

Towards Smart Irrigation System – An Artificial Intelligence Approach

Fatima Mustafa¹, Sidra Rehman^{*2}, Umair Rashid³

¹Department of Computer Science, Institute of Southern Punjab, Multan, Pakistan.

²Department of Computer Science, University of Roehampton, London, United Kingdom.

³Department of Computer Science, Bahauddin Zakariya University, Multan, Pakistan.

Corresponding Author: Sidra Rehman (srehman@roehampton.ac.uk)

ABSTRACT

Natural resources like water are one of the essential elements for the survival of life on the globe. Due to increase in population, more water is required for agricultural purposes to assure food availability. This elevated demand not only consumes a considerable amount but also wastage of these resources has been perceived. One of the major causes for this wastage is adoption of conventional irrigation methods. Hence there is a need to upgrade the irrigation processes integrating the smart techniques for the optimum utilization of available resources. Therefore, this study intends to propose a smart irrigation system utilizing Artificial Intelligence approach. This research tends to present the advanced parameters for the enhancement of smart irrigation systems. The proposed model comprises three major modules including memory, analyzer and decision maker. This study contributed to present a roadmap towards smart decision making for a smart model keeping various constraints under consideration. The presented model would lead the trail of smart advancement to an innovative era. This has been done with the least involvement of humans, but the adaptive artificial intelligence is influenced by the internet of things.

Keywords: Crop; Water resources; Irrigation system; Artificial intelligence; common sense.

1. INTRODUCTION

With the advent of human life there is also a development of agriculture with a glaring relationship. Agriculture is the source of food and food is the basic need of life. Moreover, the growth of agriculture also ensures the growth of the economy and to ensure agricultural growth, proper management of water resources is significant. Different irrigation methods are working for the proper water management. The continuity of traditional methods is threatened due to accumulative water scarcity especially in underdeveloped countries like Pakistan [1]. Water sustainability is becoming a major issue and as far as the underdeveloped countries like Pakistan are concerned; this country is facing water stress. Due to urbanization, industrial development with various other reasons has been increased and irrigation for agriculture is becoming difficult to manage here. Unfair distribution of agricultural irrigation is a challenge towards the reservations of water resources for avoiding water lessen. A big portion of water is wasted due to lack of knowledge regarding proper water management which causes the water reduction and also affects the crops assembly [2]. It can be concluded that the essential part of agriculture is the irrigation executive. Irrigation assets are leading towards scarcity. Due to lack of awareness about proper water consumption and improper arrangement of water also seems to be one of the major reasons for decline in water resources. Water operability can affect the consumption, distribution and conservation of resources. In irrigation systems, outmoded systems have been replaced by semi-automated and automated systems. Precision can be enhanced by automated systems; moreover it saves energy and resources as well. Modern techniques for irrigation in agriculture comprise drip irrigation, pot irrigation, sprinkle irrigation and many others [3]. IOT (a network of nodes) plays a major role with a combination of these methods for smart irrigation. The implementation of these systems needs technically colossal knowledge to manage smart systems efficiently. Advanced systems are deployed to reduce scarce watering including different parameters like to check the moisture level of soil, temperature, air humidity etc. like sensors are used to sense the reduction in moist level to alert the farmers [4]. Various techniques are in usage to inform about the need of water through connecting devices and also to automate irrigation through devices is becoming a common practice. Present systems emphasize common parameters like soil moisture level, temperature, water level, air humidity etc. which may support making an IOT based system. Moreover, the existing systems focused mainly on the architecture of the systems and protocols for communications etc. but the focus should be on the efficient decision makers to gather all the parameters helping in achieving the goal of ‘common sense’ [1]. The study is aimed to monitor the deficiencies of various techniques to standby the water resources considered specifically for agricultural irrigation. The intention is to propose a smart model which will remove all the drawbacks of existing systems, emphasizes on gathering real time desired parameters including all the acquaintance about the environment which provides a scenario for the proper

water application to avert the wastage of water, The importance of decision making rely on common sense-based scheduling to standby the resources. Collectively this study is to suggest a way for better reservation of water resources based on artificial intelligence, including better decision making, efficient water management, enhanced parameters which helps to incorporate 'common sense' in machines [5]. During concluding the planned research, the qualitative approach has been reflected, under which the evaluation and validation of existing systems was focused.

