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A Systematic Literature Review on IoT-based Irrigation

Nazma Tara
Department of Computer Science
National University, Bangladesh

Khondakar Shahid Hyder
Department of Computer Science
National University, Bangladesh

Selina Sharmin
Department of Computer Science and Engineering
Jagannath University, Bangladesh

ABSTRACT

The Internet of Things (IoT) has become one of the most demanding technologies throughout the world in recent times. At present the main technology behind the concept of smart home, smart vehicle, smart agriculture, etc. is the efficient use of IoT which is a ubiquitous technology of interconnected things capable of sensing, actuating, and communicating among themselves and with the environment. In traditional agriculture, a farmer has to depend only on human skills and experiences for production as there is no specific and arranged way to gather data from the field. However, this type of manual process does not ensure higher productivity and efficiency, and it is needed to modernize the agricultural system to increase production. IoT assists us to determine the appropriate necessity by analyzing the dynamic condition of the soil, weather, and plant, with a time reduction of manual monitoring. Though the practice of IoT-based irrigation and smart farming is at its inception, the world is rapidly moving towards the perfect implementation of smart farming. In this study, 56 papers are reviewed from 2015 to 2021, where IoT-based irrigation is the main concern. The objective is to abstract and accumulate the works regarding IoT-based irrigation. Based on the work, the issues regarding IoT-based irrigation, sensors, related technologies, wireless communication protocols, IoT platforms, and cloud computing will be analyzed to get a clear view and understand its future scope.

Keywords

IoT, IoT in Irrigation, Smart Irrigation, Wireless Sensor Network, IoT Sensor, smart Agriculture, IoT platform, AgIoT

1. INTRODUCTION

Effective use of land and water in agriculture is the key challenge of improving food security throughout the world. Population pressure, climate change, and the increasing demand for land and water are skyrocketing the vulnerabilities to food security. As the population increases, the amount of cultivable land does not grow by scale. According to worldometers.info, the current world population is 7.9 billion as of October 2021 and will be 10 billion in 2057 as projected. At present, around 11% of the globe's land surface is used in crop production [1]. Therefore, the concept of precision agriculture has come into reality and in this concept, IoT-based smart irrigation plays a pivotal role in making the agricultural sector more productive and sustainable.

Bangladesh is a country where agriculture is one of the most dominant sectors which is responsible for creating the largest portion of jobs (41 percent) [2]. According to the estimate (provisional) of Bangladesh Bureau of Statistics (BBS), in the fiscal year 2020-2021, 13.47 percent of contributions were made by agriculture to the GDP [3].

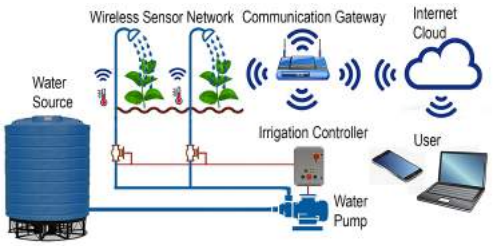

Fig. 1. IoT-based irrigation system

Irrigation is a process where a controlled amount of water is applied artificially through pipes, drains, etc. It is required to assist the growth of a plant, maintain the landscape, and mitigate the effect of insufficient rainfall, etc. Earlier irrigation was performed manually which was not adequate for ensuring higher productivity. Later, machine-based irrigation was introduced which seemed to be enough for a while. Finally, the smart irrigation method came into reality where IoT and other smart technologies were added with the traditional machine-based irrigation so that the irrigation process may be performed in a smarter way.

In Fig. 1, a generic IoT-based irrigation system is depicted. In this system, a wireless sensor network (WSN) is deployed to connect all sensors in the field so that all data may be fed through the communication gateway. The gateway is capable to access the Internet which will be used for sending data to subscribed web services on the cloud. Based on the data, decisions are made and transmitted back to the communication gateway, and then forwarded to a controller for irrigation. Moreover, farmers have the authority to access all data and manipulate the control as per requirement.

The main objective of this paper is to accumulate all the details related to applications of IoT-based irrigation. This includes the details related to data collection, various types of sensors,

deployment details, IoT platforms to access the data through the cloud. It also covers details related to different communication technologies used in IoT. Hence, some works (56 papers) during 2015-2021 regarding IoT-based irrigation are reviewed.

