Chapter 6
Smart Farming Prediction System Embedded with the Internet of Things

R. Mallikka, S. S. Manikandasaran, and K. S. Karthick

6.1 Introduction

Recently, a lack of water for agriculture has become a rising concern, especially for Asian countries such as India or Mediterranean countries. The Mediterranean countries are the most helpless against the dry season among the countries in Europe [1]. A good irrigation system is a basic requirement for the fortitude of farmers because it gives water—i.e., the lifeblood of crops—to the growing plants. Irrigation systems include various methods of getting water from various sources and conveying it to different mediums and are essential in all types of agriculture because of the unpredictable nature of the weather. It is contended that understanding the feasible and cost-proficient conventional water system techniques is important for local networks in India. The three regular conventional strategies that exist in India are complex channels utilization of stones and tree limbs, small-scale water bodies such as water system tanks to store water, and wells to gather groundwater. These techniques are commonly intended for small scale/local use for a town and large-scale or territorial applications. The small-scale customary water system techniques are not only arranged and developed by the local individuals but are also overseen by them locally, while the large-scale conventional water system

R. Mallikka (✉)
Department of Computer Science, Engineering and Applications, Bharathidasan University, Trichy, Tamilnadu, India

S. S. Manikandasaran
PG & Research, Department of Computer Science, Adaikalamatha College, Vallam, Thanjavur, Tamilnadu, India

K. S. Karthick
Bharath Niketan Engineering College, Theni, Tamilnadu, India

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strategies include the surface or flood water system techniques such as bowl, fringe, and wrinkles.

The plan and structure of every conventional water system technique are chosen by the territory and precipitation history of the district [2]. In regions of good groundwater springs, burrowed wells with creative techniques are utilized to lift the water to the surface, and in the low precipitation regions, individuals utilize strategies that capture every single drop of water where it falls. These traditional water system techniques have made life possible, even in the desert areas.

The Internet of Things (IoT) speaks to a general idea for the capacity of system gadgets to detect and gather information from our general surroundings, and share that information over the Internet where it tends to be prepared and used for different fascinating purposes. The Internet of Things is rapidly turning into a reality. We can see the evidence of it around us. The Internet of Things is a system of physical items that interface with one another through the web. Things or objects can move data remotely without requiring human collaboration.

A farmer from Bahirwadi [3], (Vishwanath) a town in the dry spell inclined Beed area of Maharashtra, has earned Rs 7 lakh (700,000 rupees; ~9592 USD) from farming on only one acre of land. This farmer chose to try multi-cropping, and he likewise decided that he could expand his harvest by building a wire fence and planting creepers and climbers on them. He additionally introduced a pipeline with his first-year earnings to guarantee sprinklers watered his plants. He has also used cultivating strategies such as raised-bed gardening and mulching throughout the year, which has been useful.

In this work, we combined a smart irrigation prediction system with the IoT to improve farming. The challenges of the existing methods are a lack of groundwater and rain, which leads to an insufficient food supply for society. To overcome the problems of the exiting methods used in irrigation systems, our proposed method used various sensors for temperature, humidity, and soil moisture. Farmers are able to predict market value based on suitable crops, soil type, appropriate weather, water requirements, maintenance cost per acre, and analysis of farming risk factors.

The researchers in [4] have recommended farming systems dependent on the embedded frameworks, IoT, and remote sensor networks for agri-farm fields and domesticated animal ranches. This chapter incorporates the portrayal of frameworks with the electronic hardware of the frameworks, utilized organization conventions, and smart remote monitoring frameworks for PCs and smartphones, and so forth. Social IoT or SIoT [5] can hugely contribute to help gauge climate, pest control, humidity, precipitation, soil fertility, determine leaf moisture levels, temperature variation, airflow, and soil moisture. SIoT can likewise control plant ecological variables through temperature, moisture levels, carbon dioxide focus, and brightening as indicated by the state of crop development in real-time, and it tends to be utilized in vertical farming.

Farming 4.0 is a term for following the enormous patterns confronting the industry, helping to bring exactness to the agribusiness, using the IoT and big data to drive business efficiency despite the rising population and environmental change. The researchers in [6] have described consolidating machine learning calculations to the embedded hardware stage for information examination to help farmers achieve precision farming. The model utilizes Raspberry Pi. Machine learning calculations have been embedded for data acquisition from different sensors such as pH sensors, fire sensors, and pressure sensors. This examination inspects SVM usage in embedded processor models and offers improved engineering productivity. The current agricultural robots are being leased, sold or enlarging social work [7] on the terrains, where products of the soil are developed. With the utilization of robots in farming, the yield of production can be increased, while the expenses related to production can be decreased over time.

The rest of the chapter is organized as follows: Section 6.2 covers the background study about the smart farming system, Sect. 6.3 explains traditional methods for smart irrigation systems, Sect. 6.4 discusses the proposed irrigation prediction system, Sect. 6.5 explain the results, and Sect. 6.6 concludes the chapter and mentions the future direction of the work.

6.2 Background Study

The taxonomy of the traditional farming system is shown in Fig. 6.1, and it includes categories such as farming, agriculture, and crops with various methods of using the tradition farming system.

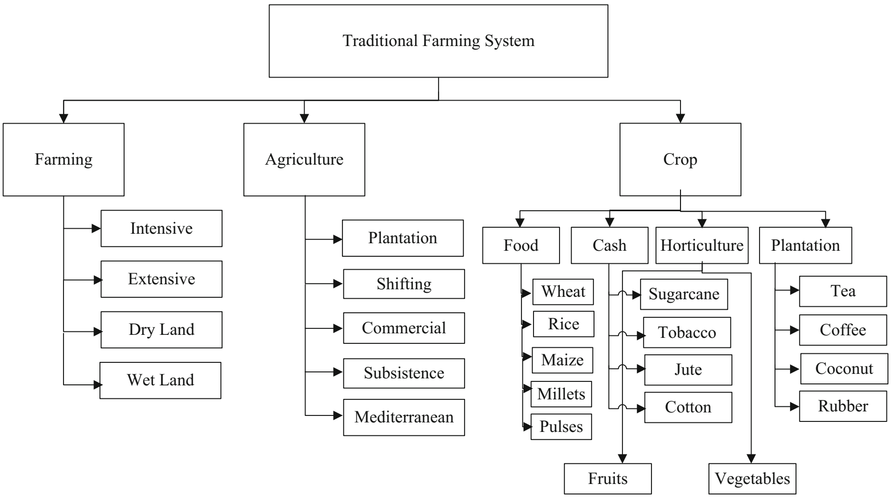


Fig. 6.1 Taxonomy of the traditional farming system

6.2.1 Traditional Farming System

The authors in [8] provided a brief literature review of traditional agriculture and management of plant disease/infections. Traditional practices have intense results on advanced agriculture and most of the best practices are based on the traditional way of agriculture. Conservation and resource management have not always been followed using the traditional farming system. The labor-based method is followed in the traditional farming system; an increased number of laborers are involved in agriculture, reducing the chances of unemployment. In [9], the authors discussed the cultivation of fodder crops using the traditional method and partial farming system. The amount of energy consumed by land preparation, fertilizer application, sowing, irrigation, and harvesting is calculated based on ratio. The energy ratio for the traditional and partial method in yield, production energy, input energy, and output energy was calculated. The results indicated that the partial farming system has higher yields compared with the traditional system.

