IMPLEMENTATION ISSUES AND CHALLENGES OF IOT IN SMART CITY IN THE CASE OF KATHMANDU VALLEY

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ABSTRACT

In developing countries, integrating IoT with other business processes is a complicated and challenging task. To improve citizens' quality of life, enhance service delivery, and promote sustainability, smart cities rely on interconnected devices, sensors, and systems. While IoT are being implemented in Smart Cities in Nepal, particularly in the Kathmandu Valley, it will be accompanied by a number of challenges and issues relating to infrastructure, data privacy, and citizen awareness.

The literature suggests that infrastructure challenges, including a lack of reliable power supply and limited broadband connectivity, pose significant barriers to IoT implementation in Smart Cities. These challenges make it difficult to maintain IoT devices and networks and limit the quality and reliability of IoT services. Data privacy is also a significant issue in Nepal, with a lack of regulations to protect citizens' personal information, and a general lack of awareness of data privacy issues among citizens and policymakers. This study highlights the importance of citizen awareness and participation in IoT implementation in Smart Cities. Citizen participation and engagement in decision-making are critical to ensure IoT implementation aligns with their needs and priorities. However, citizen participation is often limited in Nepal, and there is a need to increase citizen awareness and participation to ensure successful IoT implementation.

Keywords: *Internet of Things, Smart City*

1. Introduction

As smart cities implement Internet of Things (IoT) solutions, numerous opportunities arise for making urban environments more efficient, sustainable, and technologically advanced. However, this endeavor is not without its challenges and issues. A rapidly growing metropolitan area of Nepal, the Kathmandu Valley, was chosen to illustrate the implementation challenges and issues of IoT.

As the most densely populated region in Nepal, the Kathmandu Valley faces a plethora of urban challenges, including traffic congestion, waste management, energy supply, and water scarcity. The integration of IoT technology holds immense potential to address these challenges and create a smarter and more livable city. However, the implementation of IoT in the Kathmandu Valley requires a careful examination of the unique issues and hurdles specific to the region.

The deployment of IoT devices relies heavily on a robust and reliable infrastructure. In the case of the Kathmandu Valley, the existing communication infrastructure may pose limitations to the large-scale deployment of IoT devices. A study by emphasizes the need for enhancing communication infrastructure to support the seamless integration and functioning of IoT systems in the valley (Gautam, 2018).

Data security and privacy are concerns raised by the interconnected nature of IoT devices. Increasing connectivity increases cybersecurity risks and the risk of unauthorized access to sensitive information. In the Kathmandu Valley, it is important to make sure that IoT devices and data are protected by robust security measures and privacy policies (Aryal A. N., 2019).

The diversity of IoT devices and protocols can hinder interoperability and integration among different systems. To address this challenge, the establishment of standardized protocols and frameworks is crucial. According to a study, interoperability standards are essential for successful IoT implementations in smart cities, such as Kathmandu Valley (Shrestha S. T., 2020).

Collaboration among government bodies, private organizations, and citizens is essential when implementing IoT in a smart city like Kathmandu Valley. Deploying, using, and maintaining IoT systems requires effective governance models and policies. This paper examines the importance of stakeholder collaboration and governance for the successful implementation of smart city initiatives in Nepal (KC P. S., 2021).

The implementation of IoT in the Kathmandu Valley offers great potential to address urban challenges and create a smarter and more sustainable city. However, it is essential to address the unique implementation issues and challenges specific to the region. In addition to infrastructure limitations, security concerns, privacy concerns, interoperability problems, and stakeholder collaboration problems, stakeholders must also collaborate and govern. It is possible to use the IoT to enhance the quality of life for Kathmandu Valley residents and help other urban areas emulate the Valley if these challenges are addressed.

2. Research Objectives

The objectives of the study are as follows.

1. To analyze challenges associated with smart city implementation in Kathmandu Valley using IoT Devices.
2. To assess current state of infrastructure, IoT Devices, Internet services in Kathmandu valley.
3. To recommend a conceptual framework for IoT implementation that will help achieve effective and efficient implementation.

3. Significance of the Research

Considering the case of Kathmandu Valley, Nepal, this research could contribute to understanding the challenges related to the implementation of IoT in smart cities. The IoT will also be enhanced in smart cities through this enabling technology. IoT has the potential to

enhance efficiency, safety, and sustainability in Kathmandu Valley, Nepal, and this research could provide valuable insights for policymakers, city planners, and others.

