International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 11, November-2021

Prospect of IoT Based Smart Agriculture in Bangladesh-A Review

Olly Roy Chowdhury
Associate Professor
Dept. of Physics and Mechanical Engineering
Patuakhali Science and Technology University,
Patuakhali, Bangladesh

Sarna Majumder
Assistant Professor
Dept. of Computer and Communication Engineering
Patuakhali Science and Technology University,
Patuakhali, Bangladesh

***Abstract*—To improve the livelihood of the mass people related to agriculture, it is high time to enter into the era of Internet of Things (IoT) based smart agriculture and try to meet the demand of electric power needed to monitor and control IoT based Smart agriculture by renewable energy. This paper presents the current scenario of IoT based smart agriculture worldwide especially in case of conducting the control actions and method of powering the entire cultivation and irrigation process. We also reviewed utilization of renewable energy instead of using fossil fuel or grid power dependent irrigation and smart control. Finally the discussion focuses on future scope of using hybrid renewable resources to power up entire IoT based smart agriculture and irrigation system in the context of Bangladesh.**

Keywords*— *IoT, Smart Agriculture, Automated irrigation, Hybrid Renewable resources, Renewable energy.

I. INTRODUCTION

Agriculture is the backbone of Bangladesh. Among several other developing economies, Agriculture has consistently been marked as the largest sector. About 50% of total population are employed in agriculture sector and about 70% people, overall depend on agriculture for their livelihood [1]. The monitoring and irrigation of our cultivable field and yield is still going on following traditional/manual ways wasting a lot of time, money and man power. Machine controlled, remotely monitored "Internet of Things (IoT)" based smart agriculture system can save time and money by reducing human intervention. Smart agriculture includes sensors to monitor condition of soil and environment and acknowledgements are sent to the user i.e.; to farmers, by IoT modules through wireless internet connectivity so that they can take necessary initiatives by monitoring the situation. Proper actions like watering the crops or even fertilization can also be totally machine controlled and remotely operated.

The total amount of cultivable land we have is around 8.52 million hectares [2][3]. Though Bangladesh is blessed with lots of rivers but in dry season around 5 million hectors of our cultivable land need irrigation through electric water pumps. Electric pumps of 700-800MW used to extract underground water and pumped to cover 30% of total land area [4]. Water pumps either run by burning diesel fuel polluting environment rigorously or by using a huge amount of electricity causing more electrical crisis. Renewable energy could be a better option replacing such fuel based and electricity wasting systems and can run irrigation system in a eco-friendly way.

II. BACKGROUND OF IOT BASED SMART AGRICULTURE

A soil sensor can measure temperature, moisture, humidity, electrical conductivity and NPK (nitrogen, phosphorus and potassium). Through wireless internet, the sensor monitored data is displayed on a web page/ smart phone, notifying the user about the soil condition, letting user to decide when the watering should be done and exactly how much water the soil or crop would need, thus saving lots of underground water and labor cost. Some primary studies on IoT based smart agriculture were done simply based on smart, remote monitoring of agro farm only. Research in "Cloud IoT Based Greenhouse Monitoring System" comprises design of a greenhouse monitoring system based on CloudIoT [5]. Where authors developed a system that can automatically measure and monitor changes of temperature, light, Humidity and moisture level in a greenhouse. Again some research studies were focused on renewable energy based irrigation only using stepper motor controlled automatic valve regulation system where a signal from a moisture sensor triggers the motor operation [6].

Several advanced researches have been done integrating control and automation of irrigation system together with monitoring [6-9].

Iqbal Ahmed in their paper "IoT based Smart Irrigation System at University of Chittagong, Bangladesh" have done research on smart irrigation by measuring soil moisture only and according to that, irrigation was controlled [10].Similar study related to automatic irrigation or watering plants was done by students of Daffodil International university [11].

But now its time to think about sustainable and renewable solution to this smart agriculture since both agriculture and power generation will always be our top priorities as our daily essentials.

III. IOT BASED SMART AGRICULTURE SYSTEM AND MANAGEMENT

The main functions of a general IoT based smart agriculture system can be divided in few steps. Upon gathering sensor monitored data from soil and weather condition, each sensor node sends data information to master node using its on board wireless network protocol. Master node receives, processes and stores data information to one or more cloud server. Server performs data analysis based on several algorithms and comparison with threshold values of

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 11, November-2021

different parameters and thus makes decision on necessary control actions need to perform.
Smart agriculture focuses on some basic points like:

- Enhancing crop quality and yield by continuous sensing of parameters like, soil moisture, air temperature, humidity etc.
- Reducing human intervention by remote monitoring.
- Reduction in water consumption by smart irrigation control thus saving time, electricity, human effort and labor cost.