As indicated by the Indian National Crime Record Bureau [10], 60,670 farmers committed suicide in Maharashtra between 1995 and 2013, most of whom were from the cotton-farming belt. The high occurrence of farmer suicides has brought notice to this area and its powerful rural framework. A few families have reacted to the agrarian emergency in Vidarbha by embracing low-input, conventional, and economical farming practices dependent on the standards of sustainable farming, referred to locally as shashwat sheti. While cotton was developed [11] in Vidarbha before colonial rule, its broad development started under pressure from the British organization in an offer to increase agrarian production in India. Chief among the cotton-developing regions was Berar Province, which went under the British Raj in 1853, presently known as the Amravati area of Vidarbha. Cotton from Berar was shipped to the cotton plants of Britain during the Industrial Revolution. Indian cotton production in Vidarbha expanded significantly during the cotton famine that occurred because of the American Civil War between 1861 and 1865.

The Himalayan locale [12] is renowned for its beautiful valleys and quiet magnificence. Patio cultivating provides sustenance for Himalayan individuals, who grow an assortment of oats, millets, beats, oilseeds, and pseudo-grains. A significant part of the varieties grown in the Himalayan zones includes landraces adjusted to the natural local conditions. Additionally, different indigenous practices utilize the available resources. Such practice incorporates field planning, seed planting, weed destruction strategies, determination of yields according to the appropriateness of the ecological conditions, pest control, harvesting techniques, and germination capacity of the seeds. Indigenous individuals, as a rule, develop different crops in an intermixed or interchange way, with the goal that the soil well-being and yield efficiency can be maintained.

According to the 2011 census, there were 1034 ghost villages in Uttarakhand, and that number increased to 1768 in 2018. In the past 10 years, almost 138 individuals moved away from the state's villages. Among these, 33 stay away from their village for the indefinite future and 105 return occasionally to their villages for short spans

[13]. It is not only the relocation of individuals but also their customary information is likewise relocating alongside them. In the recently settled zones, individuals do not practice their customary information and practices. Like this, a wealth of customary knowledge is being forgotten. In the past, farming was the primary wellspring of employment for these individuals, but now farming is considered as a below average occupation. Beforehand, developing was additionally an agreeable endeavor of the residents. Individuals used to take an interest in furrowing and other agriculture acts of each other. In the past, the entire network took an interest to experience the issue of human–untamed life strife.

The interest in freshwater [14] is on the rise because of rapid population growth. Simultaneously, the impact of dangerous atmospheric deviations and environmental changes causes extreme danger to water use and food security. Therefore, irrigation systems are used by numerous farmers worldwide, especially for their detailed measure of water utilization from different sources. There is an expanded spotlight on improving the productivity of water utilization in agriculture water systems. The IoT and propelled control methodologies are being utilized to accomplish improved checking and control of the water system for farming. In this audit, a careful review of water system observations and propelled control frameworks featuring the research of the previous 10 years are introduced. Consideration is paid to ongoing research areas identified from the observations and advance control ideas for a precision water system. Typically, this audit serves as a valuable reference to inform about checking and propelled control openings identified when using water systems in farming and it helps analysts to distinguish directions and gaps for future research in this field.

According to the Economic Survey [15], 2017–18, over half of the entire workforce in India is utilized by the Agricultural division, contributing approximately 17–18% of the nation's GDP. Regardless of the motorization in the agriculture division, improved rural strategies to enhance crop production are needed. Ill-advised water system practices bring about lower food production and imperfect crop yields. Likewise, there is a need to enable the farmers to decide the most reasonable return depending on the plant. One approach to address these issues is to utilize the IoT in the agrarian area. The Internet of Things is the systems administration of sensors, organized features, and gadgets to computerize regular assignments and perform activities contingent upon the condition of the encompassing. The aim of this work is to survey the advancements in agribusiness to computerize the water system and select the best crop to plant.

6.2.2 Traditional to Smart Agriculture System

The natural [16] and monetary effects of a few supply frameworks for water systems have been examined. An off-grid (diesel motor) and on-grid (network power) vital supply framework with a PV plant was compared. The LCA technique and restitution period was utilized to decide the effects connected to every supply alternative. An affectability investigation demonstrated the life expectancy length and diesel and power costs impact. The PV framework introduced the least natural effect and life cycle cost, in spite of the fact that it demonstrated the most noteworthy initial speculation.

The communication advances of the IoT assume a significant job in a smart agriculture framework [17]. A smart water system framework dependent on LoRa innovation was proposed and tests were conducted to prove the superb performance of the proposed water system framework. The test results validate the pertinence of the proposed framework and indicate the benefits of LoRa innovation embraced in smart irrigation systems. The framework proposed encourages increasingly active communication, to limit the expense of sending and systems of support. As per the test results, the water system hub outfitted with a hydroelectric generator can work for a considerable length of time.

Regardless of more outstanding efficiency [18], the farming business faces new difficulties that undermine human development. With population growth and the intricacy of environmental change, the farming business has been compelled to progress away from mechanical techniques to information-driven administration and computerization to produce more food while utilizing fewer resources. Another worldview is conceivable with the selection of utilizations and arrangements driven by the convergence of a few key innovations, including the Internet of Things, Artificial Intelligence, and applying autonomy. Together these advancements keep a homestead beneficial and gainful by gathering and breaking down information to assist farmers with dealing with their resources, produce better crop yields and animals while enhancing vitality and compound use and alleviating hazards. Be that as it may, information-driven administration has just been the start of the new change in perspective. The ecological and financial cost of work and resources will continue developing operational proficiency. Farms are moving from information-driven administration to mechanization. The move has been in progress with new applications requiring less human intercession and addressing fundamental issues, including food deserts, work deficiencies, and specialized difficulties, for example, developing in urban conditions and perceiving plants through image processing.

