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A NEW ERA FOR SMART CITIES AND SERVICES DEVELOPMENT WITH IOT TECHNOLOGIES IN UZBEKISTAN

©Askarova F., Tashkent State University of Economics,
Tashkent, Uzbekistan, askarovaferuza07@gmail.com

НОВАЯ ЭРА РАЗВИТИЯ УМНЫХ ГОРОДОВ И УСЛУГ С ИСПОЛЬЗОВАНИЕМ ТЕХНОЛОГИЙ ИНТЕРНЕТА ВЕЩЕЙ В УЗБЕКИСТАНЕ

©Аскарова Ф., Ташкентский государственный экономический университет,
г. Ташкент, Узбекистан; askarovaferuza07@gmail.com

Abstract. With the gradual shift in population patterns from rural to urban areas, cities in developing countries are increasingly struggling to provide effective services to residents. To meet the needs of an ever-growing population and address environmental challenges, governments around the world are investing in the Internet of Things (IoT) and other advanced information technologies to create their own "smart city" models. This study aims to explore the key challenges Uzbekistan faces in implementing IoT solutions into its smart city model. A snowball sampling method was used to collect data. Forty-eight respondents participated in the study. Data processing utilized graphical presentation and descriptive statistics to accurately convey detailed information. Data were described using measures of central tendency (specifically, mean and mode), standard deviation, frequencies, and percentages.

Аннотация. В связи с постепенным изменением парадигмы проживания населения из сельской местности в города, городам развивающихся стран становится все труднее предоставлять эффективные услуги жителям. Для удовлетворения потребностей постоянно растущего населения и решения экологических проблем, правительства по всему миру инвестируют в Интернет вещей (IoT) и другие передовые информационные технологии для создания собственных моделей «умных городов». Исследование направлено на изучение основных проблем, с которыми сталкивается Узбекистан при внедрении решений IoT в свою модель «умного города». Для сбора данных в качестве стратегии выборки использовался метод «снежного кома». В исследовании приняли участие 48 респондентов. Для обработки данных применялись графическое представление и описательная статистика для точного отображения подробной информации. Данные были описаны с использованием центрального тренда (в частности, среднего значения и моды), стандартного отклонения, частот и процентов.

Keywords: Internet of Things (IoT), smart cities, environmental issues, sustainable development.

Ключевые слова: интернет вещей (IoT), умные города, экологические проблемы, устойчивое развитие.

With the world becoming more urbanized, many challenges have occurred ranging from traffic congestion to environmental pollution and resource depletion [1].

In addition to this, with a gradual shift in the residence paradigm of population from rural to urban areas, it has become also difficult for cities to provide efficient services to growing population in developing countries [2].

Thus, by 2050, the number of people living in cities is estimated to account 70 per cent of the global population [3, 6].

However, the environmental infrastructure of cities including transportation, waste management and others are not designed for such large population increases and large waves of migration [7].

To meet the needs of an ever-increasing population and solve environmental concerns, as one way to solve these emerging issues, government across the world are investing in the Internet of Things (IoT) and other advanced information technologies to build their own model of smart cities. A smart city is a concept used to describe an urban area that offer a better living conditions and services for residents while assuring perseverance of the environment and resources for present and future generation [9].

However, in the development of such smart cities, IoT is playing an increasingly important role and can be successfully implemented in various smart city domains. Smart cities transportation with integration of the Internet of Things (IoT) enhances efficiency, safety and cost management in city transit systems. IoT can address crucial urban challenges including traffic congestions, pollution and others. Besides, IoT can provide real-time tracking, predictive maintenance and dynamic route optimization, ultimately reducing fuel consumption. One of good example of effective use of IoT application in smart cities is the deployment of intelligent traffic sensors to mitigate rush hour congestion. Such sensors allow to reduce even wait times by evaluating traffic in real time. This accordingly helps cities to improve their overall traffic management [8].

Moreover, the installation of connected sensors around the city helps not only to collect data about air quality and noise pollution but also to collect data about the availability of parking spaces to help drivers to find a parking space more quickly, consequently helping to reduce overall congestion [3].

Various IoT equipped smart solutions such as sensors can promote energy conservation by optimizing energy utilization and reducing wastage. For instances, IoT sensors can be deployed in buildings and streetlights promoting energy saving practices [4].

In addition to this, waste management is one of the main challenges in cities and towns worldwide. IoT offers smart bins with sensors that send alerts when full, ultimately optimizing waste collection routes. Moreover, with interactive mobile apps linked to smart bins the governments can educate residents on proper waste disposal [9].