The rest of the paper is organized as follows: In Section II, concepts have been discussed regarding IoT, agricultural and related technologies and issues. In Section III, research methodology is presented. After that, analysis part is included in Section IV. In Section V, the discussion based on the research is provided. Finally, in Section V, the work is concluded.

2. CONCEPTS

In this section, the description of some commonly known terminologies used in IoT-based irrigation are given along with a brief overview of agricultural IoT.

2.1 Internet of Things (IoT)

IoT The term "Internet of Things" (IoT) is a term first coined by Kevin Ashton, back in 1999 [4]. It creates opportunities for more direct integration of the physical world into computer-based systems, resulting in efficiency improvements, economic benefits, and reduced human exertions. Some of the advantages of IoT are Cost Reduction, Efficiency and Productivity, Business Opportunities, Easy and Remote Access, Speedy at Work and Saves time, Multitasking, Minimize Human Effort, and Improve Security.

2.2 IoT in agriculture

AgIoT (IoT in agriculture) AgroIoT or AgIoT [4] refers to the use of sensors, cameras, and other devices to turn every element and action involved in farming into data. Some of the usages of AgIoT are Soil Monitoring, Weather and Climate Monitoring, Livestock Monitoring, Crop Health Monitoring, Greenhouse Monitoring, Leaf Disease Detection, etc.

2.3 IoT policy in Bangladesh

IoT policy in Bangladesh to ensure the use of IoT, the Government of Bangladesh has taken several initiatives as follows [5]:

—Create a 1 billion USD IoT Industry in Bangladesh by 2023.

—Establish a national IoT research and development center by 2023 to develop IoT products specific to local needs.

—Establish Three training, research, and development, innovation, and exhibition centers related to IoT by 2025.

—Create 100 IoT-based startups by 2025 to solve local problems using home-grown IoT solutions.

2.4 Sensor Devices

Broadly, a sensor [6] is a device or a set of devices whose purpose is to detect changes or events in its environment and send the detected information to other electronics, frequently a computer processor. For Example, Temperature sensors, Light sensors, etc.

2.5 IoT platform

An IoT platform, [7, 8] is an end-to-end software framework. It's the glue that pulls together information from sensors, devices, networks, and software that work together to unlock valuable, actionable data.

3. STUDY METHODOLOGY

In fact, the focus is to conduct an unbiased and detailed review of existing papers regarding IoT-based irrigation systems in order to summarize and draw a general conclusion of the current trend as well as building a platform for further research activities. Here, the following three stages have been mentioned below:

3.1 Formulation of Research Questions

Here the first step is to characterize the research questions as well as provision of the current research status on IoT-based irrigation. In this research, nine research questions are depicted in Table 1:

Table 1. Research Questions on IoT-based irrigation

NO.	Research Questions
1	What are the major targeted primary publication channels for IoT-based irrigation research?
2	How has the frequency of approaches regarding IoT-based agriculture been changed in course of time?
3	What approaches are used for identifying problems in IoT-based agriculture?
4	In which countries IoT-based irrigation is being used?
5	What are the issues which should be considered for irrigation?
6	What are different irrigation types?
7	Which sensors and boards are used in IoT-based irrigation?
8	Which wireless communication technologies/protocols are used in IoT-based irrigation?
9	Which IoT platforms are used in IoT-based irrigation?

3.2 Search Strategy

The second step is to search for relevant studies on the research topic. Initially, IEEE CS, Elsevier, ACM Digital Library, and ScienceDirect were targeted for searching using a set of keywords related to our research topic: 'IoT-based irrigation', 'smart irrigation', 'smart apps', 'smart devices', 'intelligent agriculture', 'cloud in the agriculture', 'moisture sensor', 'data monitoring system', 'cloud platform', 'agriculture system', 'internet-of-things, 'smart agriculture', 'advanced agriculture practices', 'future food expectation', 'machine learning, 'fertility level', 'crop prediction', 'LoRaWAN', 'real-time systems', 'environmental monitoring', 'sensor systems', 'self-powered, 'soil measurements' and 'analytics data in the agriculture. Besides, Google has been used as the search engine for keywords throughout our survey. In the search, the paper from the year 2016 to 2021 was emphasized, especially from Bangladesh along with some papers from other countries. The acceptability and credibility level of the papers were evaluated using the 'Impact factor'.

3.3 Extracting information

The most relevant problems of interest were gathered and extracted from our selected papers. The extracted information depends on the initial research questions mentioned above, and it will be analyzed in the following section.