Scientists have undertaken diverse experimentations on different level of functional activities of smart agriculture. For example, graphical application via internet has been used as data monitoring system instead of sensors in paper [12]. Researches have been done with types and no. of sensors used for soil monitoring [13][14]. For example, soil moisture, temperature, humidity, leaf wetness ultraviolet and solar radiations, wind vanes, etc. [13]. One or more sensors [13],[14] or sensor nodes stay embedded at different layers or levels of soil.

Variations have also been seen in use of microcontrollers acting as master controllers (ATMEGA328P, ESP8266 etc) [15],[16]; wireless communication network protocol (using ZigBee, LoRa, Bluetuth, Wi-Fi) [13],[14],[17],[18],[19]; data handling and management (cx. Cloud computing, GUI designed in MATLAB)[13],[20]; using fuzzy logic as data interfacing [21],[22],[4]. But most prominent variations and major developments have been found in the process of conducting the control actions in application level and in the process of powering up the entire smart agriculture. Portable or stationary.

A. Smart control over irrigation process

In case of smart agriculture or automation in agriculture, remote control of irrigation reducing human intervention is truly important. Again since this is an era of sustainable renewable energy generation, powering up the monitoring and irrigation process of a smart greenhouse or IoT based smart agriculture remains incomplete without renewable energy.

In IoT based smart agriculture, several researches have been done on the control of irrigation process i.e.; from decision making to control of water pump. It can be, i) fully automated (auto mode), ii)or can be operated manually (manual/remote control mode) where the user controls the switching of irrigation process ON/OFF remotely by studying the data values displayed on web page/android app, iii) or can have both auto mode and remote controlled mode together.

In “solar based smart irrigation system” Upendra singh et al. have implemented both fully automated irrigation process switching water pump on and off automatically based on moisture sensor value and together with that they kept option of fully manual mode where the user has to switch the irrigation process ON/OFF manually by going onsite [23].

In [13], Shweta et al. has proposed an IoT based smart agriculture where, some sensor nodes sense soil parameters and send data to a master node via ZigBee. Master node receives and stores the data in storage (eg. one or more cloud server) and processes data. Server performs the data analysis and after taking decisions about the actions required, the controlling actions are transmitted to the sensor nodes. The microcontrollers on each sensor node conducts the directed actions such as watering and then sends a report to user about recent field information through an android application [13].

Anuvab Gulati et al. in “Smart Irrigation Using Internet Of Things” have also proposed a method to monitor the soil content and to water soil automatically through mobile app, whenever the moisture content falls below the threshold value [19].

In [16] authors have developed a prototype for solar powered automated smart irrigation comprising microcontroller ESP8266 as it’s master controller which, with the help of an irrigation algorithm, monitors moisture control and processes decision making about the water pump to lead or to stop the water flow.

Again, Srishti rawal, in [15] has also proposed automated watering process based on sensor measured soil moisture level using microcontroller ATMEGA328P on arduino uno platform as the control unit. Information from the sensors gets updated regularly on a webpage using GSM-GPRS SIM900A modem, helping a farmer to check whether the irrigation process is ON/OFF at any time.

Authors of “Internet of Things (IoT) Based Smart Irrigation” have discussed a system that uses two sensor nodes (programmed Arduino board) acting itself as a coordinated node, measuring moisture, humidity and pH parameters and sending data once in every minute, to an arranger node through ZigBee wireless communication protocol. The arranger node after gathering the parameters wirelessly, stores and analyzes the knowledge. The board has ‘Associate in Nursing LAN’ interface that allows the user to look at the information from online browser and to control the irrigation system ON or OFF remotely [14].

Some advanced features like theft detection and presence of both auto mode and remotely controlled manual mode has been discussed in [8] by Nikesh Gondchawar where irrigation will be fully machine controlled in auto mode whereas in manual mode, user will be able to switch the water pump on/off of remotely via mobile or computer.