IoT devices can help to monitor air quality and traffic patterns in real time. Accordingly, such technologies use in cities can ultimately lead to efficient and effective environmental solutions and help cities to achieve a more sustainable way of living, reducing pollution and utilizing cleaner energy sources [2].

One of the most prevalent ways of helping the environment with saving energy. For instance, IoT powered devices today are being practiced in automatically devices on or off depending on the situation or are programmed to ensure that energy is being efficiently used automatically. In addition to this, IoT devices can be deployed in farms to make harvesting and watering processes more efficient and friendlier towards the environment [10].

Besides, since regular practices of factories have a significant impact in the environment, some of their processes could be optimized with IoT solutions. Such practices could help the pollution level to be significantly reduced. Although the rapid adoption of IoT based smart city implementation is often used aiming to address the challenges faced by the city's urbanization, it also comes with its

own challenges. One of the major challenges of implementing IoT and smart city projects in developing countries is related with the lack of adequate and reliable infrastructure including the internet, roads, buildings and electricity. This is the case with Uzbekistan as well. In the country, urban city development system is found not to respond to the parameters of the smart city [11].

Internet access in Uzbekistan leaves much to be desired. Among other neighboring countries Uzbekistan has still the lowest Internet speed. In 2020, Uzbekistan ranked 181st amount 207 countries. Despite, recent developments of the country, Uzbekistan inconsistently maintain its traffic infrastructure and fail to keep up with the mobility of a growing population. Although main roads in the city of Tashkent are relatively well maintained, many of its secondary roads inside and out of the city are in poor condition [13].

However, a growing population in the country is requiring the government to offer more services for maintaining a better living. To meet this growing need and its sustainability goals, Uzbekistan is making its first steps to introduce its smart city model by entailing some information and communication technologies into various areas of life [5].

Today, the country is working on some pilot projects including 1) smart transport where the focus is being given on improving traffic condition and increase the mobility services; 2) smart education implied the deployment of innovative technologies with the purpose of improving the level of education and people's literacy across the country; 3) smart grid is one of the system being practiced by the country to maintain sustainable, efficient and reliable energy system; 4) smart water supply and sewage is introduced to optimize water intake and disposal; 5) smart buildings is promoted to improve quality of living of residents. Despite, IoT integration offers significant benefits and is often used to tackle the environmental concerns and challenges faced by the urbanization, it also comes with its own challenges such as establishing effective communication networks, difficulty related with integrating these heterogeneous digital devices and others. Keeping this in mind it should be said that, Uzbekistan needs to take various factors in developing smart city concept. The main purpose of this research is to conduct a comprehensive insight into identifying the main challenges faced by Uzbekistan while deploying IoT solutions into its smart city model development. In addition to this, benefits for Uzbekistan from IoT based smart city development will be also studied. Understanding the key challenges faced by the government in introducing its IoT based smart city can help the top management or policymakers do proper planning, designing and controlling services necessary for the support of smart cities.

The following research questions attempt to find a feasible answer in the end of the research:

What are the major challenges in IoT based smart city adoption in Uzbekistan?

What are the main benefits for Uzbekistan from IoT based smart city development?

What strategies can help Uzbekistan to promote its smart city concept with IoT technology integration?

The present study conducted to identify the main challenges faced by Uzbekistan in its adoption of IoT based smart city is a quantitative in nature. To collect a quantitative data, as a sampling strategy a snowball technique was used. This method was effective in collecting data from respondents who were not indifferent towards IoT based smart city development in the country. Overall reached out respondents' number in the study was 48. For data processing, graphical display and descriptive statistics were applied to depict a detailed information in accurate format. Data in this study were described using central trend (specifically mean and mode), standard deviation, frequencies, and percentages. In study conducted to identify the main challenges faced by Uzbekistan in developing its IoT based smart city overall at about 48 respondents provided their answers. In the research the percentage of female participants accounted for 66,6 per cent at the time when responses collected from male respondents estimated 33,3 percent. In the study as it can be seen from the provided Table

1, most of respondents were at the age category of from 36 to 45 at 58,3 per cent. Besides, in the study the percentage of respondents with bachelor’s degree level of education was higher (64, 5 percent) than those who had Master’s degree (31,2 percent). Only 4,2 percent of respondents had PhD level of education.