4. DATA ANALYSIS

In this section, the extracted data from the set of selected papers will be analyzed according to the research questions given in Table 1.

4.1 Major targeted primary publication channels for IoT-based irrigation research

To address the first research question, several publication sources have been identified as well as channel categorization and impact factor. It has been depicted in Table 2 and Table 3.

Table 2. Publication source, Reference and impact factor (IF) part 1

Publication Sources (Conference)	Ref.
Int. Conf. on Computer and Communication Technology (ICCCT)	[9]
Int. Conf. on Computer and Information Technology (ICCIT)	[10, 11]
IEEE Int. Conf. on Innovations in Green Energy and Healthcare Technologies (ICIGEHT)	[12]
IEEE Globecom Workshops (GC Wkshps)	[13]
Int. Conf. on Software Engineering and Information Management (ICSIM)	[14]
Int. Conf. on Innovations in Science, Engineering and Technology (ICISET)	[15]
Int. Conf. on Cybernetics and Intelligent System (ICORIS)	[16]
Int. Conf. on System Engineering and Technology (ICSET)	[17]
Int. Conf. on Industrial and Information Systems (ICIIS)	[18]
Int. Conf. on Robotics, Automation, Artificial-intelligence and Internet-of-Things (RAAICON)	[19]
Int. Ethical Hacking Conf. 2018. Advances in Intelligent Systems and Computing	[20]
Int. Conf. on Advances in Electrical Engineering (ICAEE)	[21]
Int. Conf. on Advanced Computing & Communication Systems (ICSCCS)	[22]
Int. Conf. on Smart Structures and Systems (ICSSS)	[23]
The 9th Int. Symposium on Computational Intelligence and Industrial Applications (ISCIIA)	[24]

4.2 Frequency of approaches regarding IoT-based agriculture been changed in course of time

To address the second research question, the year wise frequency of papers has been identified which is represented by a bar graph in Fig. 2.

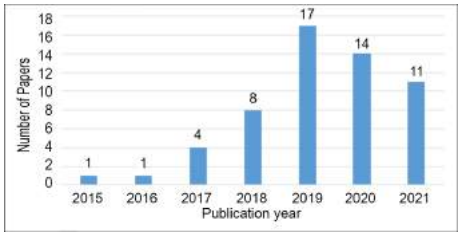

Fig. 2. Year-wise frequency of papers

4.3 Different approaches for identifying problems in IoT-based irrigation

To address the third research question, several approaches have been identified which are required for irrigation. It has been depicted in Fig. 3.

Table 3. Publication source, Reference and impact factor (IF) part 2

Publication Sources (Journal)	Ref.	IF
Int. J.of Engineering Research & Science (IJOER)	[25]	
Int. J. of Computer Applications	[26, 27]	3.12
Global Internet of Things Summit (GIoTS)	[28]	
Int. J. of Advanced Computer Science and Applications (IJACSA)	[29]	0.712
Int. J.of Science and Research (IJSR)	[30]	3.033
Int. J.of Engineering and Manufacturing Science	[31]	
Int. J.of Electrical, Electronics and Data Com. (IJEEDC)	[32]	0.543
Procedia Computer Science	[33–35]	2.09
Int. J. of Engineering and Advanced Technology (IJEAT)	[36, 37]	
Int. J.of Research Studies in Science, Engineering and Technology	[38]	
Int. J.of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE)	[39]	
Int. J.of Engineering Research and Technology	[40]	
J.of Physics: Conf. Series, Int. Conf. Computer Science and Engineering (IC2SE)	[41]	
J.of Emerging Technologies and Innovative Research (JETIR)	[42]	
Int. J.of Engineering Sciences & Research Technology	[43]	
IEEE Access	[44]	3.367
Engineering Reports	[45]	
Int. J.of Applied Engineering Research	[46]	0.602
Cognitive Informatics and Soft Computing. Advances in Intelligent Systems and Computing	[47]	0.634
Int. J.of Engineering Research & Technology (IJERT)	[48, 49]	7.87
Int. J.of Recent Technology and Engineering (IJRTE)	[50], [51]	
Advances in Meteorology	[52]	1.962
Applications in Ubiquitous Computing. EAI/Springer Innovations in Communication and Computing	[53]	0.9
Research Square	[54]	
Information Sciences Letters	[55]	
J.of Robotics and Control (JRC)	[56]	
Applied Sciences	[57]	
Int. Research J.of Modernization in Engineering Technology and Science	[58]	
Women in Precision Agriculture	[59]	
Complexity	[60]	4.621
Scientific Programming	[61]	1.025
Annals of R.S.C.B.	[62]	0.9
Int. J.of Modern Agriculture	[63]	-
Microprocessors and Microsystems	[64]	1.161

4.4 Countries in which IoT-based irrigation is being used

To address the fourth research question, some countries have been identified where IoT-based irrigation is widely. It has been depicted in Figure 4.