Multiple algorithms and systems have also been developed to receive, store, analyze data information gathered by sensor nodes. Nikesh Gondchawar et al. developed a GPS robot to perform tasks like weeding, spraying, moisture sensing, bird and animal scaring, keeping vigilance, etc. They also have integrated smart irrigation control by intelligent decision making based on real time data [8].

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 11, November-2021

B. Solar or Renewable energy powered IoT based smart agriculture

IoT based smart system runs twice or thrice time a day by consuming maximum power and for rest of the time system remains in "standby" condition consuming lowest power. Thus power requirement of the total system can be well designed and managed by renewable energy.

Remotely accessible smart agricultural monitoring system together with automatic irrigation technology could be very beneficial to the mass people of our country earning their livelihood through agriculture by saving their time, money and effort; moreover powering up the entire system by renewable energy, can save lots of grid based power. Smart, remote monitoring of agricultural field with automated irrigation, powered by renewable energy would be a proper step to boost up our traditional, human intervened agricultural process with conventional energy or fossil fuel based irrigation system; to enter into a new era, where sustainable, renewable sources will be the only scope for future energy generation.

a) Use of solar energy as main renewable source of power for smart agriculture

Bangladesh due to its geographical location, has abandoned source of solar energy rather than wind and other sources of energy. Solar radiation here varies from 4 to 6.5 kWh/m2 in various districts [24]. Bangladesh Govt. has vision to increase the use of renewable energy over conventional energy [4]. To achieve this target, solar energy should be given highest priority as solar is the most effective renewable source of energy in Bangladesh. Solar systems are highly reliable and have mostly maintenance free setup but still have the limitations of higher investment costing and lower energy conversion efficiency [4].

Already many scientists have used solar energy for powering up IoT based smart agriculture. S. Harishankar et al [6] proposed a solar powered irrigation system which automatically drives water pump, pumping water from bore well to a ground level storage tank from which water flows to the field through a moisture sensor dependent and intelligent algorithm controlled simple valve mechanism, eliminating the need of using another pump.

Md. Sharfaraj Hussain[4] proposed a solar energy powered irrigation system controlled by fuzzy based switching. Solar radiation varies along with the time of the day, depends on weather and also on the site of installation. Keeping these factors in mind, the proposed system used multiple pumps of different size and made use of intelligent switching to operate the pump motors so that maximum output from the solar panels could be utilized.

In [25], researchers came up with the development framework for creating a utility model that served as a guide to develop a solar powered smart agricultural irrigation and monitoring system by adopting IoT and using Adaptive Gateways for dIverse muLtiple Environments (AGILE) methodology.

In [16] and [23] authors have also developed smart irrigation and monitoring process powered by solar energy generated power. Use of solar panels with LDR (Light Dependent Resistor) based tracking system to power up fuzzy controlled, Arduino operated smart irrigation has been seen in "Renewable Energy Based Smart Irrigation System" by Sudharshan N. et al. [22].

b) Hybrid sources of renewable energy in agriculture

Solar generated DC power is converted to AC power and directly used to run AC pump without the help of any storage battery reducing the costing since storage batteries are highly expensive which makes the total system cost go high [Abul Hasnat, A brief study of the prospect of hybrid solar irrigation system in Bangladesh]. Need of storage batteries cannot be avoided totally when, the question of powering the system at low sunshine or during night time arises. So to make this project profitable, hybrid system should be developed to power up the entire system in the absence of proper sunshine and without battery. Integration of hybrid renewable sources of energy increases the system working hour in sustainable and in eco-friendly way. Hybrid systems can also overcome the limitations of uninterrupted power supply in remote areas.

Though not renewable, but as replacement of batteries, Md. Abul Hasnat has integrated grid power as secondary source energy for powering irrigation system in his paper "A brief study of the prospect of hybrid solar irrigation system in Bangladesh" [3].

IV. PROSPECT OF HYBRID ENERGY SOURCE POWERED IOT BASED SMART AGRICULTURE IN BANGLADESH

Most of the countries in general, have used wind solar hybrid systems for powering irrigation sector. Before planning to set up wind energy harvester systems in Bangladesh, some points need to be considered first. The first factor is that, wind energy systems have huge installation cost which can be a major drawback for developing countries like Bangladesh. Another point is that, the installation site should have at least 7 m/s wind velocity to extract maximum power from a turbine. Whereas, average wind speed ranging from, 3 m/s - 6 m/s passes through the coastal area of Bangladesh from March to September. Speed gets lower during October to February [26][27]. Thus Bangladesh is a country of moderate wind speed that too varies from medium to low during the year. With recently developed wind turbine designs it is possible to extract power from wind having velocity of 2.5 m/s. It has already been found that, it is feasible to establish small wind turbines in coastal zones [27][28]. A long way back a project named as Wind Energy Study Project (WEST) from Bangladesh Government measured wind speed at seven coastal zones at 25 meter height for one year, where Kuakata was found to have maximum average wind speed as shown in fig.1.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 11, November-2021