Researchers in [19] indicated that a reason to use smart farming system was because a farmer needs to go to the homestead to check the water level in the field and to turn the water siphon on or off, even at mid-night. This issue can be overcome by improving old farming techniques. Another framework can be created or planned, which changes the old conventional growing into smart development. Researchers attempted to make a straightforward water siphon controller, with the soil moisture sensor, utilizing Esp8266 NodeMCU-12E, which is helpful in the agribusiness field. Framework security was provided by using transport layer security (TLS) and secure attachment layer (SSL) cryptographic conventions. Esp8266 NodeMCU-12E has easy, low force utilization, and a small size microcontroller, which makes the proposed framework suitable for the given application. The high accuracy soil moisture sensor provides simple readings, so soil moisture content is effectively measured. Finally, it showed soil moisture amounts and water siphon state in web page and mobile applications.

Dangers brought about by environmental change [20], growing population, and diminishment of natural resources present a need to search for alternatives that improve manageable crop production. Bioprospecting new assortments that are flexible to the content of the atmosphere and tolerant to biotic and abiotic stresses is of great importance. Supplanting old varieties and finding promising unique assortments could bring a new period of reasonable production. In the national seed framework, especially in the farming world, the assortments utilized by the farmers ought not to be more seasoned than 10 years aside from for certain exceptional circumstances. Furthermore, administrative bodies, breeding associations, seed organizations, and national seed frameworks should be responsible for moving the hereditary additions related to the varietal substitution rate. In addition, a five-point system's viable usage could positively upgrade the VRR, which will eventually lead to reasonable efficiency.

Researchers in [21] explained their challenges in seed priming in field crops. A portion of the difficulties regarding seed adaption preparation involves the life span of seeds after traditional sorts of preparing under surrounding stockpiling conditions and an absence of studies on hermetic bundling materials for broadened capacity. This investigation [22] affirms that steady information about homesteads prompts ideal choices. Rural administration frameworks can deal with farm information so that outcomes are arranged to address revised answers for each farm. This guide for farmers as advanced arrangements joins powers with mechanical technology and artificial intelligence to assist in agriculture. Following 30 years of extraordinary hopes—and dissatisfactions—of applying autonomy to agribusiness, the planning appears to be nearing an end. Nonetheless, to get the most out of Agriculture 5.0, profound preparation should be conveyed to clients; in a perfect world, youthful farmers will be anxious to learn and apply present-day advances to agriculture and conceding a generational restoration still to come. Now is the correct opportunity to push ahead toward advanced and practical agriculture that is fit for demonstrating the full intensity of information-driven administration to confront the challenges presented to food production in the twenty-first century. The advancement to Agriculture 5.0 is in the plan of most significant homestead gear producers for the following decade, and subsequently off-street hardware makers will assume a vital job in this move if agriculture robots are considered as the coming—smarter—age of farm machines. Smart farming technologies raise moral issues related to the expanded corporatization and industrialization of the agriculture area. Specialists investigate the idea of biomimicry to conceptualize smart farming technologies as biological developments that are installed in and as per the indigenous habitat. Such a biomimetic approach of smart farming technologies takes a bit of leeway of its capability to relieve environmental change, while at the same time keeping away from the moral issues identified with the industrialization of the rural area. Six standards of the idea of biomimicry were investigated and these standards were applied with regard to smart farming technologies in [23].

Large data applications in smart farming and recognition of the related financial difficulties to be tended were discussed in [24]. Following an organized methodology, an applied system for examination was built that can likewise be utilized for future investigations on this theme. The survey shows that the extent of big data applications in smart farming goes past essential production; it affects the whole food supply chain. Substantial information is employed to give prescient bits of knowledge in farming tasks, drive continuous operational choices, and update business forms for game-changing plans of action. A few creators in this way propose big data will cause significant movements in jobs and force relations among various players in current food supply chain systems. The partners' scene displays a fascinating matchup between amazing tech organizations, financial speculators, and frequently small new companies and new contestants. Simultaneously, there are a few open foundations that distribute transparent information under the condition that people's protection must be ensured. The fate of smart farming may disentangle in a continuum of two extraordinary situations: shut, exclusive frameworks in which the farmer is a piece of a profoundly coordinated food supply chain or open, cooperative structures in which the farmer and each other partner in the chain organization is adaptable in picking colleagues for the innovation concerning the food production side. The further improvement of information and application framework stages and principles and their institutional implementation will assume a pivotal role in the fight between these situations.

Farming is a tremendous undertaking for humans that affects the lives of the general public [25]. Agriculture is the most significant aspect of social progress. The mechanical headway in remote communication and decrease in size of sensors has extended their use in different fields, such as ecological observing, precision farming, social insurance, military, smart home, and so forth. This work [25] gives an understanding into the different requirements of remote sensor technologies, wireless sensor bits utilized in agriculture, and the difficulties associated with the arrangement of wireless sensor networks (WSN). Smart farming (SF) has assumed a significant role to improve production in agribusiness. This effort centers on smart farming as well as contrasted and customary techniques in agribusiness.

These days, the expanded rural production at a lower cost is increasingly determined by the IoT and the distributed computing ideal models. Numerous explorations and ventures have been explained so far in this unique circumstance. It targets decreasing human endeavors such as resources and force utilization. For the most part, such experiments are dependent on gathering different information relating to the rural territory and sending it to the cloud for additional investigation. Be that as it may, the significant distance between sensors/actuators and the cloud prompts a vast increase in inertness, which prompts a lessening of performance of the irrigation systems, pesticide checking, and so on. This work [26] presents an elective arrangement dependent on fog nodes and LoRa innovation to advance the quantity of hubs organization in smart homesteads. The proposed arrangement decreases the absolute inertness prompted during information transmission toward the cloud for handling.

Smart farming [27] includes the joining of data and communication advances into hardware, gear, and sensors for use in rural production frameworks. Innovations, for example, the IoT and distributed computing, are required to propel this turn of events, presenting artificial intelligence into farming. Accordingly, the points of this paper are twofold: First, to portray the logical information about SF that is accessible in the overall literature dependent on the fundamental variables of advancement by nation and after some time and second, to depict current SF possibilities in Brazil from the viewpoint of specialists in this field. The exploration included directing semi-organized meetings with market and analyst specialists in Brazil and utilizing a bibliometric overview using methods for information mining programming. A combination of the diverse, accessible frameworks available was distinguished as one of the principles restricting elements to SF development. Another restricting variable is the instruction, capacity, and abilities of farmers to comprehend and deal with SF devices. These confinements uncovered an open market door for undertakings to investigate and help tackle these issues, and science can add to this procedure. China, the United States, South Korea, Germany, and Japan contribute the biggest number of research studies to the field. Nations that put more in R&D produce the most distributions; this could show which nations will be pioneers in smart farming. The utilization of both examination strategies in a reciprocal way permitted seeing how science outlined the SF and the main boundaries to embrace it in Brazil.