2. LITERATURE REVIEW

IOTs with the combination of various mechanisms can lead to an automated system of irrigation. Crop water availability is scrutinized by automated system with the help of sensors and controlled irrigation that ensures the watering. With the amalgam of IOT based application, soil moisture and temperature are focused for controlled monitoring. Major focus is the monitoring of water supply and plants by means of SMS [6]. This study further elaborated that the Management of water resources under climatic changes entails step wise approaches that consume time. An interactive program CSDSS having three modules combined in MATLAB and a graphical user interface which runs with ten Global climate models (GCMs) and emission scenarios (RCP 4.4,6.0,8.5) which causes hydro-climatic parameters based on input from GCMs, field and soil conditions and water balance model. It definitely helps the managers to make fast decisions for water management. An Automatic Wireless Water Management System (AWWMS) has been proposed in [7] focusing the optimal usage of water and declined labor manually in order to decrease time, power and expense. Solidarity of sensors mounted in the soil helps to gather real time information like air humidity, soil moisture and environmental temperature which then comes under the IOT gateway. An Automated irrigation system [8] unifies cloud computing, optimization tools and cloud computing by deploying low cost sensors to sense soil type, pH, weather conditions and soil moisture. Irrigation in computation is done by optimization model using solenoid valve meticulous by ARM controller. Reduction in water usage, data availability increment and visualization is exhibited. The main purpose of the study in [9] is the establishment of mechanic irrigation management by integrating sensing data remotely. It has distributed water-energy hydrological models and meteorological forecasting. Few studies proposes a system for irrigation monitoring and controlling erected on Wireless Sensor Network (WSN) and Internet of Things [10]. This involves data from the remote fields and collected through WSN and finally transfers to the cloud. Stored information in database helps in the attainment of feedback. Cloud via IOT gateway is occupied as information pathway. This study uses mobile hotspot as IOT gateway. When dry soil is recognized, a feedback signal is created by management system to switch over the pump ON. Condition and properties of soil fluctuates with time, so the monitoring of soil is needed. Studies has presented a digitally IOT based solution which is integrated with mobile and is presented to ensure smart gardening. Again sensors are used to collect data and all main vegetation conditions like humidity and soil moisture, light intensity and temperature with respect to time. For effective decision making from user by an Android app, collection data is analyzed by system to generate information via multi skilled IOT approach. ON/OFF actions on water pumps are done by actuators and microcontrollers through servers. An intelligent agent is used for recommendations to access plants data and provide commendations using plants predefined and current state so to help customized guidance for gardening [11]. A novel scheme has been proposed by [12] utilizing emerging smart technologies and IOTs for smartly irrigation of the crops in southern regions of Algeria to achieve the maximum efficiency for water consumption, to manage and monitor the irrigation system remotely. An effort has been made by [13] focusing on incorporating soil water balance model achieved by satellite and climatology forecast for the sustenance of smart irrigation. The amalgamation of soil water balance model and climatic forecast gives the idea of crop water necessity. Soil moisture is directly computed by using temperature sensors and satellite with precise values so to concern for energy balance and soil water for validating hydrological parameters of soil. Cost-effective and accessible sensors are used for real time data securing about plants and climatic conditions like intensity of light, soil moisture, air temperature and humidity etc. Smart choices regarding watering requirements are engaged by Fuzzy logic and the parameter of security that is fulfilled by Block- chain which provides reliability, privacy and scalability in the proposed system. By using SWS application in Android, it allows multiple users to display and interact with plants remotely. Fuzzy Logic actuators can securely and inexpensively handle the plant watering process [14]. 85% of water resources are used for irrigation purposes and the demand is rising day by day. A self-operated irrigation system is needed as water is the far most important commodity. Due to processing and storage aptitudes, cloud computing emerges as an attractive resolution to large amount of data. It is a mobile integrated irrigation system under control of IOTs which have the objective of plant monitoring and water supply with the help of smartphones [12]. Agriculture sector greatly needs systematic management for water reserves. Study proposes a smart system works on a truncated cost and customized soil moisture sensor to control water supply in areas that are water inadequate one. An interface is designed for the daily record of moisture data. Monitoring is

possible through wireless and low-cost sensing hardware. Method can be absorbed in automatic drip irrigation system to perform precision agriculture with water control at central level [15].

3. PROPOSED MODEL

A real time smart system is proposed which makes smart decisions focusing on parameters which helps to boost the factor of 'common sense' in machines [16]. Different modules took part in boosting the efficiency of the system. The model is using the following parameters. Outer world information includes (soil moisture level, temperature, air humidity etc.). Weather forecast information (from online weather forecast module). Need of crop for watering (from base knowledge and history). Proposed model illustrates in Figure 1.