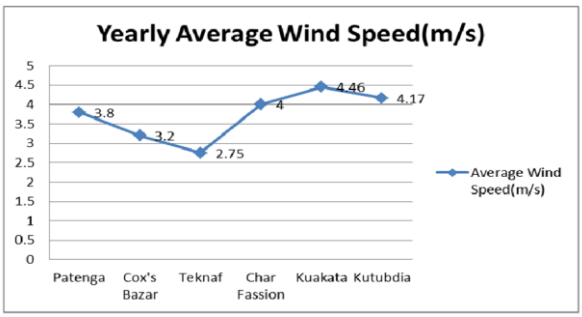

Fig. 1. Yearly Average Wind Speed at six WEST stations [29]

Again in another study done by BCSIR, Saint Martin Island was found to have yearly average wind velocity of 4.79 m/s [28][30]. Thus installing solar wind hybrid energy system for adding power to national grid or for providing continuous power supply for irrigation and smart agriculture conducted in remote areas, in coastal areas or in islands can be a good option to plan for.

Another option for uninterrupted power supply during the absence of sunshine is to add grid power as one of the sources with hybrid solar wind energy system where grid power will be used to continue the powering process only when other sources fail to work. Combining photovoltaic system with grid power needs no additional cost so only solar grid hybrid energy system also turns out to be economically feasible and environment friendly way to power up smart remote agriculture. Md. Abul Hasnat in [3] has discussed the prospect of such a hybrid system considering both technical and financial analysis of the solar irrigation system and grid connected pumping system and finally after that, combined the analysis for further results.

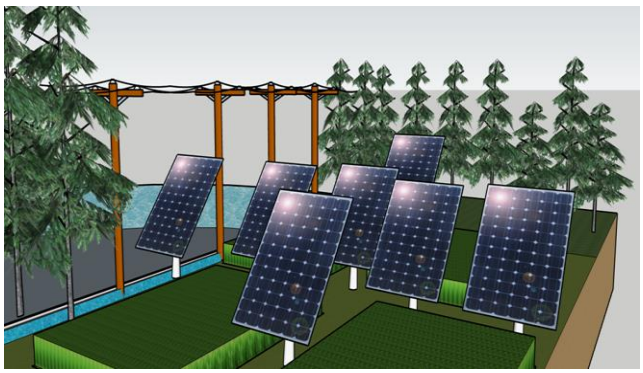

Fig. 2. Solar + Grid hybrid plant

In Bangladesh, smart agriculture in areas other than coastal, can be planned with solar, grid hybrid plant excluding wind turbines (fig.3) because of inadequately lower wind speed almost all over the country. This will also make the system economically feasible, as set up of wind turbines require huge installation cost.

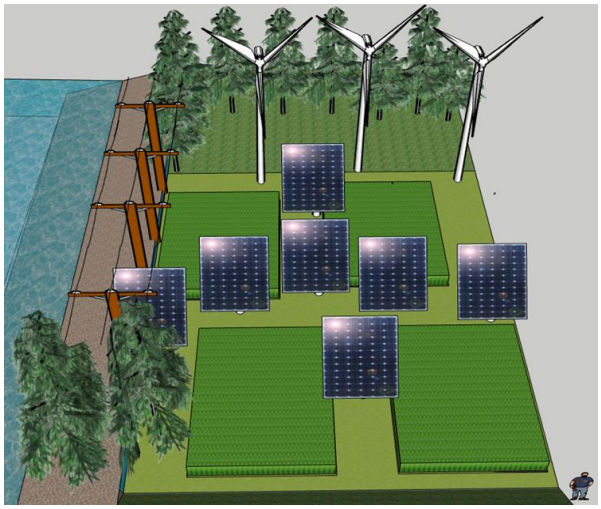

Fig. 3. Hybrid solar, wind and grid power plant for powering IoT based smart agriculture