Since sustainability is challenging and there is a need to secure the production of high-quality, affordable, and healthy food, alternative food production/distribution schemes have emerged that can increase food production without burdening the environment by using technological or organizational innovation [28]. Short food supply chains (SFSCs) and smart farming have potential as solutions for these challenges. Theoretically, introducing smart farming technologies into SFSCs could increase the value-generating capacity of short food supply schemes. However, it is questionable if such technologies are compatible with SFSCs. In this study, the authors followed a mixed research design, to analyze Greek farmers' and consumers' perceptions of the compatibility between smart technologies and SFSCs, and they examined the extent to which compatibility perception affects willingness to engage in smart SFSCs. The authors found that perceived (in)compatibility was central in predicting willingness for both farmers and consumers. The study revealed the existence of two different types of compatibility: actual compatibility, which involves the consistency of smart technologies with the technological advancement of farms and the real everyday needs of farmers, and symbolic compatibility, which involves the meanings attributed to both SFSCs and smart technologies by farmers and consumers. The study concludes that smart technologies are viewed as tools that can lead to a conventionalization of SFSCs, which alters their preferred distinct nature, and that the promotion of smart farming should include more than just traditional views of smart technologies as tools that increase farm efficiency and also pay attention to their compatibility with different types of agriculture and to the ways they can bring about change to farming systems.

Drones are beginning to be used in farming. It is assessed that drones in the rural market will be valued at billions of dollars in the next few years. As editor of the UN Food and Agriculture Organization and the International Telecommunication Union's exploration report on "UAVs and agriculture," data master Gerard Sylvester said that as farmers work to adjust to environmental change and address different difficulties, drones are required to enable all agricultural endeavors to improve proficiency [29]. With the progression in drone advancements and new companies/producers demonstrating interest in the business, it is expected that the expense of the robots and the extra gear will decrease. Likewise, flight time and distance should be increased as a result of basic advancements, for example, battery stockpiling and reduction in payloads. These improvements will guarantee that farmers get more advantages from the utilization of robots in farming [30].

6.3 Supply Chain Management in Agriculture

The study in [31] portrays the overarching promoting courses of action in Tanzania at local, provincial, national, and fare markets utilizing contextual analysis models. The significant obstacles for trade in Tanzania have been sorted into three groups: (1) physical foundation, (2) know-how and capital, and (3) institutional system. A lack of physical foundation including streets increases the expense of transportation, acts as a casual market barrier, creates a wedge between the provider cost and purchaser cost, and expands the loss of short-lived items. The absence of expertise appears in poor market direction and business abilities and prompts challenges in overseeing and getting financial advances. Moreover, the current institutional structure cannot bolster the arrangement of solid brokers and makers' affiliations and other agent bodies to upgrade the limit building and to expect more pleasant terms of exchange. Also, the absence of market data and the weak legal framework lead to challenges in arranging exchange understandings and upholding the current agreements. At present, the important institutional structure has been filled in for by long supply chains of go-betweens and depends on close to home connections between makers, merchants, and intermediaries. To understand the maximum capacity of agrarian exchange as an instrument in the battle against poverty, the recommended approach mediations are to organize and expand financing for a physical framework from both national and universal sources; place accentuation on rural non-farm work and intra-territorial exchange advancement (horizontal integration); advance large-scale limit working in business abilities and market direction; improve access to credit and improve the administration of the current plans; implement the current laws and bolster formalization of agreements to decrease trade dangers; lastly improve dispersion of market data to permit markets to work proficiently.

Supply chain management [32] generally indicates dealing with the connection between organizations liable for the proficient production and supply of agribusiness items from farm level to buyers, to dependably meet buyers' necessities as far as amount, quality, and cost. This regularly incorporates the administration of both horizontal and vertical coalitions. In developing nations, the supply chain of rural items regularly includes numerous players or operators with numerous farmers on one side and shoppers on the other. These conventional supply chains are firmly connected with social structures. For the most part, small farmers in developing nations are not able to set their own price and their contact with "business sectors" is regularly restricted to associating with a produce gatherer or to deals at the neighborhood/town market and area advertising. Indian agribusiness is ruled by small holders, approximately 86% having the land property of up to 2 ha, with a normal, size of the land property of 0.53 ha according to the Government of India. The survivability of these small holders is questionable because their failure to access markets is a significant restriction. The broadening of farming toward high value wares has been proposed as a conceivable choice for small holders. A move is occurring in the types of food Indian buyers prefer, including a nutritious eating regimen of organic products, vegetables, milk, and meat. Continued financial development and a quickly developing urban populace are powering fast development for sought after high worth food items. Moreover, the exported portion of horticulture and animal food products in agriculture products expanded from 24% in 1981 to 35% in 2003. The farmer's portion of the wholesale price continues to only be approximately 35%, with the significant portion going to middlemen as promoting cost, as a result of wasteful supply chains. Thus, supply chain management might be an incredible asset in connecting farmers to the business sectors to increase their pay.

Third-party logistics (3PL) specialist organizations [33] can assume a significant job in the agriculture supply chain management for consumer loyalty and cost reduction in overseeing supply chains. Determination of the providers is one of the significant elements that should be thought of because choosing the best 3PL providers can expand the competitiveness and sustainability of the supply chain. In any case, this choice becomes confused when there are numerous 3PL providers having different models and incorrect boundaries. Also, the vagueness and suspiciousness of the experts' feelings exacerbates the issue. In this way, a dynamic device dependent on multi measures has been utilized generally as a fuzzy logic, progressive procedure approach to determine the best 3PL specialist co-ops. The principle point of this exploration is to build up a blueprint of various rules for provider's choice dependent on literature reviews and methods utilized to choose the best 3PL providers. Moreover, this study gives an increasingly exact, compelling, and proficient decision help tool for choosing the best 3PL suppliers. This exploration may help in expanding the inclination to outsource logistics activities to upgrade the manageability of the IoT-based agribusiness supply chain.

The authors in [34] investigated and analyzed factors influencing cauliflower post-harvest losses (PHL) at the farm level in the Surat area of Gujarat. Sample data was gathered from 120 cauliflower producers from 12 towns using the survey method. Multiple regression analysis was carried out to decide the indicators of factors that lead to fresh produce PHL. The main reasons for PHL at maker level were: damage during harvest, damage because of disease, damage because of pests, damage during transportation; and an absence of legitimate cleaning and washing indicated a positive connection between every autonomous variable and the reliant variable. To diminish PHL, farmers need to focus on reducing the above concerns because these factors were shown to have a noteworthy impact on the amount of PHL of fresh produce.