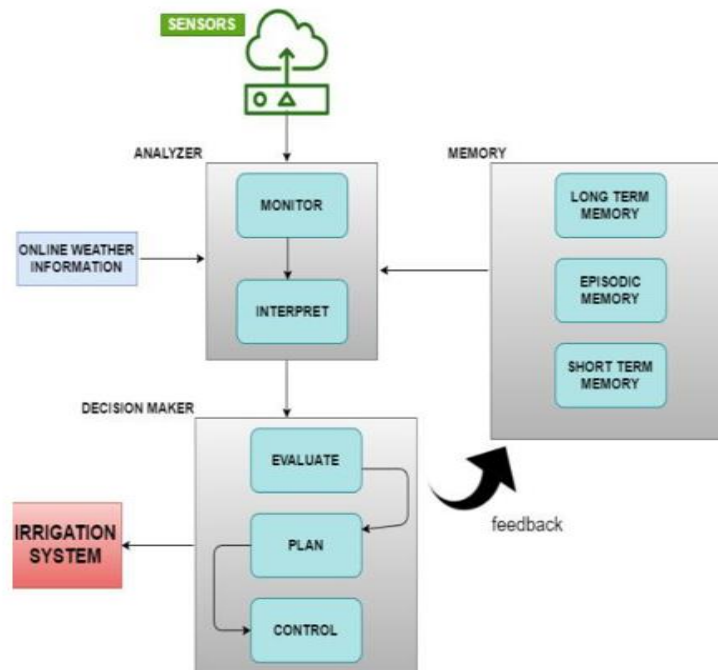


Figure 1. The Proposed Model

3.1 Sensors

These are the devices which are used to sense from the environment and give hypothesis to measure any property on the base of information sensed from the outer world and allowing the ability to respond back. In this study the discussion of sensors is about their correlation with the outer environment which perceives the different parameters from surroundings. Moreover, for soil it gives some variables to help in making a smart decision. They may incorporate soil moisture sensor, temperature sensor, air humidity sensor etc. The sensors are one of the foundations for input.

3.2 Analyzer

The working of the analyzer module communicates to the analysis of data, focusing on the structure and bringing in patterns to relate data. Here the analyzer contains two modules i.e. monitor and interpreter.

a) Monitor

Monitor module is introduced to monitor the sensor values from the outer natural environment at unvarying time intervals. Some threshold values are set for alert situations and when that situation appears, input values are passed for further description to the interpret module.

b) Interpreter

This module could gather more constraints to make the system 'environment aware'. This gets the base knowledge about soil and crop accumulated in long term memory which is considered below. Integration of input from sensors cited below, base knowledge and weather forecast evidence obtained from online weather forecast systems revealed in sections below, are inferred in the interpreter module and the input is explicated for more actions. This information is passed to the decision maker where it first meets the evaluation phase.

3.3 Online Weather Forecast module

Online weather forecast system is committed with an analyzer which will give the precise charge about the weather online. Many algorithms and models running on the large scale at the backend instead of some defined models and data set of previous years is urging for a reason for online systems, as its accuracy is trusted more [16]. This module offers the accurate and reliable variable for further evaluation.

3.4 Memory

There are three kinds of memories which are shown in the system. First is the long-term memory which contains the knowledge based information about the environment and as well as about crops and then the episodic memory which stores the feedback of required samples. Finally a short-term memory which is temporary memory for variable storage.

3.4.1 Long Term Memory

Long term memory has 'base knowledge' which contains many information regarding type of soil, condition of land that either it is arid (arid region requires more efficient ways of irrigation because of unavailable water resources), semi-arid, kind of crop, lifespan of crop, spell of cultivation, edaphic factors of soil. It conveys to the composition and formation of soil including fertility, a defined humidity and pH of soil, type of crop etc. The third constraint (need of crop for watering) is taken from the base knowledge, particularly focus on the life span of crop or the time of cultivation.

3.4.2 Episodic Memory

The basic role of episodic memory is the storage of events which occurred as an episode. It stores the feedback and if the same condition occurs, it can be beneficial. It has been saved for the future use and characterized as previous experience in future capacity or learning [17].

3.4.3 Short term memory

Short term memory is known as temporary memory for the storage of run time variables temporarily.

3.5 Decision Maker

It involves three major steps including evaluation, plan and control. Operational description of these steps is delineated in this section, whereas flow chart of the whole process is illustrated in Figure 2.

3.5.1 Evaluation

Evaluation step needs input where the outcome of watering the land is taken, which is a foremost pinnacle. Evaluation step underlines the 'yes' or 'no' values where the necessity of soil for watering is shown by 1, crop needs or time to water the crop is demonstrated by 1 and the weather forecast is exhibited by 0 and vice versa. A threshold value is stage set for the weather forecast i.e. for <90 is 1 and for >90 is 0 as the rain is estimated so there is no need to water the crop, it would be for the circumvention of over-humidity. Sort of fitness function is undertaken for decision design which takes the values in form of 0 and 1 and behave accordingly. The first four standards of soil situation show the inactiveness of monitor phase for supplementary interpretation. As the monitor phase continuously takes the values on specific time intervals, cycle remains in the monitor stage. If the values cross the threshold level, soil situation goes to 1 for further actions. Let's suppose the soil needs moisture i.e. 1 of that parameters, rain is expected i.e. 0, crop does not need water i.e. 0 then as a whole it becomes 0 (no watering is required). Let's suppose the soil needs moisture i.e. 1, rain is expected i.e. 0, and crop needs water; 1 then it remains 0 (no watering is required because as the expectancy of rain is present there will be a probability of over moisture the soil which will definitely cause damage). Let's suppose the soil needs water i.e. 1, rain is not expected i.e. 1 and the crop does not need water i.e. 0, as a whole it becomes 0 again means no need for watering. At last if the soil needs moisture i.e. 1, rain is not expected i.e. (1) and the crop needs water i.e. (1) the overall result will be 1 which means 'yes', there is a requirement for water.

