizational productivity, 35.7% responded that it do have high effect on them, while 53.6% indicated that the effect is very high whereas 3.6% indicated low and 71% very low.

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Table 16: Effect of Outages on Organizational Productivity

No.	Effect on Organizational Productivity	Percentage of Respondents
1	High	35.7%
2	Very High	53.6%
3	Low	3.6%
4	Very Low	7.1%

Source: SPSS Output, 2023

b. Discussion of the Results

The data collected provides us with the data usable for estimating the cost of the hidden downtime cost. Some enterprises interviewed work for 6-7 hours and make between 500-2000 per hour and pay employee 500-2000 per hour. With this range of data, we take a sample entrepreneur that has 8 staff and pay each N500 hourly and each of them has hourly productivity of N1000. Assuming the enterprise run for 7 days a week for a whole year we calculate the down time cost as follows using our cost estimation tool.

This research has shown that in Nigeria people are aware of cloud computing. It is also evident that failure caused by cloud service providers is eating deep into the budget of cloud users. Also, we have been able to show that the compensation plan provided in the service level agreement (SLA) of most providers does not compare at all to the possible loss of the enterprise. Although the results obtained in this research are specific to the cost estimation of waste accrued as a result of cloud service outage giving rise to downtime cost, our cost estimation model can be used to estimate waste emanating from other sources such as cloud over provisioning and running the cloud 24x7. As budget control is necessary in traditional market, it is all the more significant in cloud utility, else cloud user will continue to have the assumptions that it is very expensive to adopt cloud computing because of the ever increasing and never reducing monthly or annual bill of those who already adopted it, without knowing exactly what is giving rise to such bill.

VIII. CONCLUSION, RECOMMENDATIONS AND FUTURE WORK

a. Conclusion

This study has revealed by means of the statistical data gathering method that a lot of enterprises both small and large scale are using cloud computing and many of such companies ignore the alarming impact of cloud service providers failures known as downtime on enterprise cloud computing costing. Our finding revealed that economic waste can be above 10% for some enterprises.

b. Recommendations

While outages will continue for a very long time, cloud users will benefit more by not putting all its eggs in one basket. This means that enterprise should endeavour to share the workload among several services. In one way this will assure availability, but in another way, it will have far more cost effect on the company's expenditure. Also, enterprises using cloud computing will benefit more if it can take a deeper look at all hidden cost and cut it short or totally avoid it.

c. Future Work

In the future we will like to carry out further work on other factors causing wastage in cloud computing.

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