

Modern Irrigation Technology and Its Impact: A Review

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Abstract: This paper provides a clear overview of automatic irrigation systems. It explains how modern technologies such as GSM, wireless, sensors, ARM, and the Internet of Things, which are often powered by solar energy, are used in farming. Different sensors check parameters such as humidity, soil moisture, temperature, and water levels in the tank. Some systems even use mobile apps and websites so that farmers can control irrigation from a distance. This review shows that these systems are useful, affordable, and can be used in many ways. The use of these technologies in agriculture can save water and increase crop production in our country. In dry and semi-dry areas, such as Northern Egypt, managing groundwater is very important because water is scarce. This review focuses on studies conducted in the Qalyubia Governorate, located in the Nile Delta region. It compared traditional flood irrigation with modern water-saving irrigation methods using a computer tool called GMS. These results show that water-saving irrigation sends less water into the ground than flood irrigation. This effect on groundwater in the Nile Delta is important and should not be ignored when planning sustainable water use. Irrigation technology is undergoing significant changes, and instead of just trying to irrigate more land, the focus is now on improving how efficiently we use water. Old methods, such

as flood irrigation, are slowly being replaced by more advanced systems, such as sprinklers and deep irrigation, which waste less water. Experts believe that by 2035, drip systems will be widely used, replacing not only flood irrigation but also sprinklers. This study also helps to understand how modern irrigation systems can help farmers use less water while growing more crops. It examined how these systems affect both the environmental and social aspects of farming. The research found that using advanced methods, such as drip irrigation and smart automatic systems, can make water use much more efficient, cutting water usage by up to 50% and increasing crop yields by as much as 30%.

Keywords: Water efficiency, Smart irrigation, Ethiopia, Irrigation method, Diffusion, Micro-Organism, Precision Irrigation

Introduction: India is the largest developing economy in the world today, and agriculture plays a major role. To make the best use of manpower and increase profits in farming, advanced engineering and modern techniques must be used. One of the most important areas is water management in irrigation. To grow healthy crops

and obtain a good harvest, the right amount of water or soil moisture must be maintained. In India, many farmers face crop failure due to droughts, which have also caused a serious drop in groundwater levels. Therefore, it is essential to use every drop of water wisely. With a growing population, the demand for food is also increasing. This means that more water is required to grow sufficient food. However, we are also dealing with problems such as less groundwater, climate change, global warming, and unpredictable monsoons. Therefore, saving water while growing more food has become increasingly important. Traditional irrigation methods often involve farmers manually watering crops at fixed intervals. These systems can be inaccurate and require more labor to operate. A better solution is to use automated irrigation systems that efficiently manage water. The main goal is to develop smart irrigation systems that:

- Use water in the most efficient way
- Keep crops healthy and productive
- Avoid overwatering or underwatering
- Reduce water wastage
- Minimize the need for human involvement

In recent years, digital technology has changed almost every aspect of our lives, and farming is no exception. Traditional agriculture is now moving towards what we call *digital agriculture*, where new tools and smart systems help farmers work more efficiently. One of the biggest changes has been in irrigation, where precision irrigation methods, also called smart or digital irrigation, have become very popular.

Unlike the traditional method of watering crops, precision irrigation uses modern tools such as sensors, controllers, and automatic pumps or valves. Based on this data, the system can decide when and how much water should be provided to the crops. This means that plants receive the right

amount of water exactly when they need it, instead of wasting water.

This approach is especially important today, as water resources are under pressure, and farmers are looking for sustainable ways to grow food. Studies have shown that precision irrigation can help save water, improve crop yields, and reduce negative effects on the environment.

A smart irrigation system is composed of several important components, such as devices, network connections, and cloud technology. All of these work together to collect data, keep track of what is happening, send information, and allow the devices to communicate with each other.

The system is usually built on three main layers.

- **Perception layer:** where sensors collect data about soil, plants, and weather.
- **Network layer:** This layer sends the collected data from the field to storage or processing units.
- **Application layer** – where the data are analyzed and turned into actions, such as opening or closing water valves.

In summary, smart irrigation systems rely on proper monitoring, control strategies, and decision-support tools to ensure that water is delivered efficiently and precisely to crops.