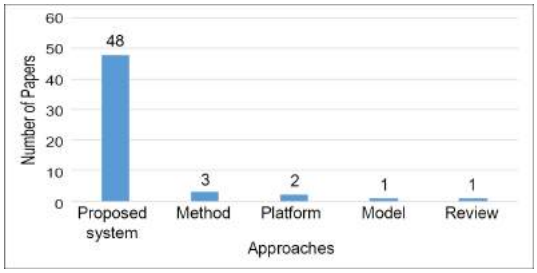

Fig. 3. Frequency of papers of different approaches

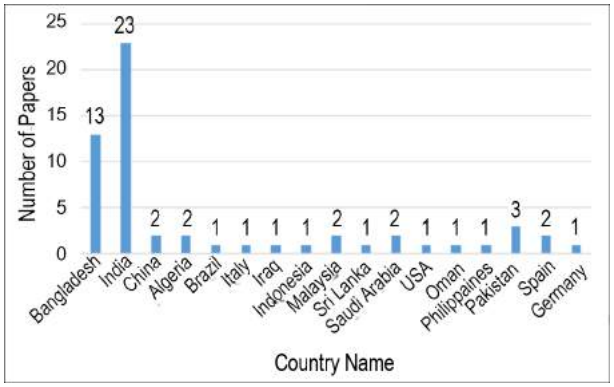

Fig. 4. Frequency of papers based on different countries

4.5 Issues in irrigation

To address the fifth research question, several issues have been identified which are required for irrigation. It has been depicted in Table 4.

Table 4. Different Issues Regarding Irrigation

Issues	Description
Soil moisture	Soil moisture is the water content situated in the soil. [10, 12, 14, 16–27, 29–36, 38–42, 45–51, 53–64].
Soil temperature	Soil temperature is the factor which indicates the hotness or coldness of soil. [12, 14, 25, 29, 39, 46].
Soil pH	Soil pH is the factor which indicates the acidic or alkaline characteristics of soil. [20, 23, 35, 46, 51, 56, 58].
Soil nutrients	Soil nutrients is the factor which indicates the items located in soil required for healthy plants. [23, 46, 56].
Air temperature	Air temperature is the factor which indicates the hotness or coldness of air. [12–14, 16–20, 22–25, 29–31, 35–37, 40–42, 45–47, 49–51, 53–55, 57, 59–64].
Air humidity	Air humidity is the water vapor situated in the air. [12, 14, 16–20, 22, 24, 25, 29–31, 34, 36, 37, 41, 45, 46, 49–51, 54–57, 60, 62–64].
Luminosity	Luminosity is the indicator of light intensity. [10, 14, 16, 29, 30, 34, 60].
Precipitation	Precipitation means the water fall from the atmosphere to earth surface. [14, 18, 19, 29, 45, 49, 58, 60].
Leaf wetness	Leaf wetness is the indicator of how much water is located on the surface of a plant [46].
Plant height	Plant height is a term which refers the the distance between the plant's highest level and the ground level [20].

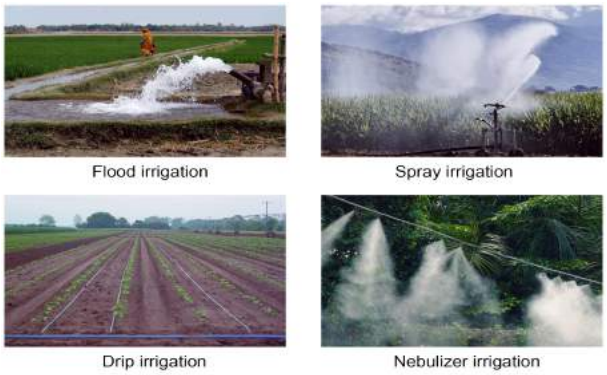

Fig. 5. Types of irrigation

4.6 Different irrigation types

To address the sixth research question, it is required to identify the types of irrigation. There are many types of irrigation in agriculture nowadays, depending on how water is distributed throughout the field. Among those, four of the most widely used irrigation systems (Fig. 5) are discussed below:

Flood irrigation has been practiced and followed for many years. This is a technique where water is distributed over the surface of the soil like a flood. Although this method is widely used, a lot of water is wasted in this method.