Moreover, the results of this research may contribute to smart city implementation globally as well. The research will not only provide valuable resources for cities looking to implement IoT, but also contribute to developing best practices for IoT deployment in smart cities by identifying the main challenges and developing strategies to address them (Sarin, 2016).

IoT implementation in smart cities has the potential to advance knowledge and enhance citizens' quality of life, with this research as an example.

4. Scope of the Research

The purpose of this study is to examine the challenges and issues surrounding the implementation of IoT in smart cities in Kathmandu Valley, Nepal, including the adoption of:

1. As part of our study in Kathmandu Valley, Nepal, we examined the main implementation challenges and concerns related to Internet of Things in smart cities, including a lack of cohesive strategies for integrating IoT technologies into infrastructure and systems, concerns about interoperability, and privacy concerns.
2. The efficiency, safety, and sustainability of the city will be assessed as a result of these challenges.
3. To overcome identified challenges and improve IoT implementation, strategies are being developed in Kathmandu Valley, Nepal.
4. In order to determine the effectiveness of the strategies developed, issues and challenges associated with IoT implementation in Kathmandu Valley are evaluated.

IoT implementation outside Kathmandu Valley, Nepal, will not be covered in this research. The focus will be on smart cities in Kathmandu Valley, Nepal, where IoT is being implemented in smart cities. A technical and operational perspective will be taken toward IoT implementation, with no consideration to social, economic, or political aspects.

5. Limitation of the Research

This research studies can have various limitations that can affect the validity and reliability of their findings. Some common limitations include:

1. Small sample size: If the study has a small sample size, the results may not be representative of the entire population, and the findings may not be reliable.
2. Selection bias: If the study participants are not randomly selected, it can lead to selection bias, where the sample is not representative of the entire population.
3. Measurement bias: An inaccuracy or consistency in the measurement tools or methods may lead to measurement bias.
4. Confounding variables: If the study does not control for other variables that can affect the outcome, it can lead to confounding variables, making it difficult to draw a cause-and-effect relationship.
5. Generalization: If the study findings are based on a specific population or context, it may not generalize to other populations or contexts.
6. Data availability: Data availability can be a challenge in some research studies, particularly in developing countries like Nepal. The lack of data can limit the scope and depth of the study.
7. Infrastructure limitations: Some research studies may require advanced infrastructure or technology, which may not be available or accessible in the Kathmandu Valley or other developing regions.
8. Cultural and language barriers: Language and cultural barriers may exist in some research studies, which can affect the accuracy and validity of the data collected.
9. Ethical considerations: Ethical considerations, such as informed consent and privacy, need to be addressed in research studies. However, there may be challenges in ensuring ethical standards are met in some regions, including the Kathmandu Valley.

6. Literature Review

History and Evolution of Internet of Things

First use of the term Internet of Things was made by Kevin Ashton in 1999. IoT has not been around for that long, even though it was first introduced in the 1970s. In fact, it has existed under several names, such as pervasive computing or embedded internet (Lueth, 2021). A number of smart city transformations have increased the use of the term in recent years. It makes our lives easier and more convenient and gives us a sense of being smart and in control. In daily life, IoT devices provide several benefits (Talari, 2017). IoT devices are becoming more popular due to the features that have made our lives easier. It was initially thought that the IoT concept would be based on embedded systems that combined several devices to make a system that could be processed more quickly. During the summer of 2010, the concept became popular. A part of the Five-Year Plan of the Chinese Government outlined IoT as a strategic priority.

Digital Revolution

Typically, when studying the digital revolution in academic literature, we look at the studies done by previous researchers. There are different niches of the digital revolution that range from specific software to digital platforms or IT-enabled enterprise solutions. Data collected from any case study is used for the literature review on such revolutions, such as surveys, interviews, document reviews, or observations (Chae B. K., 2019). Study trends lately have emphasized innovation types such as digital platforms, research methods, and data sources (Chae B. , 2015). An analysis of computing networks was applied to the study he conducted on big data innovations in the Internet of Things. Digital revolution was a game changer due to IoT, according to this study, which was one of the first to recognize it.