Blockchain technology (BT) has affected the supply chain by removing the trust-related issues [35]. Studies are being performed worldwide to use the advantages BT can provide to improve the presentation of the supply chains. The literature has shown that BT offers different benefits prompting enhancements in the sustainable performance of the agribusiness supply chains. Usually, BT will bring a change in perspective on how the transactions are conveyed in the agriculture supply chains (ASC) by decreasing the high number of middlemen, deferred installments, and high transaction lead times. India, a developing economy, must consider the food security needs of an ever-developing populace and address numerous difficulties influencing ASC supportability. Therefore, it is necessary to embrace BT in the ASC to use the different advantages. The authors recognized and built up the connections between the empowering agents of BT selection in ASC and identified 13 empowering influences from the literature, which were approved by the specialists before applying a joined interpretive structural modeling (ISM) and decision-making trial and evaluation laboratory (DEMATEL) procedure to imagine the complex causal connections between the distinguished BT empowering influences. The authors found that, among the recognized empowering agents, traceability was the most critical purpose behind BT execution in ASC, followed by auditability, immutability, and provenance. The discoveries of the investigation will assist the experts in designing BT execution methodologies in agribusiness, making an ongoing information-driven ASC. The outcomes will likewise help the policymakers create arrangements for quicker usage of BT guaranteeing sanitation and practical ASCs.

Agriculture supply chain management involves everything associated with the process of moving farm products from the field to the client, and it is an important part of a nation's economy [36]. This study aimed to determine the difficulties present in the farming supply chain in India based on reviewing the literature and the Delphi method. The authors then used the decision-making trial and evaluation laboratory approach to show the determined difficulties, investigate the cause–effect interrelationship, and to build up the deliberate progressive structures of difficulties through an interpretive structural modeling strategy. Considering the Indian setting, two elements, specifically limited mixing among the national agriculture markets and restricted farming market infrastructure, were determined to be the most significant ones. The incorporated model acquired as a yield of this examination plans to direct the agrarian arrangement and chiefs to improve the presentation of the rural supply chain in India. Additionally, some basic proposals have been given to improve the proficiency of the rural supply chain management.

6.3.1 Farmer to Factory (F2F)

The agriculture sector is made up mostly of family businesses, which face difficulties participating in worldwide business because of the Free Trade Agreement (FTA) [37]. In this paper, the authors suggest business strategies to help the family businesses compete in the worldwide value chain. The researchers conducted a literature review on family-owned businesses and farming to determine the challenges they faced and propose systems that can help family farms compete. Two main challenges were determined, in particular the use of labor and capital. It was found that Indonesia's family-owned businesses used a higher amount of labor than worldwide businesses, on average. Even so, the all-out estimation of capital use in Indonesia's family businesses was lower than worldwide businesses because farmers cooperated and shared know-how. Capital use was found to be driven by social capital fortification, capital allotment, and capital accessibility, and the Indonesian family-owned businesses were found to not be able to take advantage of capital use. The authors proposed a procedure for the family-run company to defeat the danger of work through its capital utilization quality. Addressing these challenges should help to fortify family-owned businesses in the agriculture sector to conquer worldwide trade challenges and engage in new opportunities. This work may benefit governments in drawing up arrangements for helping the family-owned businesses in the farming sector to become global. This work adds to the scarce literature related to family farming businesses in Indonesia.

The sustainable development goals (SDGs) [38] are a significant system that sets the development plan for the following 15 years. Although the SDGs seem to address improvement challenges in a thorough manner, they have many flaws. This is clear in their origination and comprehension of sustainability, particularly according to agribusiness and its duty to reduce poverty and promote development. By concentrating on the agriculture segment of the SDGs, the author shows how the interests of agribusiness are expressly adjusted and progressed through a flawed view of sustainability that is found in the SDGs. The author suggested that the "agriculture for development" plan available in the SDGs is more about guaranteeing the interests of agribusiness to the detriment of guaranteeing genuine sustainable development. The author concludes that the social and political endeavors originating from such an arrangement sabotage endeavors to progress genuine sustainability and meaningful ecological relations.

This year the fund subject gathered information on extra regions that are fundamental to agrarian accounts; however, global procedures are not completely evolved. Partial credit guarantee frameworks and rural loaning shares are two zones of the account point examined. Partial Credit Guarantees (PCGs) can be a useful asset to build credit for agribusiness. They diminish the hazard that monetary establishments take when loaning to farmers and agribusinesses by going about as an insurance substitute, wherein "if the borrower neglects to reimburse, the moneylender can fall back on partial reimbursement from the underwriter." However, the presence of a PCG does not ensure expanded farming division loaning; rather, PCG plan and usage effectively affect program manageability and adequacy. Because there is no "one-size-fits-all" structure for PCGs, the group decided not to score this information. The information gathered shows that 18 of the 62 nations reviewed have a PCG specifically for rural advances given by business banks. Only two high-income nations, Italy and Korea, have PCGs.

The reason to make an agriculture marketing organization is to help overcome any barrier among producers and buyers. The general murkiness surrounding production has created a rift between the industry and consumers, leading them to scrutinize their food, and a general lack of understanding about the farming lifestyle. A rural promoting firm in California is attempting to close the gap between producer and consumer by speaking to and advocating for local businesses. In general, the American farmer exceeds expectations at numerous things; however, they often fall short regarding communication. Current farmers have had the option to create more food than any time in recent memory in spite of fewer resources and inputs. As the population grows and more individuals relocate from rural to urban areas, the populace engaged with agribusiness declines, and a knowledge gap is made. Essentially because of where individuals live, there is a distinction between general society and the story of farming. The average farmer is seen as a blockhead, who does nothing but farm and sleep [39]. Today, farming proceeds as a generational business based upon previous family achievement and having a gainful future for future generations — farming remains a lifestyle. Agriculture faces a purported farm issue. A farm issue is a barrier to better open comprehension by the urban majority of the country of the issues and needs of agribusiness.

This study aimed to distinguish a connection between agrarian added value share and the agriculture employment share [40] through a correlation analysis utilizing the Pearson's correlation coefficient. The results indicate that the lower the portion of the agriculture added value in the Ecuadorean economy, the greater the portion of the employment in the area, which implies that Ecuadorian farm workers generally become poorer relative to others laborers over time.

The success of some urban farmers has attracted worldwide intrigue. The authors conjectured that cultural inclinations and the worthiness of urban farming undertakings and items decide the achievement or disappointment of urban agriculture businesses. The authors studied 386 urban participants in Berlin, Germany, to determine general inclinations for the gainful utilization of urban space, the acknowledgment of various urban agriculture structures, and requests and desires with respect to agriculture items. The outcomes show that more than 80% of the respondents favored having open frameworks, for example, open green spaces, intercultural nurseries, and rooftop gardens. In fact, land uses that do not give openness, for example, glades, aquaponic farms, or concentrated rural and green scenes were less favored (under 40%). While 60% of members communicated acceptance of rooftop gardening, agribusiness in the urban periphery, or in downtown brownfields, 65% dismissed having farming in multi-story structures, agro parks, or aquaponic farms [41].