Table 1

PROFILE OF RESEARCH RESPONDENTS

Gender		
male	16	33,3%
female	32	66,6%
Age		
From 25 to 35	7	14,6%
From 36 to 45	28	58,3%
From 46 to 55	9	18,7%
Above 55	4	10,4%
Education		
Bechelor	31	64,5%
Master	15	31,2%
Phd	2	4,2%

In the study conducted to analyse the challenges encountered by Uzbekistan in its adoption of IoT based smart city, various areas were discussed. For instance, it was found that in transportation sector, when deploying IoT solutions the country is challenged by various regulatory frameworks that are not prepared for such new technologies integration (mean: 4,00; S.td: 0,00). Respondents also strongly agreed with the fact that for smart city development the road’s condition create a main challenge (mean: 3,90, S.td: 0,30). Another challenges that impend the country from smart city concept development were found to be a lack of investment and public acceptance. In education sector, the main challenge for the government to deploy IoT as a part of “Smart education” was found to be existing limited access of students to new technologies in rural areas (mean: 4,00; S.td: 0,00), not enough investment and infrastructure (mean: 3,90; S.td: 0,30) and low level of necessary skills and specialists understanding such technology integration into this sector (mean: 4,00; S.td: 0,00).

In energy, waster and waste management sector, the government is challenged by difficulty of integration of IoT technology on existing platform (mean: 4,00; S.td: 0,00). Another issue was related with skills gap as well. There are very lack of specialists and workforce having a good understanding on how to put such technologies into practice in the country (mean: 4,00; S.td: 0,00). In addition to this, it was found that at a time when the government is planning to save energy, IoT systems themselves are found to consume energy. Besides above, the study also found the challenge associated with integration of IoT solutions into the environment is related with high cost, skills gap and workforce development.

Table 2

CHALLENGES RELATED WITH IOT BASED SMART CITY DEVELOPMENT IN UZBEKISTAN

	Mean	Mode	S.td	Level of opinions
Transportation				
Regulatory frameworks are not prepared for new technologiesintegration	4,00	4,00	0,00	Strongly Agree
Public acceptance	2,59	3,00	0,51	Agree
Roads in poor condition	3,90	4,00	0,30	Strongly Agree

	<i>Mean</i>	<i>Mode</i>	<i>S.td</i>	<i>Level of opinions</i>
Investment is not enough	2,55	3,00	0,48	Agree
Education				
No access to these technologies in education setting in rural areas of the country	4,00	4,00	0,00	Strongly Agree
Not enough investment and infrastructure is provided by the government	3,90	4,00	0,30	Strongly Agree
Low level of necessary skills and specialists	4,00	4,00	0,00	Strongly Agree
Energy, waste, water management				
Difficulty related with integration of IoT technology on existing platform	4,00	4,00	0,00	Strongly Agree
Skills gap and workforce development	4,00	4,00	0,00	Strongly Agree
IoT systems themselves consume energy	3,12	4,00	0,33	Strongly Agree
Environment				
Not enough investment and infrastructure	2,59	3,00	0,51	Agree
The initial cost of IoT implementation can be high	4,00	4,00	0,00	Strongly Agree
Skills gap and workforce development	3,90	4,00	0,30	Strongly Agree

Strongly disagree: 1,00-1,74; / Strongly disagree: 1,75-2,49 / Agree: 2,50-3,24 / Strongly agree: 3,25-4,00.

However, despite existing challenges, if the country would be able to successfully implement IoT technologies into various sectors as a part of its smart city development plan Uzbekistan can get a number of benefits from such practice.

IoT role in smart transport system creation is immerse. Respondents strongly agree with the fact that with IoT solution integration into transportation system Uzbekistan can reduce traffic congestion (mean: 4,00; S.td: 0,00), level of pollution (mean: 3,90; S.td: 0,30), optimize transportation system and can be able to introduce some new innovative solutions which could help the country to improve the quality of living for residents (mean: 4,00; S.td: 0,00).

IoT solutions deployment into educational sector can bring Uzbekistan improved school management efficiency (mean: 2,59; S.td: 0,51), real time data collection (mean: 4,00; S.td: 0,00), improved level of digital skills of students and teachers (mean: 4,00; S.td: 0,00).

In addition to this, IoT technologies' successful implementation in energy, waste and water management is believed to help the country to streamline its resources and achieve resource efficiency (mean: 4,00; S.td: 0,00).

Table 3
 BENEFITS FOR UZBEKISTAN FROM IOT BASED SMART CITY DEVELOPMENT

	<i>Mean</i>	<i>Mode</i>	<i>S.td</i>	<i>Level of opinions</i>
Transportation				
Optimized transportation system	4,00	4,00	0,00	Strongly Agree
Reduced traffic congestion	3,90	4,00	0,30	Strongly Agree
Reduced level of pollution (Improved air quality)	4,00	4,00	0,00	Strongly Agree
Introduction of innovative services such as mart parking	3,77	4,00	0,42	Strongly Agree
Education				
Improved school management efficiency	2,59	3,00	0,51	Agree
Real-time data collection	4,00	4,00	0,00	Strongly Agree
Address safety concerns	2,55	3,00	0,48	Agree
Improved level of digital skills	4,00	4,00	0,00	Strongly Agree