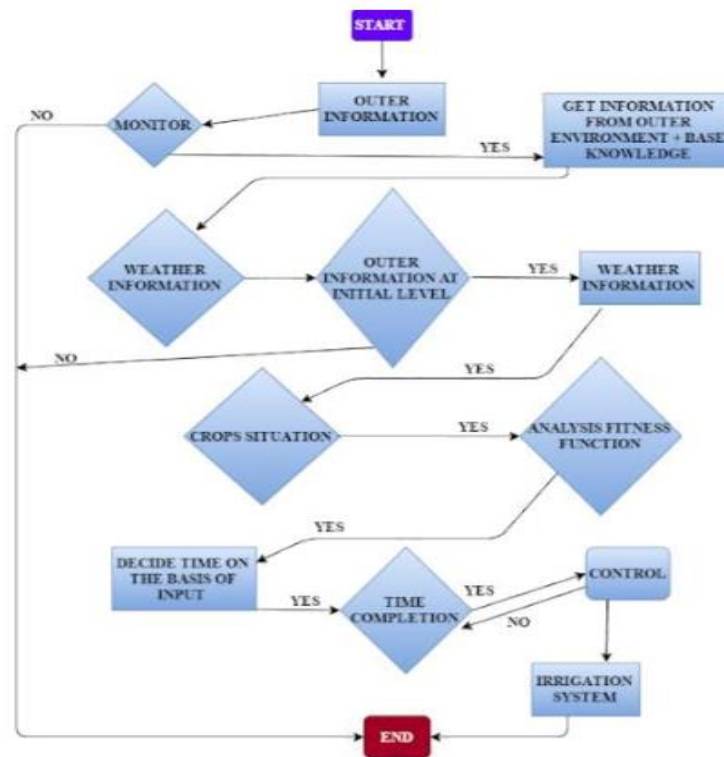


Figure 2. Flow of the proposed model

3.5.2 Fitness function

The function which assesses the solution of a conclusion to the optimum level, it summarizes a set of values to a single point of apprehension.

3.5.3 Plan

The decision further moves to the plan segment where the plan for watering is evaluated i.e. time period for watering concentrating on the physical feasibility of the environment including the structural design of the irrigation system. The decision of the period for watering changes based on several parameters like the current amount of moisture present, type of crop, age of crop, previous experiences etc. Decisions taken for watering or not considered by defined parameters will go to the recollection as feedback and flatters an episode in episodic memory.

3.5.4 Control

The control phase will stimulate, having a check which ON/OFF the irrigation organization for calculated time intervals.

3.6 Irrigation system

The irrigation system which incorporates the physical architecture includes either the water pump, sprinkle method, drip method and will activate it after getting control evidence from the control phase of the decision maker. Considering the recommended model, water can be reserved more as some comprehensive parameters with the coincidence of their detailed description that will make the system work more elegantly. The system is based on artificial intelligence to take assessment accurately and close to the way humans consider. The study is validated through experts' opinion employing the content analysis including the discussion, research notes, open ended questions, and interviews. These experts' of the domain were selected from various Universities of the Punjab. All the experts reliably informed dissimilar opinions after recognizing the model. However all the experts were equally persuaded of the utility of the proposed model and all were convinced that the recommended model is efficient for agriculture technology. In addition to that, their reviews on the implementation of the proposed model was critical

that no large farmer having huge resources will not implement the proposed model. On the other hand, the farmer whose resources are limited depends on how he implements the novel model. Due to lack of funds, implementations are difficult and the implementation of the proposed model is quite intricate in the future but in spite all, it will be of major importance if there is an implementation. All experts unanimously concurred that the recommended model is a novel technology innovation that will be somewhat convoluted and can be made easier to regulate and manage with the assistance of applied technologies. All experts were of the opinion that technology is evolving day by day, due to which the proposed model has to be restructured with future changes in the context of a smart environment.

4. VALIDATION

The main purpose of validation is to make sure that the proposed model overcomes all the problems that have led to the proposition of novel model. The irrigation system is the backbone of any country and the equal distribution of water resources means a lot to all those folks whose farming depends solely on the canal system. All the countries of the world are urban and rural areas with different modalities and in some countries rural areas are particularly difficult to accept for an innovative system. To validate the proposed model a comprehensive survey based on questionnaire survey has been conducted. Expert opinion from irrigation department officials has been gathered and on the basis of results it can be validated that the proposed model is more efficient than cited models of irrigation. In the local circumstances of developing countries like Pakistan, the proposed model pay keen contribution in betterment of the irrigation system. Such findings are hereby portrayed in Figure 3 to Figure 10 respectively. The gathered opinions of the irrigation department professionals were of meticulous significance when finalizing the results of the survey.