Agriculture assumes a critical job in Metropolis Ruhr cultivating approximately 33% of the metropolitan zone; however, on-going loss of farmland and transient rent of land influence farms extensively by complicating access to land. Generally separated and differentiated farms require a certain measure of farmland to be effective, which is compromised by further farmland losses in addition to expanded rivalry for the rest of the farmland [42]. Long haul arranging security is pivotal for farms that focus on high added value crops and organic farming. Dynamically developing participatory farming activities exhibit urban farms' capacities to inventively adjust to cultural preferences. Better knowledge of proficient urban agribusiness' homestead exercises and plans of action is of significance for farms and their related advisory services to more accurately address the urban setting in farm advancement methodologies, in addition to aiding public authorities' land-related decision-making with regard to planning and polices. The economic viability of expert urban farming is the key prerequisite for extra social, environmental, and landscape improvements inside urban territories.

6.4 IoT-Based Smart Farming

The flowchart of the IoT-based farming system is graphically represented in Fig. 6.2. Run of the mill business sensors for agribusiness irrigation system frameworks are extremely expensive, making it inconceivable for small farmers to utilize them [43]. Although, producers are currently offering low-cost sensors that can be associated with hubs to implement affordable frameworks for irrigation management and to monitor farms. In light of the ongoing advances in IoT and WSN innovations applied in the improvement of these frameworks, the authors presented an overview of the

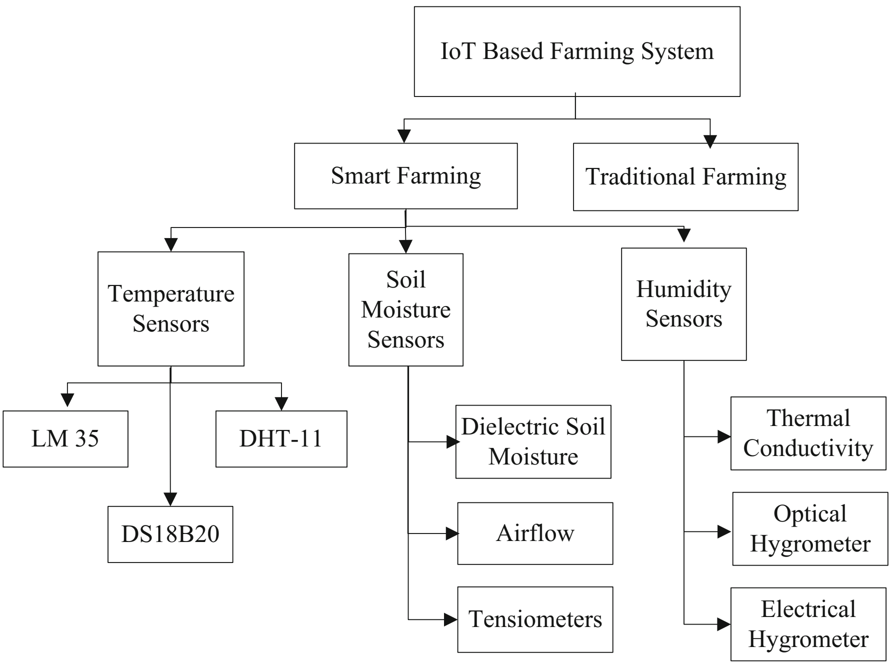


Fig. 6.2 IoT-based farming system

current best-in-class smart irrigation systems. The parameters that are monitored in irrigation systems include water amount and quality, soil attributes, and climate conditions. The researchers give an overview of the most used hubs and wireless technologies and examine the difficulties and the accepted procedures for the usage of sensor-based irrigation systems.

6.4.1 Arduino UNO

Arduino UNO is an Atmega328-based microcontroller board created by Arduino.cc. Sensors and different gadgets are incorporated into the Arduino adding to its incredible on-board capabilities. It has 6 simple pins and 14 digital pins. Arduino IDE is utilized to program Arduino Uno. Its working voltage is 5 volts. Arduino UNO reads the qualities from the sensors, and dependent on these qualities, it will train the engine driver to turn on/off the engine siphon. Figure 6.3 shows the IoT circuit in agriculture.

A soil moisture sensor, humidity sensor, and water level sensor are connected with the Arduino UNO board through wires and breadboard. The soil moisture sensor will detect the moisture of the soil. A limit has been set for both least and most extreme so that at whatever point the moisture content crosses the predefined threshold limit, the engine will be turned on/off. The water level sensor functions in the same way, where a base and highest limit have been set so that at whatever point the water level crosses the predefined threshold limit, the engine will be turned on/off to fill the tank. An LCD is associated with Arduino and all the sensors to show the status of moisture content in humidity, soil, and water level in the tank. A 5 V engine siphon was utilized for this work because this is a structure model, and the Arduino used in this work can give a limit of 5 V power. Figure 6.4 illustrates the schematic design of a smart farming prediction system.