In fig. 3, a 3D hybrid power plant model combining solar, wind and grid power has been shown. Bangladesh is blessed with huge solar energy but only solar panel based power plant reduces working hour. Average wind speed required for energy generation is insufficient in Bangladesh. But we can install small turbines capable of energy generation at comparatively lower wind speed, near coastal areas as coastal areas especially Kuakata have found to have maximum wind speed among other places. These small turbines can be combined with solar photovoltaic contributing to power up smart agriculture at coastal areas. To ensure 24 hour long, uninterrupted power supply and make smart monitoring and remote controlled automated irrigation smooth, grid power can be added to solar wind hybrid energy plant where grid power will confirm continuous power supply all the time in any type of climatic condition if other sources fails to provide sufficient power. Addition of grid power will cost almost nothing in comparison with adding batteries to the system for using during nighttime. Moreover we can feed excess energy generated from renewable sources to national grid through this connection.

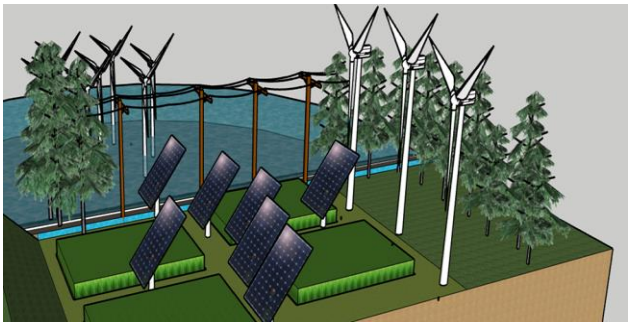

Fig. 4. Smart agriculture with hybrid power plant utilizing near shore areas

We can use our abandoned shoreline areas, near shore and offshore areas to place wind farms, floating solar panel saving cultivable land areas as shown in fig. 4. Thus we have huge scope to utilize our natural resources of renewable energy to overcome the difficulties related to agriculture and

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 11, November-2021

most importantly irrigation in an economically feasible and sustainable way.

V. Conclusion

IoT based smart agriculture and irrigation powered by renewable energy is advanced and promising technology saving time, energy, effort, money and conserving underground water. Considering the consequences of global energy crisis and water insufficiency this idea of IoT based smart agricultural monitoring together with controlled adequate irrigation system powered by hybrid renewable sources of energy, can contribute a lot to put an end to the sufferings related to energy and water shortage.