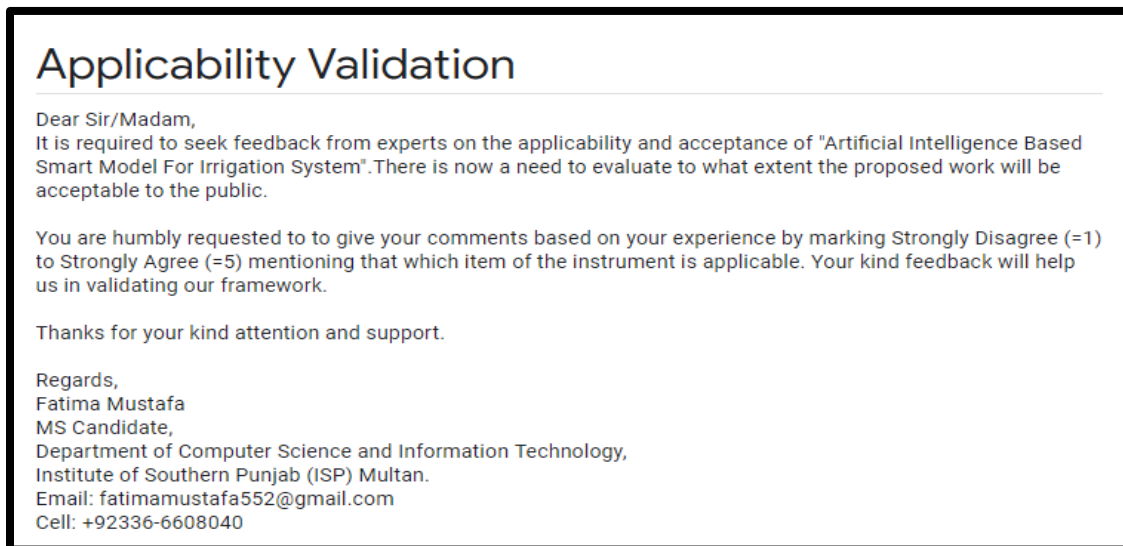


Figure 3. Description of Validation

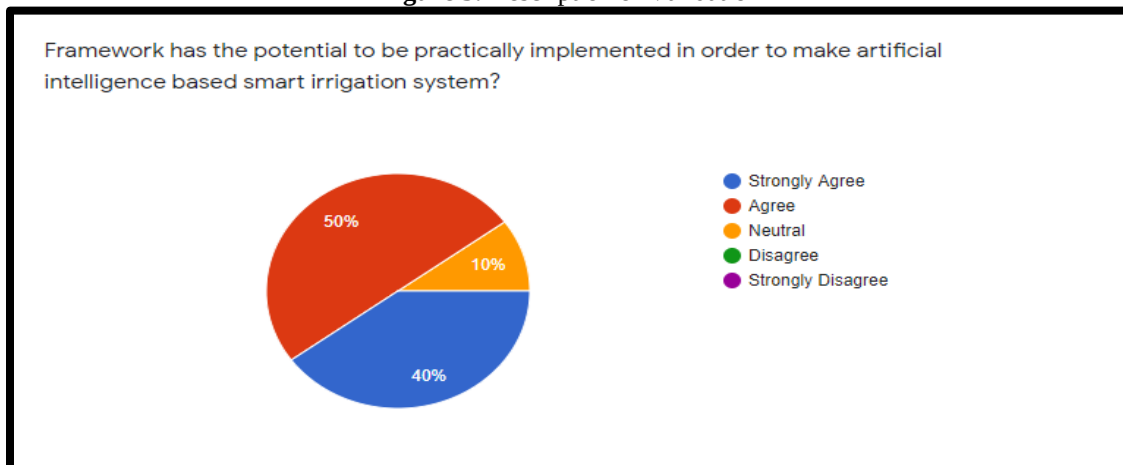


Figure 4. Survey responses of practical implementation of proposed framework

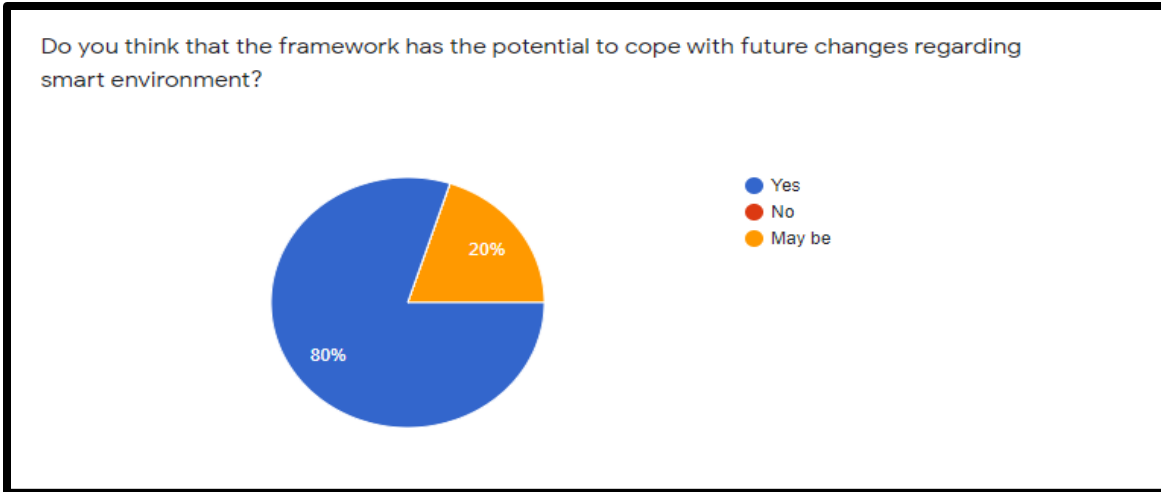


Figure 5. Survey responses of Cope with future changes

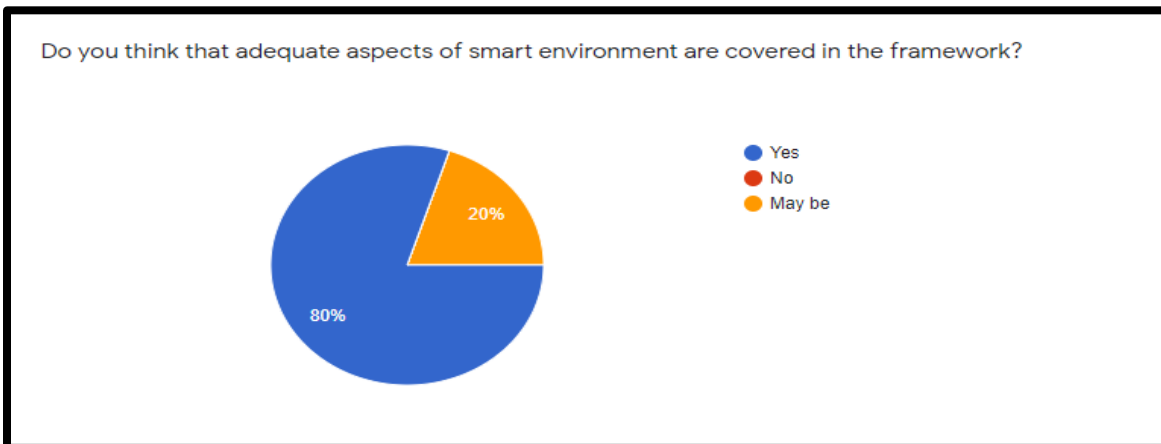


Figure 6. Survey responses of smart environment

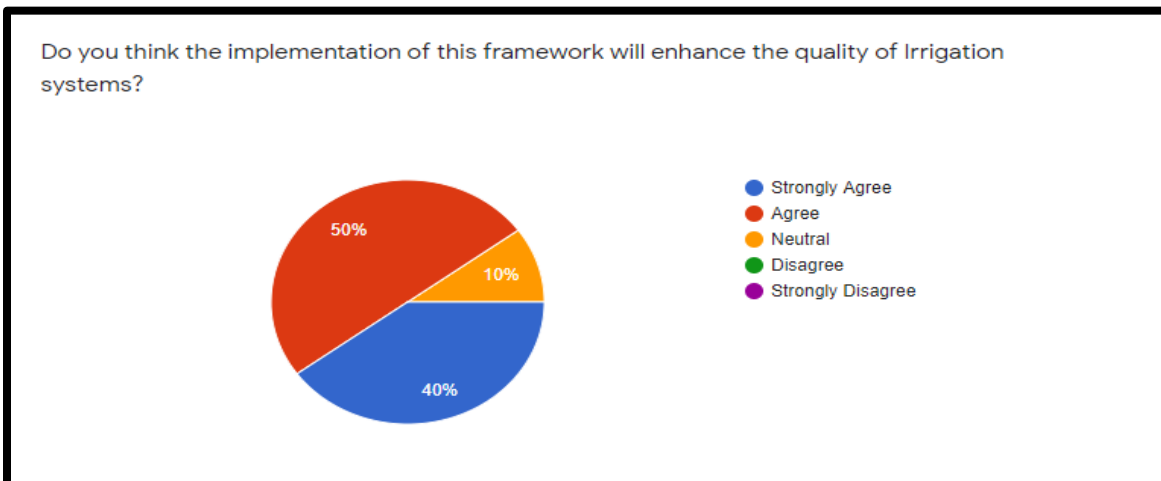


Figure 7. Survey responses of quality enhancement of irrigation system

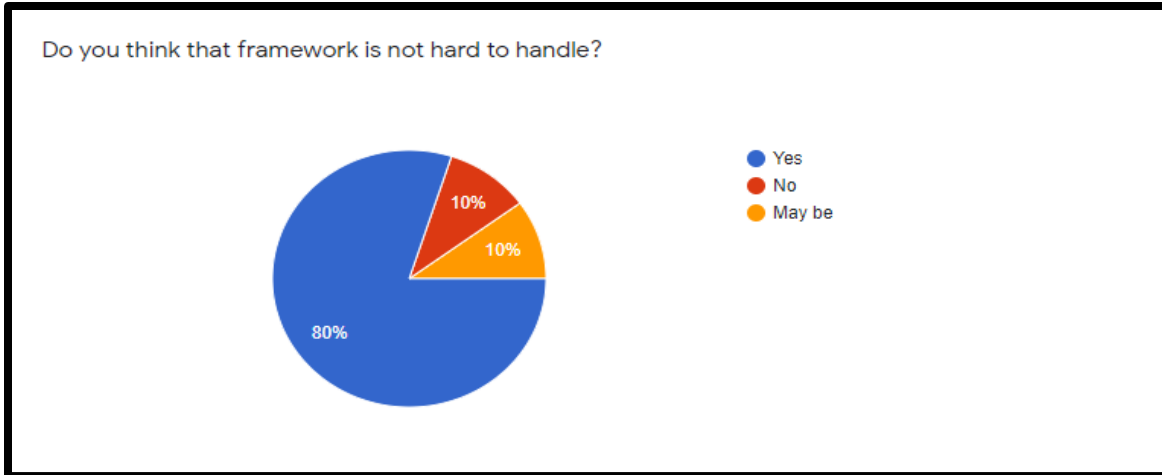