Digital innovation in Smart Cities

Urbanization has taken place in almost every country today, and smart cities can have a significant impact on the transformation of urbanization. The dual idea of sustainability and

holistic development are believed to be represented by smart cities by several researchers. Using technology to transform cities with better services is the idea behind the development idea (Nilssen, 2019). It is indisputable that smart cities enable a citizen-centric approach as opposed to a technology-centric approach. In this way, smart cities focus more on satisfying the basic needs of their citizens and providing better service. Rather than simply adding technology to smart cities, (Joss, 2017) advocate the development of smart cities that are more citizen centered. The analysis can be critical for developing economies like Nepal who are able to change their focus from expensive technology to investing more in people's needs. A city's happiness will matter more than its state-of-the-art infrastructure at the end of the day.

Technology and components of smart cities

Multi-domain IoT applications are used in a smart city. People have developed multiple IoT applications over the last decade, from a basic concept to a complex smart city transformation. There are a wide range of applications for IoT, from smart farming to smart grids to smart health care (Son, 2018). A study of the progress in IoT and smart cities between 2009 and 2017 is examined in this paper. A review of users of existing IoT devices, connected devices in IoT, and communications made in IoT are included in the paper's overview of the IoT and smart city. IoT components and their role in implementing smart cities can be better understood through the paper's review. In order to improve IoT communication, reliable communication medium is necessary. It can be argued that the paper is merely a class review of existing papers without any original research being done.

A number of smart city components are being examined. IoT has been applied to solve day-to-day problems in a place where LPG gas is used in a simple yet reliable way using IoT. A simple application is outlined in (Garg, 2018) to help determine how the gas stove is doing, which is critical in avoiding any unwanted outcomes. Embedded devices and the internet are combined to provide a cost-effective and simple smart solution. It is not state-of-the-art facilities that make a smart city, but innovative technology that can address daily problems. The authors propose a

similar solution in addition to the water tank. In order to reduce the motor's power consumption, it sends a notification to the user about the water level in the tank.

Smart cities, Big Data, and IoT

Data and information generated by IoT devices are growing as their usage increases. In this case, this phenomenon can be described as big data. Managing Big Data requires complex systems that cannot be handled manually (Solanki, 2018). In recent years, the advancements in technology have made smart devices essential for human life. Large amounts of data have been accumulated, and it has been argued that data is private. Big Data is a term used to describe the use of such data by different businesses in order to help them thrive (Solanki, 2018).

IoT and Nepal

IoT implementation in developing countries is of great interest to some researchers. In different developing countries, there have been some studies conducted. These issues are highlighted in the paper by (Tan, 2020). It is particularly challenging to implement smart cities in the Kathmandu Valley. In all metropolises of Nepal, improper waste management is a major issue. (Arjun, 2019) Have proposed to develop four (4) smart cities within the Kathmandu Valley. The waste management system in Kathmandu is inadequate. In the process of implementing Smart Cities, Nepal has to face many challenges.

7. Research Methodology

Mixed methods were used for this research. Qualitative and quantitative research components are combined in this methodology. Comparatively, mixed methods optimize data synergy by combining qualitative and quantitative data. Although this method was originally developed in the social sciences, it has been adapted to other fields of research as well. Recently, this approach has been refined to fit the research needs of all domains by incorporating a number of refinements (Wisdom, 2018). In addition to using qualitative and quantitative methods for data collection, this method was also described by the paper. It has gained rapid popularity among researchers since 1980 to blend both data sets.

The researcher conducted the research using a mixed approach. Case studies from different cities were reviewed as well as papers from previous research. An online survey was conducted as well as interviews with municipal employees. IoT implementation in smart cities faces multiple technical challenges and gaps. In direct responses, researchers and respondents are directly in contact, eliminating non-response problems. Interviewers and interviewees can express themselves freely without being restricted by a structured interview. With such interviews, there is the risk that the research topic may get strayed from. Because the researcher is aware of the situation, he or she made sure that the interview is within the scope of the subject matter.

Data collection for the research was conducted via an online survey form. Consequently, a structured questionnaire was designed using the Microsoft Forms application. In addition to IT department employees, the survey form was distributed to stakeholders of local bodies. Statistics Subscription part 64 bit edition of IBM SPSS was used to analyze the data.