Spray irrigation is the method of applying water in a controlled manner that is similar to rainfall. Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air through a spray nozzle so that it breaks up into small water drops which fall to the ground. It is also known as Sprinkler irrigation.

Drip irrigation is a modern type of irrigation system that has the ability to save water and nutrients by allowing water to drip slowly to the roots of plants, either from above the soil surface or buried below the surface. Here, the main objective is to place water directly into the root zone and minimize evaporation. It is also known as Trickle irrigation.

There is another irrigation method by which tiny water droplets come out and create fine fog. This arrangement is somewhat like **spray irrigation**, but this method creates an atmosphere of fog instead of rain. That is why it is also known as Fog system irrigation.

4.7 Sensors and boards are used in IoT-based irrigation

To address the seventh research question, the sensors and boards used in the reviewed papers have been identified and listed in Table 5 and Table 4.7, respectively. Analyzing these two tables, two graphs have been presented in Fig. 7 and Fig. 8. Some sensors and boards are also presented in Fig. 9

4.8 Wireless communication technologies/protocols are used in IoT-based irrigation

To address the eighth research question, some commonly used wireless technologies have been identified from the reviewed pa-

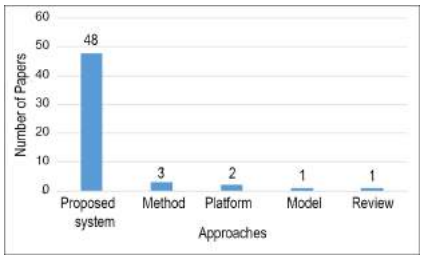

Fig. 6. Frequency of papers of irrigation issues

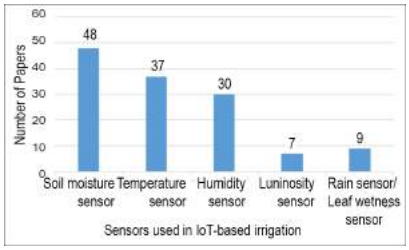

Fig. 7. Frequency of papers of different sensors

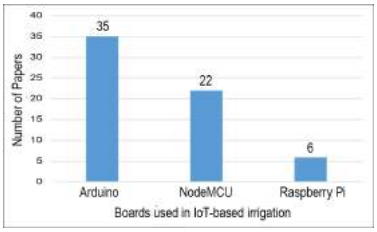

Fig. 8. Frequency of papers of different boards

Table 5. Different Sensors used in IoT-based irrigation

Sl.	Sensor Name	Description
1	soil moisture sensor [10, 12, 14, 16–27, 29–42, 45–51, 53–64].	The soil moisture sensor is one kind of sensor used to gauge the volumetric content of water within the soil. Example: YL-69, VH400, FC-28, 200SS, HA2002.
2	Temperature sensor [12–14, 16–20, 22–25, 29–31, 35–37, 40–42, 45–47, 49–51, 53–55, 57, 59–64].	A temperature sensor is an electronic device that measures the temperature of its environment and converts the input data into electronic data to record, monitor, or signal temperature changes. Example: DHT11, LM35, DHT22.
3	Humidity sensor . [12, 14, 16–20, 22, 24, 25, 29–31, 34, 36, 37, 41, 45, 46, 49–51, 54–57, 60, 62–64].	A humidity sensor is an electronic device that measures the humidity in its environment and converts its findings into a corresponding electrical signal. Example: DHT11, DHT22
4	Luminosity sensor [10, 14, 16, 29, 30, 34, 60].	A luminosity sensor is an electronic device that measures the humidity in its environment and converts its findings into a corresponding electrical signal. Example: LDR, BH1750, TSL2561.
5	Rain sensor/Leaf wetness sensor [14, 18, 19, 29, 45, 46, 49, 58, 60].	A rainfall sensor/leaf detection sensor is an electronic device that can be used to monitor leaf moisture and rainfall. Example: LW100.