Figure 8. Survey responses of management of proposed model

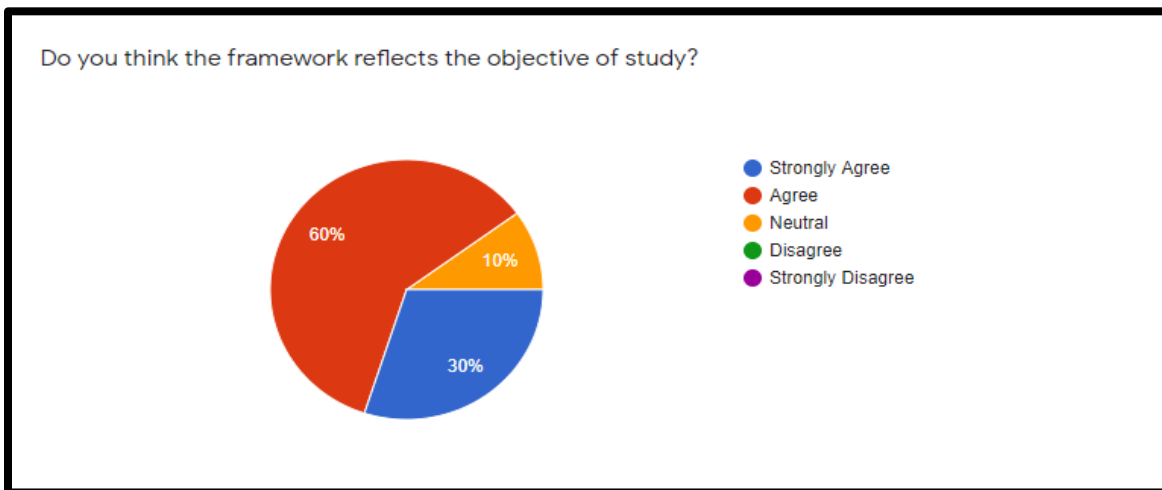


Figure 9. Survey responses of objective of study

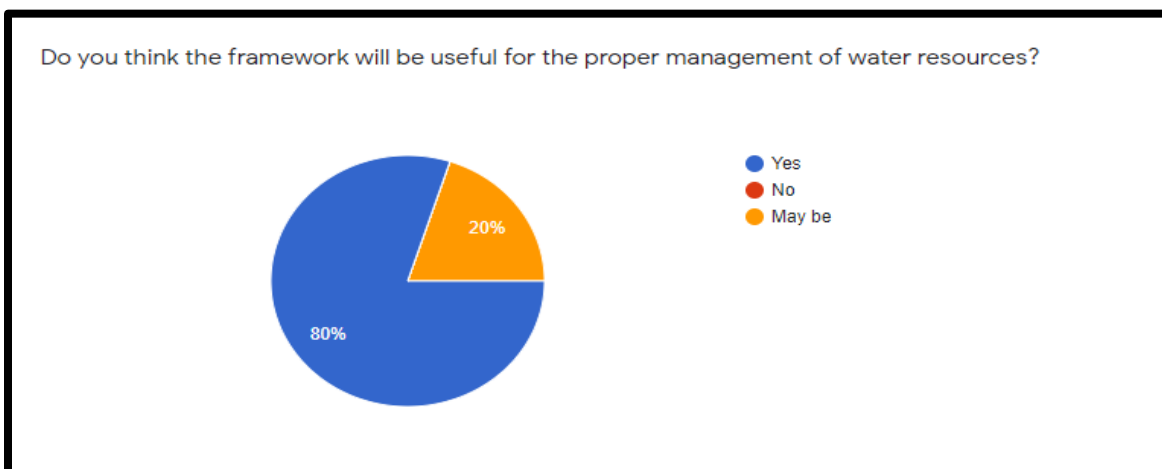


Figure 10. Survey responses of management of water resources

5. CONCLUSION

The findings of the study would be conducive for the agricultural field where there is demand for a system that makes smart decisions which will provide enhanced benefit for the management of water resources. The greater the water scarcity would be expected in coming years the greater would be the need of efficient systems to lower the wastage of commodities that would be scarce. For agriculturists the proposed system would be beneficial as the system lowers the manual labor, proposed decision making on the basis of artificial intelligence which does work more with machines and minimizes human involvement. This would be beneficial for the administration of a country as its practical implementation will minimize the risk of water shortage (that would be alarming for the survival of life).