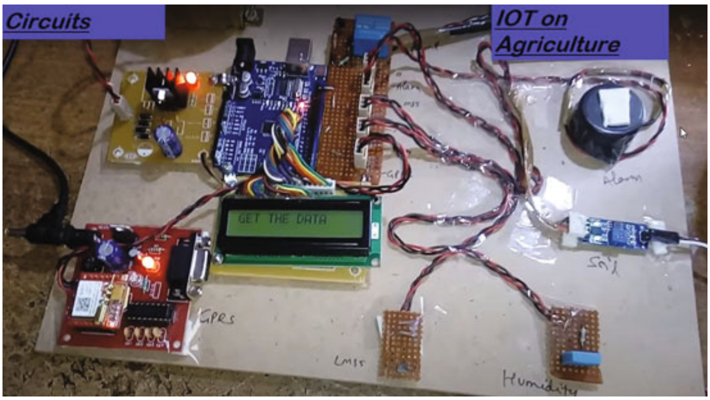


Fig. 6.3 IoT in agriculture

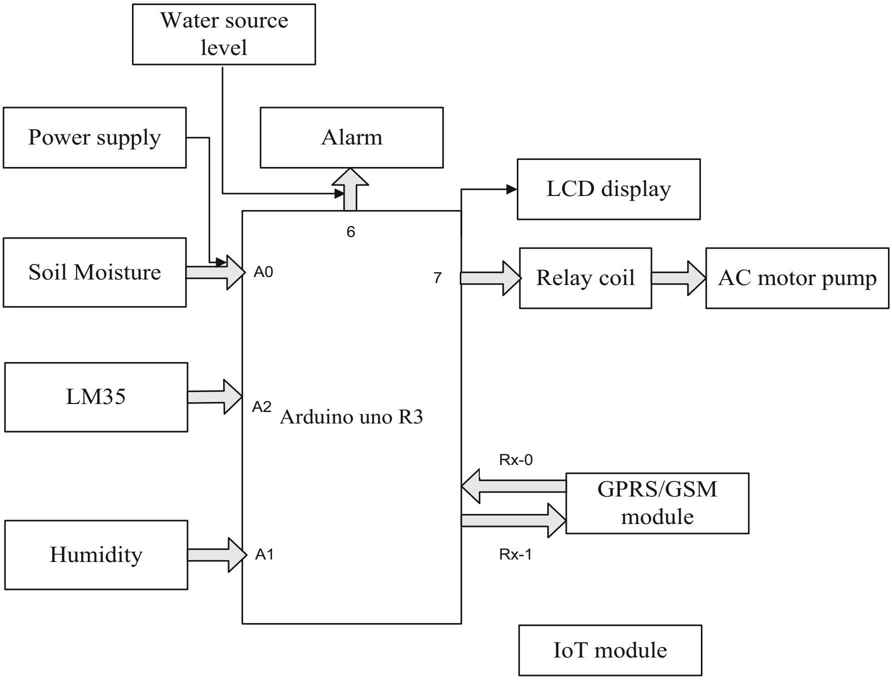


Fig. 6.4 Schematic design of smart farming prediction system

Figure 6.5 explains the workflow of the proposed smart farming prediction system.

Table 6.1 gives a summary of various sensors used in smart farming. LM35 is a temperature sensor that yields a simple sign that corresponds to the immediate temperature. The yield voltage can acquire a temperature reading in Celsius. The benefit of LM35 over thermistor is that it does not require any outer alignment. LM35 temperature sensor has 4-20 V, OUT, and GND. For the working principle of DS18B20 temperature sensor, the default goal at power-up is 12-piece. The DS18B20 controls up in a low force inactive state. Following the change, the following warm information is put away in the 2-byte temperature register in the scratchpad memory, and the DS18B20 returns to its inactive state. The moisture-detecting part of the DHT11 is a moisture holding substrate with the terminals applied to the surface. The adjustment in the opposition between the two terminals corresponds to the relative humidity. The reading for a dry soil is somewhere in the range of 3 and 5, approximately one for air, and approximately 80 for water. The most reasonable alternative for estimating soil moisture content is robust state sensors, which cost approximately $35–60 for each sensor unit. Different kinds of soil properties, including compaction, structure, soil type, and moisture level, produce interesting distinguishing marks. At the point, when covered in the dirt, the clay tip of the tensiometer permits water to move openly in or out of the cylinder.

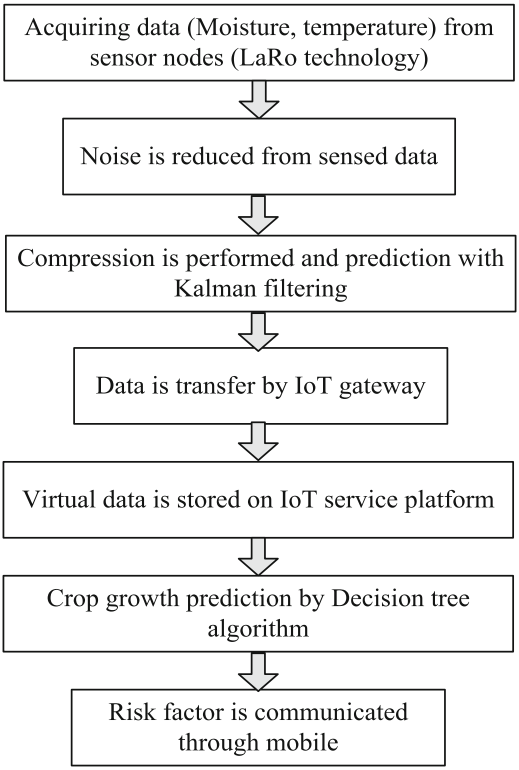


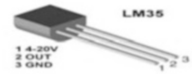
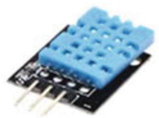
Fig. 6.5 Workflow of proposed system

As the soil dries out, water is sucked out through the porous clay tip, making a partial vacuum inside the tensiometer, which is read on the vacuum measure. In the thermal conductivity humidity sensor, one thermistor is hermetically fixed in a chamber loaded up with dry nitrogen while the other is presented to open condition through little vent openings. An optical hygrometer gauges the retention of light by water from the surroundings. A light producer and a light locator are orchestrated with a volume of air between them. In an electrical hygrometer, generally, a sensor estimates changes in a layer of lithium chloride or another sort of semiconductor.

6.5 Results

The hardware setup of the proposed smart farming prediction system is shown in Fig. 6.4. An Arduino board set up is used for an automatic or manual function to predict crop growth. The prediction is based on sensors for temperature, soil moisture, and humidity. Water source-level data is fixed before the buzzer so that the information is transferred according to the water level. 16x2 LCD is used to display farming risk factors, which are sent through a mobile device. Relay coil and Ac

Table 6.1 Summary of sensors used in agriculture

Sensors	Sensor Types	Sensors	Functions
Temperature	LM35		It can measure temperature more precisely than utilizing a thermistor
	DS18D20		Reads with a precision of ±0.5 °C from –10 °C to +85 °C and ± 2 °C exactness from –55 °C to +125 °C.
	DHT-11		It is an essential, ultra-minimal effort computerized temperature and humidity sensor
Soil moisture	Dielectric soil moisture		It works by utilizing two cathodes to quantify the electrical opposition in the soil
	Airflow		It measure soil air penetrability
	Tensiometer		Uses probes to measure soil compaction
Humidity	Thermal conductivity		Measure the warm conductivity of both dry air and air with water vapor
	Optical hygrometer		The retention of light by water from the surroundings
	Electrical hygrometer		Estimations on changes in electrical obstruction or capacitance

motor pumps are fixed for reliability. In an IoT module, GSM.GPRS is invoked for authentic communication. Ranges for automatic functions of temperature increased by more than 70, communication is sent through a mobile device. If the humidity range is more than 50 or the soil moisture range is more than 160, then this will be communicated. Based on the threshold value of each sensor, a farmer can predict water source level for various crops. In summer season, more water is required for paddy fields, whereas less water is consumed during winter.