Smart cities adoption was studied using stakeholders from local authorities as part of a survey to determine the issue and challenges involved. The sample was chosen using a non-probability sampling technique, and the participants were selected based on their knowledge and expertise of the subject under study. IoT, smart cities, and Big Data were important issues for the sample population selected for the research. Local government members are working on transforming the city into a smart city. In some places, implementations are already underway, while others plan to initiate the movement in the near future. Smart cities, IoT, big data, connectivity, and 5G are being discussed among the sample population (Timsina A. , 2021).

Online surveys were conducted in some key municipalities outside Kathmandu apart from those within the city. It is believed that Dhukhel Municipality is the first smart municipality in Nepal. It is located in Kavre District in Bagamati Province. It is expected that the researcher will also examine 13 smart cities planned by the Nepal government. A link to Google Forms was provided online, as well as printed forms were distributed offline. Total 400 online and Offline Questionnaires are distributed and response resulted is 311.

8. Data Analysis

A summary of the survey data is presented after the survey has been completed. Data collection method, data cleaning method, and analysis method are all examined. As a result of the SPSS program, tables and graphs are produced presenting the statistical findings. Questions were mapped to the objectives of the study, and vice versa. As a result of the format in which the data were collected, SPSS software was easily able to load the data. This section answers the questions raised by the research question, ensuring research objectives are met.

Reliability Analysis

To ensure that all questions in the survey measure the same variables, reliability testing is performed. A smart city can be created using IoT devices, as demonstrated by this survey. For better service delivery, the survey also considers big data analytics. There should be questions in a survey regarding variables such as smart cities, IoT, and big data. A reliability test determines the quality of a question. George and Mallery established the following rules with states:

In terms of quality, 0.9 is excellent, 0.8 is good, 0.7 is acceptable, 0.6 is questionable, 0.5 is poor, and 0.5 is unacceptable.

SPSS uses Cronbach's alpha reliability as a measure of reliability between 0 and 1. A coefficient value closer to 1 indicates greater internal consistency of the variables. In the table 1, Cronback's alpha test results are shown for the questions used in the survey. A few questions were left out of the survey since they had no significant impact on the results.

Table 1: Reliability statistics

Case Processing Summary

		N	%
Cases	Valid	311	79.9
	Excluded[a]	78	20.1
	Total	389	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.779	32

The Cronbatch alpha coefficient value is .779, which is acceptable.

Regression Analysis

Table 2 Model summary

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.072[a]	.005	.002	.70672

a. Predictors: (Constant), independent1

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.808	1	.808	1.617	.204[b]
	Residual	154.331	309	.499		
	Total	155.138	310			

a. Dependent Variable: dependent1

b. Predictors: (Constant), independent1

9. Evaluation

IoT and big data analytics were investigated in this study as a possible way to improve service delivery in Nepal by leveraging big data analytics. Our study examined how metropolises can

transform into smart cities, as well as what these transformations might mean for challenges and opportunities. A major component of this study was to examine how big data analytics could improve citizen services in cities. This chapter will conclude with a short summary of the findings, possible future research areas, and potential research areas for future studies.

It is not only technology advances that are providing solutions that are driving smart cities and IoT devices. While implementing smart cities, cities face challenges and hindrances. When implementing smart cities and using IoT devices, any smart city might face the following challenges:

- Insufficient knowledge of smart cities
- IoT devices are not well understood
- Infrastructural deficits
- Manpower shortages
- Affecting the economy
- Insecurities
- Using smart devices is not a priority
- Lack of willingness to share personal and health information
- Speed and connectivity of the Internet
- Electricity and Internet are unavailable without interruption
- Insufficient knowledge of big data
- Analyzing big data is not a priority
- Better service delivery and smarter cities are not as important as urban development

During the survey for the research, some of the challenges were found. The implementation of smart cities is difficult due to all of these challenges / factors. Political, economic, and technological challenges are just a few of the challenges.

Respondents in Kathmandu attributed the lack of implementation of smart cities to technical challenges despite Nepal's favorable political situation and public belief that smart cities can be

implemented despite other developmental priorities. Smart cities face a number of challenges, including poor internet connections, slow speeds, interrupted power supplies, and lack of requisite technologies. A complete description of each challenge can be found in the following section.