	Mean	Mode	S.td	Level of opinions
Streamlined education	4,00	4,00	0,00	Strongly Agree
Energy, waste, water management				
Streamlined waste, energy and water management	3,77	4,00	0,42	Strongly Agree
Energy and other resources efficiency	4,00	4,00	0,00	Strongly Agree
Environment				
Air , water quality monitoring	3,90	4,00	0,30	Strongly Agree
IoT in environment helps in saving endangered species	2,59	3,00	0,51	Agree
Resource efficiency is achieved	4,00	4,00	0,00	Strongly Agree

Strongly disagree: 1,00-1,74; / Strongly disagree: 1,75-2,49 / Agree: 2,50 – 3,24 / Strongly agree: 3,25-4,00.

The main challenges encountered by Uzbekistan in its adoption of IoT-based smart cities vary depending on the sector. For instance, it was found that in the transportation sector, the country is challenged by regulatory frameworks that are not prepared for the integration of such new technologies, roads that are not ready for smart transport integration, and a lack of investment and public acceptance. In the education sector, the main challenge for the government to deploy IoT as part of “Smart Education” was found to be the limited access of students to new technologies in rural areas, insufficient investment and infrastructure, and a low level of necessary skills among specialists regarding the integration of such technology into this sector. In the energy and waste management sectors, the government is challenged by the difficulty of integrating IoT technology into existing platforms, as well as a skills gap. In the country, very few specialists and workforce members have a good understanding of how to put such technologies into practice [12, 14].

On the other hand, despite existing challenges, the country is believed to receive a number of benefits from successfully implementing IoT technologies into various sectors as a part of its smart city development plan. For instance, with the integration of IoT solutions into the transportation system, Uzbekistan is believed to be able to reduce traffic congestion and pollution levels, and optimize the transportation system. Moreover, the country will be able to introduce new innovative solutions which could help improve the quality of life for residents. Besides, the deployment of IoT solutions into the educational sector can bring Uzbekistan improved school management efficiency, real-time data collection, and an improved level of digital skills for students and teachers. In addition to this, the successful implementation of IoT technologies in energy, waste, and water management is believed to help the country streamline its resources and achieve resource efficiency.

Conclusion

Like many other developing countries, Uzbekistan is challenged by various environmental concerns, including climate change, air pollution, and traffic congestion. Additionally, the country faces a growing population and a trend of rural-to-urban migration. To meet the increasing demands of the population and provide high-quality services and better living conditions for residents, the government of Uzbekistan is investing in smart technologies, such as the Internet of Things (IoT), to build its own smart city model. This model comprises projects such as "smart transport," "smart education," and "smart energy, water supply, and sewage." However, despite these initiatives, several challenges must be addressed when developing a smart city strategy. The study found that in the transportation sector, the country is hindered by regulatory frameworks that are not prepared for the integration of new technologies, inadequate road infrastructure, a lack of investment, and limited public acceptance. In the education sector, the main obstacles to deploying IoT as part of "smart education" are limited access to technology for students in rural areas, insufficient investment and

infrastructure, and a shortage of specialists with the necessary skills to integrate such technology. In the energy and waste management sectors, the government struggles with the difficulty of integrating IoT into existing platforms, as well as a significant skills gap. There are currently very few specialists and workers who understand how to put these technologies into practice. To successfully implement IoT solutions within the smart city project, the country must overcome these challenges.

Despite all limitations being eliminated, the present city has some shortcomings which need to be taken into account in the future research for more in depth research of the issue. In the study, only the viewpoint of people who are not indifferent for IoT based solutions to be promoted in the country were considered due to some time-restrictions. The views of experts who have a long working experience in transportation, energy, education and other sectors need to be taken for more comprehensive research on IoT solution integration into these sectors.

There are many factors that affect on implementation of IoT and its deployment into smart city building. However, by having a good understanding on such existing factors that create a challenge for IoT implementation in smart cities, management in the government who are in charge of such smart city building projects could be able to better design, direct and control services in smart cities. Moreover, policymakers could also create a favourable environment necessary for IoT based smart city adoption by introducing frameworks supporting new technologies' integration.

It is important to come up with practical plan for the country so that successfully implement IoT solutions into its smart city development. As a first thing to do, the government should have a clear strategy and concrete goals towards a smart city building. The government in this process can encourage cities, communities, industries and other interested parties to make their contribution in smart city development with integration of IoT. Moreover, it is critical for the policymakers to propose a new regulation framework, legislations creating a favourable environment for IoT based smart city adoption.

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