Figure 6.5 explains the workflow of the proposed smart farming prediction system. Data is acquired from sensor nodes using LoRa technology. Noise is reduced from the sensed data. Compression takes place for prediction using Kalman filtering (KF). In this work, nominal packet size is utilized for transmission to accomplish better pressure; however, the Kalman filter sends every second at least, which can lessen the sum of energy needed for every exchange. Rather than utilizing models dependent on schedule for predication, the KF-based procedure utilizes a total model for predication where a few states are obscure, which gives a more detailed prediction investigation. Because of the decrease in the pace of transmission, the reproducibility of information is diminished. To accomplish better quality, KF eliminates noise from detected information gained by leaf hub and makes the reproduced sign more precise compared to unpleasant perceptions. Data is transferred by the IoT gateway. Water source level data is stored on the IoT service platform. A decision tree algorithm is performed to predict crop growth and, finally, the farming risk factor alert is communicated through a mobile device.

The output result of prediction analysis based on maintenance cost per acre along with predicted market price per kilogram in rupees is shown in Fig. 6.6. Various crops are shown in the x-axis such as paddy, wheat, groundnut, corn, and onion. The value of maintenance cost for paddy is 201 and market price is 75. Maintenance cost for wheat is 229 and market value is predicted as 26. For groundnut, 164 is the maintenance cost and 137 is the predicted market value. The value of maintenance cost for corn is 260 and the market price is predicted as 42. The maintenance cost for onion is 257 and the predicted market price is 50. The proposed smart farming prediction system predicted maintenance cost is high and predicted market price is low for corn. The crop corn has a high risk factor according to the proposed sensors.

In the Harvard setup, the water source level data is used to predict the required water for the particular corp. Figure 6.7 shows the maximum water required per day in millimeters. Experimental results show paddy required 1350 mm or maximum water. Wheat required 1267 mm of water, groundnut required 600 mm of water, corn required 430 mm of water, and onion required 126 mm of water. Based on the results, farmers can easily predict which crop is suitable for farming.

A farmer can easily understand and predict the farming system from Table 6.2 based on the suitable season, water required per day, the temperature in Celsius, maintenance cost per acre, a market predicted value of the particular crop, which is mentioned in rupees per kilogram, and predict the risk factors of the particular crop to yield or not. This prediction system is useful to the farmers to prevent loss in production. From the chart, a farmer can predict suitable crops from the soil condition and the water requirements. The irrigation system may by via pond, well,

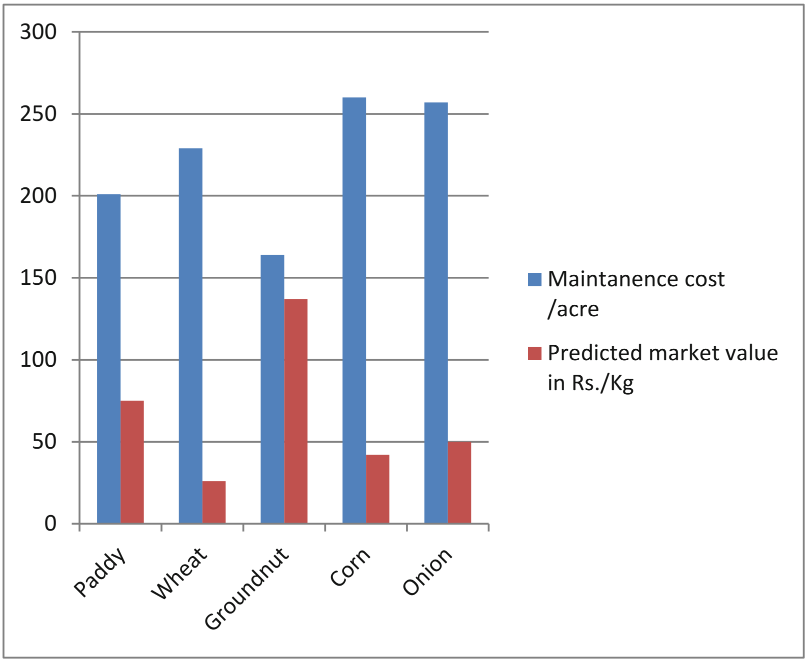


Fig. 6.6 Risk factor of the crop

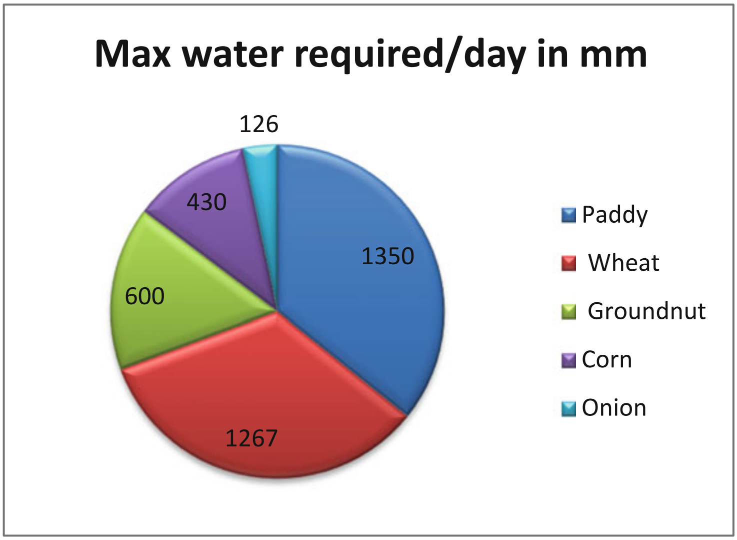


Fig. 6.7 Water consumption based on the crop

Table 6.2 Farmers prediction chart

Crop	Season	Water required/day	Temperature in Celsius	Maintenance cost/acre	Predicted market value in Rs./Kg	Risk factor
Paddy	Summer 1100-1250 mm		20–27	201	75	Low
Wheat	Winter 130.7–136.7 mm		21–26	229	26	Low
Groundnut	Summer 400-600 mm		27–30	164	137	Low
Corn	Spring 2.5–4.3 mm		18–23	260	42	High
Onion	Winter 10-12 mm		12–25	257	50	Moderate

or river according to the land. Agri-IoT-based sensors can be used to sense weather conditions, water status, soil moisture, and humidity.

6.6 Conclusion

In this chapter, we have depicted Agri-IoT, an IoT-based structure applying ongoing stream handling, examination, and thinking in the space of agriculture, in light of sensors, encouraging increasingly educated and exact dynamic by farmers and occasion choice. We have examined the presentation of IoT in smart farming and its chances, through the consistent blend of heterogeneous advances and the semantic mix of data from different sources such as sensors, online life, associated farms, administrative alarms, guidelines and so on, guaranteeing an increase in production and efficiency, better quality items, environmental protection, less utilization of resources(for example, water , fertilizer, and energy), and quicker response to capricious occasions, as well as provide greater transparency to the purchaser.

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