After contemplating the previous models, it gives an impression to find a new type of model to be recognized and addressed as a solution for distinct problems. As the world is evolving towards the smarter descriptions of the prominent services, it is necessary to headway for a smart environment. The proposed model is advancing towards the smart blend of irrigation water management which includes artificial intelligence for decision making (a highlighted parameter of managing anything). A human-like thinking approach is recommended to embed common sense in contraptions. Apart from previous prose, the present one focused on the needs of a machine. To think like humans by indulging the factors like history, base knowledge, weather information and outer information in a form will make a system able to decide estimations like humans. The model recommended in the research is highlighting the importance of decision making by identifying the combined parameters of the system in a real sense for approach till the thinking of the human. The combination of evidence from sensors, the weather forecast information, history and elements of that specific area (which will let a machine suggest a decision by focusing on consequences on the other hand) made this system a progressive march to the field of artificial intelligence.

The ground-based implementation of the proposed model will be an essential direction for the future as it depends on ground work technology-rich infrastructure and sufficient funding as well.

ACKNOWLEDGEMENT

This work is part of MS research conducted in the Department of Computer Science, Institute of Southern Punjab, Multan, Pakistan.

REFERENCES

- [1] K. Vijaya, V. Kowshika, S. Monisha, and G. Kaushika, "Smart irrigation and soil monitoring system using IoT," 2019.
- [2] C. Fisch and J. Block, "Six tips for your (systematic) literature review in business and management research," *Management Review Quarterly*, vol. 68, pp. 103-106, 2018.
- [3] J. F. Wolfswinkel, E. Furtmueller, and C. P. Wilderom, "Using grounded theory as a method for rigorously reviewing literature," *European journal of information systems*, vol. 22, pp. 45-55, 2013.
- [4] J. Webster and R. T. Watson, "Analyzing the past to prepare for the future: Writing a literature review," *MIS quarterly*, pp. xiii-xxiii, 2002.
- [5] J. D. F. Selvaraj, P. M. Paul, and I. D. J. Jingle, "Automatic wireless water management system (AWWMS) for smart vineyard irrigation using IoT technology," *Int. J. Ocean. Oceanogr.*, vol. 13, pp. 211-218, 2019.
- [6] M. S. Munir, I. S. Bajwa, and S. M. Cheema, "An intelligent and secure smart watering system using fuzzy logic and blockchain," *Computers & Electrical Engineering*, vol. 77, pp. 109-119, 2019.
- [7] S. Vaishali, S. Suraj, G. Vignesh, S. Dhivya, and S. Udhayakumar, "Mobile integrated smart irrigation management and monitoring system using IOT," in *2017 international conference on communication and signal processing (ICCSP)*, 2017, pp. 2164-2167.
- [8] A. Kumar, K. Kamal, M. O. Arshad, S. Mathavan, and T. Vadamala, "Smart irrigation using low-cost moisture sensors and XBee-based communication," in *IEEE Global Humanitarian Technology Conference (GHTC 2014)*, 2014, pp. 333-337.
- [9] L. García, L. Parra, J. M. Jimenez, J. Lloret, and P. Lorenz, "IoT-based smart irrigation systems: An overview on the recent trends on sensors and IoT systems for irrigation in precision agriculture," *Sensors*, vol. 20, p. 1042, 2020.
- [10] N. A. M. Leh, M. S. A. M. Kamaldin, Z. Muhammad, and N. A. Kamarzaman, "Smart irrigation system using internet of things," in *2019 IEEE 9th International Conference on System Engineering and Technology (ICSET)*, 2019, pp. 96-101.

- [11] E. Udayakumar, S. Balamurugan, and P. Vetrivelan, "A Neural Network-Based Automatic Crop Monitoring Robot for Agriculture," in *The IoT and the Next Revolutions Automating the World*, ed: IGI Global, 2019, pp. 203-212.
- [12] M. Senapati, R. K. Das, and B. Samal, "Wireless Smart Irrigation System," *Int. J. Eng. Res. Technol*, vol. 8, 2020.
- [13] J. Patel, E. Patel, and P. Pati, "Sensor and Cloud Based Smart Irrigation System With Arduino: A Technical Review," *Int. J. Eng. Appl. Sci. Technol*, vol. 3, pp. 25-29, 2019.
- [14] P. Y. Julien and O. A. Martyusheva, "Smart water grids and network vulnerability," in *smart water grid international conference*, 2013, pp. 12-14.
- [15] S. Harishankar, R. S. Kumar, K. Sudharsan, U. Vignesh, and T. Viveknath, "Solar powered smart irrigation system," *Advance in electronic and electric engineering*, vol. 4, pp. 341-346, 2014.
- [16] P. Ranade and S. Takale, "Smart irrigation system using FPGA based wireless sensor network," *International research journal of Engineering and Technology*, vol. 3, pp. 2229-2232, 2016.
- [17] M. D. Dukes, M. Shedd, and B. Cardenas-Lailhacar, "Smart Irrigation Controllers: How Do Soil Moisture Sensor (SMS) Irrigation Controllers Work?," *EDIS*, vol. 2009, 2009.