In the chosen sample population, more Male respondents were present based on statistical analysis than Female respondents. We distributed 400 samples online with survey questions. In Nepal, the majority of people are male and inclined toward ICT fields, which can explain the reason why female are more interested in and aware of smart cities, IoT and Big Data. Despite this, men are still interested in ICT, although they are inclined towards banking and administrative roles. There were respondents between the ages of 20 and 60. IoT and related devices are widely known to people of all ages, so age has little influence on the results. Responses from the 20-30 age bracket accounted for the largest proportion of responses, which is not surprising since this is the population that is most active and aware.

According to the results, people in low income countries like Nepal still do not understand the concept of Smart Cities as they still consider urban development as a benchmark of development. Less than a third of the population is aware of IoT and IoT-related devices at present. Some people may not be familiar with how to use smart phones, which may explain this result.

Big data's impact on smart cities and the delivery of services is not well known by the general public. There are several reasons for this, the most obvious being its technical nature. The ICT and its products will not appeal to everyone. It appears that only a quarter of people understand Big Data. According to (Arjun, 2019), Kathmandu Metropolitan has a poorly mangeed waste management system, one example of people lacking understanding of smart cities.

Smart cities and IoT devices rely on a reliable and high-speed internet. A continuous supply of electricity will ensure that smart devices are operational and will collect data for future use. From the survey it was found that 50% of respondents had poor or average internet connections based

on the statistical findings. Fewer than one third of survey respondents thought their internet connection was fast while one third were satisfied with their connection.

Over half of the population still relies on mobile data to access the Internet. Trying to implement smart city concepts under these circumstances is a concerning scenario for the administration. There is a major technical challenge with implementing smart cities in Nepal because of the limited and expensive 4G Mobile network. When it comes to internet service in Nepal, it is one of the most expensive, making it difficult to implement smart city concepts.

The technology and interconnected devices that make up a smart city will be abundant. Smart cities can only be implemented effectively if the city is technologically equipped. A major objective of this study is to determine whether the people and authorities of the city believe in the technology available to them. Almost half of those surveyed believe that technology cannot assist in creating smart cities. From the graph, we can see that one-fifth of the respondents are neutral to the question, which means that they are neither in agreement nor in disagreement.

Citizens' input should always be taken into consideration by the administration. Among respondents, the city was rated as the most important city. It appears that people prefer urban development and smart service delivery to smart cities according to the findings. In contrast to technological development, people believe the development of roads, bridges, and other physical infrastructure is crucial. Since most people are not familiar with computers and technology, they prefer traditional approaches to service delivery.

Nepal announced the implementation of smart cities after the 2018 elections. Using state-of-the-art technologies is a great way to make people's lives easier and change for the better. Is our economy ready, however? Also, this question was addressed by the survey. Most respondents believed that implementing smart cities would be economically feasible, which was a quite surprising result. Despite the current economy, people strongly believe smart cities are possible. According to the findings, the concept of smart cities, IoT, and big data appears to mismatch

expectations of people. Studying how smart cities can succeed when citizens are unaware of technology can be an interesting topic for someone to research.

10. Conclusion

During the implementation of the smart city concept, any city may encounter technical, economic, political, and social challenges. Technology is at the core of smart cities, and this is important to remember. An implementation and success of the smart city concept require a city to be technically prepared. Approximately 50% of respondents never heard of the concept based on the survey data analysis. There is still a massive reluctance among a large percentage of the population in utilizing smart devices in their everyday lives. Consequently, the city authorities will have a hard time delivering the output. Any smart services in the city must be made known to the citizens. This is why e-literacy has been proposed by the researcher as an implementable variable for cities. People can successfully implement the concept as long as they understand the technical aspects.

Based on the survey, the technological infrastructure for smart city implementation is still insufficient. These infrastructures appear to be insufficient to build a smart city based on the survey results. The Internet of Things will create a sprawling jungle of interconnected devices, according to some definitions of smart cities. In order to accomplish this, a high-speed internet connection will be required without any interruptions in service. Due to the lack of availability of these components in Nepal, the government should prioritize them when purchasing devices.

One of the newest concepts in ICT, big data, is still unknown to many people in Nepal. A survey shows that three-quarters of respondents do not know what Big Data is and believe it is a new term. Research is needed to improve the quality of data collected from big data. City authorities should use big data analytics to improve their services. Big data can play a pivotal role in successful transformation into a smart city, according to respondents to the survey. However, the output of the concept cannot have a significant impact on the research output regardless of

whether it has been tested in Nepal. Nepal could benefit from further research and exploration into Big Data Analytics, according to the researcher.

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