Table 6. Different boards used in IoT-based irrigation

Sl.	Board Name	Description
1	Arduino [10–12, 17, 19, 21–23, 25–27, 31–36, 38–40, 42, 43, 47–49, 51–56, 58, 60, 62, 64].	Arduino is a term which refers to an open-source platform used for setting up electronics projects. It consists of both a microcontroller and an IDE (Integrated Development Environment), used to write and upload computer code to the physical board.
2	NodeMCU [15–17, 19, 23, 30, 32, 34, 37, 39–41, 49, 51, 53–55, 57, 58, 62–64].	NodeMCU is an open-source firmware for which open-source prototyping board designs are available. The name "NodeMCU" combines "node" and "MCU" (micro-controller unit).
3	Raspberry Pi [10, 37, 45, 46, 52, 59, 64].	The Raspberry Pi is a credit-card sized computer which is widely used in many areas, i.e. weather monitoring. The reasons behind its popularity is low cost, modularity, and open design.

pers [65] as well as internet searching. It has been depicted in Table 7.

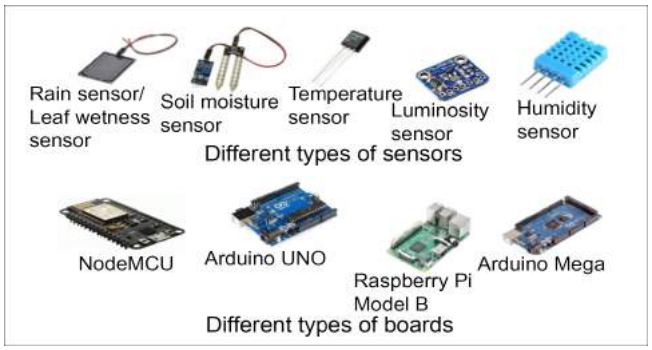

Fig. 9. Different type of sensor and other devices to Implement IoT-based Irrigation System.

4.9 IoT platforms are used in IoT-based irrigation

To address the ninth research question, several IoT platforms are discussed which are commonly used for irrigation. It has been depicted in Table 8.

5. DISCUSSION

In the research, 56 papers were reviewed from the year 2015 to 2021. After a rigorous analysis, various issues are identified and discussed in this section. In the first subsection, the main findings will be focused; in the second subsection, research implication will be discussed; and in the third subsection, study limitations will be discussed based on our review.

5.1 Main Findings

In this review, a complete view on IoT-based irrigation is going to be presented; therefore, nine research questions have been formulated to address the specific issues. 56 papers were collected across the globe and were scrutinized in an efficient manner.

Based on the existing work, information regarding IoT-based irrigation was obtained which are depicted in tabular format, figure as well as relevant graphs. Though the review process was based on the papers from 2015 to 2021, the papers of 2020 and 2021 were emphasized to keep our work up-to-date. This review indicates that, most of the papers focus on implementation, whereas, there are very little work on literature review. Analysis of the collected data specifies that soil moisture is the most important parameter for irri-

Table 7. Wireless Communication Protocols

Parameters	Standard	Frequency Band	Data Rate	Transmission Range	Energy Consumption	Cost
Wifi	IEEE 802.11 a/c/b/d/g/n	5 GHz-60 GHz	1Mbps-7 Mbps	20-100 m	High	High
LoRaWAN	LoRaWAN R1.0	868/900 MHz	0.3-50 Kb/s	¡30 KH	Very Low	High
WiMAX	IEEE 802.16	2 Ghz – 66 Ghz	Mb/s-1 Gb/s (Fixed) 50-100 kb/s 3G:200 kb/s 4G:0.1-1 Gb/s	¡50 Km	Medium	High
Mobile Communication	2G-GSM, COMA.-3GUMTS, CDMA2000, 4G-LTE	865 MHz 2.4 Ghz	2G: 50-100 kb/s 36:200 kb/s 4G:0.1-I Gb/s	Entire Cellular Area	Medium	Medium
LR-WPAN	IEEE 802.15.4	868/915 MHz, 2.4 Ghz	40-250 Kb/s	10-20 m	Low	Low
RFID	ISO 18000-6C	860-960MHz	40 - 160 kbit/s	I -5 m	Low	Low
ZigBee	IEEE 802.15.4	2.4 GHz	20-250 Kb/s	10-20 m	Low	Low
MQTT	OASIS	2.4 GHz	250 kbps -	-	Low	Low
SigFox	Sigfox	200 kHz	100-600 bit/s	30-50 km	Low	Low

gation. The sensing of moisture values in soil is done by soil moisture sensors. These sensors are deployed throughout the field so that the soil moisture data can be obtained in a systematic way. It is also found that Arduino is the most commonly used boards needed for implementing such system. Depending upon the relevancy, 13 Bangladeshi papers were selected, where all were implementation paper. Since no review paper was found based on the context of Bangladesh, this work may be considered as the Bangladeshi trailblazer on IoT-based irrigation review. In this research, a special focus was also made on Indian trends so that a summarized view can be obtained of what is going on in the neighboring country. All IoT Protocols and popular IoT platforms were collected to make the implementation easy in future.