References

[1] https://www.thedailystar.net/supplements/30th-anniversary-supplements/news/revitalising-bangladeshs-agriculture-sector-2042629
[2] S. I. Khan, S.R. Mizanur and Q. Islam, "Design and analysis of a low cost solar water pump for irrigation in Bangladesh," Journal of Mechanical Engineering, vol. ME 43(2), Dec 2013.
[3] M. A . Hasnat, M. N. Hasan, and N. Hoque, "A brief study of the prospect of hybrid solar irrigation system in Bangladesh," In Proceedings of the International Conference on Mechanical and Energy Engineering, Dec 2014.
[4] M. S. Hussain, D. M. Abdullah, W. M. Abdullah, & L. Ali, "Development of a fuzzy logic based smart solar system for irrigation," 9th ICME, Dhaka, Bangladesh, RT-050, 2011.
[5] V. Keerthi, GN. Kodandaramaiah, "Cloud IoT based greenhouse monitoring system," International Journal of Engineering Research and Applications, vol. 5(10), pp. 35-41, Oct 2015.
[6] S. Harishankar, R. S. Kumar, K. P. Sudharsan, U. Vignesh, T. Viveknath, "Solar powered smart irrigation system," Advance in electronic and electric engineering, vol. 4(4). Pp. 341-346, Jan 2014.
[7] J. G. Jagüey, J. F. Villa-Medina, A. López-Guzmán, and M. Á. Porta-Gándara, "Smartphone irrigation sensor," IEEE Sensors journal,vol. 15(9), pp. 5122-5127, May 2015.
[8] N. Gondchawar, and R. S. Kawitkar, "IoT based smart agriculture," International Journal of advanced research in Computer and Communication Engineering, vol. 5(6), pp. 838-842, Jun 2016.
[9] B. Kaur, D. Inamdar, V. Raut, A. Patil, and N. Patil, "A Survey On Smart Drip Irrigation System," IRJET, vol.3(2), Feb 2016.
[10] Ahmed, I., and Akash, M. S. "IoT based Smart Irrigation System at University of Chittagong, Bangladesh," International Journal of Computer Applications, 975, 8887.
[11] S. Ahmed, and M. Khatun, "Automatic Water Irrigation System," 2018.
[12] J. Gutiérrez, J. F. Villa-Medina, A. Nieto-Garibay and M. Á. PortaGándara, "Automated Irrigation System Using a Wireless Sensor Network and GPRS Module," in IEEE Transactions on Instrumentation and Measurement, vol. 63(1), pp. 166-176, Jan. 2014.
[13] S. B. Saraf, & D. H. Gawali, "IoT based smart irrigation monitoring and controlling system," In 2017 2nd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT), pp. 815-819, IEEE, May 2017.
[14] R. Hemalatha, G. Deepika, D. Dhanalakshmi, K. Dharanipriya, M. Divya, "Internet of things (iot) based smart irrigation," International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST), vol.2(2), pp.128-132, Feb 2016.
[15] S. Rawal, "IOT based smart irrigation system," International Journal of Computer Applications," vol. 159(8), pp. 7-11, Feb 2017.
[16] K. K. Rout, S. Mallick, and S. Mishra, "Solar powered smart irrigation system using Internet of Things," In 2018 2nd International Conference on Data Science and Business Analytics (ICDSBA), pp. 144-149, IEEE, Sep 2018.
[17] W. Zhao, S. Lin, J. Han, R. Xu and L. Hou, "Design and Implementation of Smart Irrigation System Based on LoRa," 2017 IEEE Globecom Workshops (GC Wkshps), pp. 1-6, 2017.
[18] I. Gautam, and S. R. N. Reddy, "Innovative GSM based Remote Controlled Embedded System for Water," International Journal of Computer Applications, vol. 47(13), pp.1-7, Jun 2012.
[19] A. Gulati, and S. Thakur, "Smart irrigation using Internet of Things," In 8th International Conference on Cloud Computing, Data Science & Engineering (Confluence), pp. 819-823, IEEE, Jan 2018.
[20] J. John, V. S. Palaparthy, S. Sarik, M. S. Baghini and G. S. Kasbekar, "Design and implementation of a soil moisture wireless sensor network," Twenty First National Conference on Communications (NCC), Mumbai, pp. 1-6, 2015.
[21] A. Abdullah, S. A. Enazi and I. Damaj, "AgriSys: A smart and ubiquitous controlled-environment agriculture system," 3rd MEC International Conference on Big Data and Smart City (ICBDSC), Muscat, pp. 1-6, 2016.
[22] N. Sudharshan, A. K. Karthik, J. S. Kiran, and S. Geetha, "Renewable Energy Based Smart Irrigation System," Procedia Computer Science, vol. 165, pp. 615-623, Jan 2019.
[23] E. U. Singh, M. Vyas, G. Sharma, S. P. Singh, and S. Khan, "Solar Based Smart Irrigation System," International Journal of Recent Research Aspects (IJRRA), vol. 3(1), pp. 105-108, March 2016.
[24] J. P. Dunlop, "Analysis and design optimization of photovoltaic water pumping systems" In Conference Record of the Twentieth IEEE Photovoltaic Specialists Conference, pp. 1182-1187, IEEE, Sep 1988.
[25] R. M. A. Velasco, "Internet of Things Applied to Solar-Powered Smart Agricultural Monitoring System: A Prototype Development" 2019.
[26] S. Ahmed, "Investigation and Analysis of Wind Pumping System for Irrigation in Bangladesh", M.Sc Engineering Thesis, BUET, Dhaka, Bangladesh ,Feb 2000.
[27] Md. T. Amin,"Prospects of Wind Energy in Bangladesh," International Journal of Advanced Renewable Energy Research," vol. 2(8), pp. 213-218, 2015.
[28] M. G. K. Khan, T. Rahman, and M. M. Alam, "Wind energy in Bangladesh: Prospects and utilization initiatives," In 3rd International Conference on Electrical & Computer Engineering ICECE, pp. 28-30, Dec 2004.
[29] A. Z. A. Saifullah, M. A. Karim, and M. R. Karim, "Wind energy potential in Bangladesh," American Journal of Engineering Research (AJER), vol.5(7), pp. 85-94, 2016.
[30] Local Government Engineering Department (LGED), "Sustainable Rural Energy" web site(http://www.lged.org/sre)