5.2 Research Implications

This research provides a platform for further research on IoT-based irrigation. Especially the farmers, who are in direct contact with agriculture can get benefits from it if these technologies are taken to the grassroots level. This study also indicates the technologies used to develop IoT applications during the period reviewed, and it has extensive knowledge about advanced IoT applications to automate agriculture and farming processes. Furthermore, the study identified collected sensor data and technology, most considered for the development of IoT-based applications in agriculture and agriculture sectors towards the significant improvement of the business.

Table 8. List of IoT Platform

IoT Platform	Real Time Data Capture	Data Visualization	Cloud Service Type	Data Analytics	Developer Cost
ubodots (http://ubsdots .com/)	yes	yes	Public	yes	Free
Thing Speak (https://thingspeak .com/)	yes	Yes (Mat lab)	Public	yes	Free
ThingWork (https://thingWork .com/)	yes	yes	Public (IaaS)	yes	PPU
Xively (https://Xively .com)	yes	yes	Public (IoTI-aaS)	yes	Free
Piotly (https:// piot .ly)	yes	Yes (Mat lab)	Public	yes	Free
Nimbits (www.nimbits .com)	yes	Yes (Mat lab)	Hybrid	yes	Free
Connecterra (www.connecterra .com)	yes	yes	Private (IaaS)	yes	PPU
Axeda (www.axeda .com)	yes	yes	Private (IaaS)	yes	PPU
Phytech (www.phytech .com)	yes	yes	Private (IaaS)	yes	PPU
Arkessa (www.arkessa .com)	yes	yes	Private	yes	PPU
Yaler (www.https://yaler .net)	yes	yes	Private	yes	PPU
AWS (https://aws.amazon .com/)	yes	yes	Private	yes	PPU
AZURE (https://azure.microsoft .com/en-us/)	yes	yes	Private	yes	PPU
SmartThings (https://www.smartthings .com/)	yes	yes	Private	yes	PPU
Kura (https://www.eclipse .org/kura/)	yes	yes	Private	yes	PPU

[a]PPU=Pay Per Use.

5.3 Study Limitations and Future Scope

The research is a pioneer work in Bangladesh; however, it also has some limitations. In this work, just 56 papers were reviewed, where proposed system papers were 48, methods were 3, platforms were 2, model was 1, and review was 1. These do not reflect the entire

scenario in the context of IoT-based irrigation. Furthermore, there are very few works based on the Bangladeshi context. Out of the 56 papers, thirteen (13) papers were based on the Bangladesh context. Therefore, this paper can be regarded as a milestone for further research in the field of IoT-based irrigation along with other related IoT-based agriculture issues in Bangladesh. Investigation on the commercial services, android apps, implementation procedures are left for future exploration.

6. CONCLUSIONS

The most relevant to the problems of interest were gathered and extracted from 56 papers from 2015 to date and different sources using the internet search engine. The extracted information depends on the initial research questions mentioned earlier are projected in the tabular format. IEEE CS, IEEE Transaction, topic were emphasized as well as Google search engine throughout the survey. During searching, the paper during the period of 2015 to 2021 from Bangladesh were emphasized. as well as from some other countries (i.e. India, China, Algeria, Brazil, Italy, Iraq, Indonesia, Malaysia, Sri Lanka, Saudi Arabia, USA, Oman, Philippines, Pakistan, Spain, and Germany) which have the similar research problems. By analyzing the extracted information for research, efforts were made to answer irrigation issues, different sensors, different wireless communication technologies/protocols, different IoT platforms, and different cloud databases used in IoT-based irrigation. This research may be helpful for farmers, who are the direct user group of these technologies; for researchers, who are continuing research on AIoT; for technologists, who are implementing and commissioning the technologies; for AgIoT business people, those who trade IoT devices and services by knowing the current and upgrading trend and practice. Hence, this type of research should be patronized by the government so that the full advantages may be obtained from it.

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