Smart Irrigation Water-Saving Control Tools

(a) Open-loop control system (OCS): An open-loop system is the simplest type of control system. It operates in a straight, one-way manner without feedback. This means that once it is turned on, it stays on until it is manually switched off, just like a basic light switch. Because of its simplicity, the OCS is easy to design, inexpensive to install, and simple to maintain.

In farming, OCS is often used with an irrigation timer. Farmers decide when to turn on the water and for how long, usually following a fixed schedule. The main advantage is that it does not require sensors or complicated equipment, which makes it affordable and easy to use.

(b) Closed-loop control system (CLS): A closed-loop system is also known as a *feedback system*. Unlike OCS, it constantly compares what is happening with what is desired and adjusts itself. For example, if the soil is already moist, the system reduces or stops watering.

This type of system provides a much higher level of automation than the previous systems. Therefore, closed-loop systems are widely used in advanced technologies such as automated machines, robots, and vehicles.

Role of Irrigated Agriculture in Ethiopia

In Ethiopia, agriculture is the backbone of rural life and the primary means by which people meet their daily needs. Because rainfall in the country is often unreliable in terms of both amount and timing, irrigation has become very important. It is now considered one of the best ways to increase food production and meet the rising demand for food.

Irrigation development not only improves crop yields but also helps to fight poverty and food insecurity. With irrigation, farmers can grow two or even three harvests annually instead of just one. This leads to more food, better nutrition, and higher incomes, especially when farmers grow cash crops that can be sold in the market.

However, irrigation in Ethiopia still faces significant challenges. Although the country has around 112 million hectares of land, of which 30 to 70 million hectares are considered suitable for

farming, only about 5% of the potential irrigable land is actually irrigated. Because of this, the contribution of irrigation to the national economy is still very small.

Irrigation Methods

Irrigation is the process of supplying water to crops. One of the oldest and most common methods of doing this is surface irrigation, where water flows over the soil surface or remains ponded for some time. Although these methods are simple, their efficiency is not always high because water can be lost owing to uneven soil absorption, changing crop patterns, or weather conditions. Generally, surface irrigation methods are only 40–80% efficient.

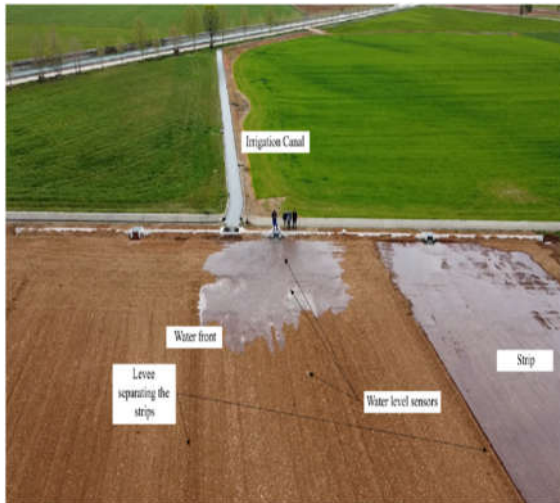
The main types of surface irrigation are as follows:

1. Uncontrolled Flooding

Water is introduced into the field from ditches and allowed to spread freely without guidance. It is cheap and easy to set up because no land preparation is required. However, water is often wasted, as too much is collected near the inlet, while crops at the far end may not receive enough. It works best when there is plenty of water, the land is uneven, and crops are not harmed by excess water.

2. Border Strip Method

The field is divided into long, narrow strips (3–20 m wide and 100–400 m long) separated by small borders. Water flows slowly down the slope of each strip, wetting the soil evenly. It is suitable for most soils (clay, loam, and sand), but the slope must be carefully managed to prevent erosion. It requires high land preparation costs but provides better control over water.



3. Check Method

The land is divided into small, level plots surrounded by small bunds (i.e., levees). Water is applied plot by plot, providing farmers with good control over the distribution. It reduces water loss and provides more uniform irrigation.

4. Basin Method

It is mostly used for orchards. Each tree (or group of trees) is surrounded by a circular or square basin. Water was filled in each basin to irrigate the tree roots.



5. Furrow Method

Instead of flooding the entire field, small channels (furrows) are dug between the crop rows. Water flows through these furrows and seeps sideways and downward into the soil. It is commonly used for row crops such as corn, potatoes, and sugar beets. Furrows reduce evaporation loss because only part of the field is wetted. The depth and spacing of furrows depend on the soil type and crop spacing.



Trends and Future Scenarios for Irrigation Technologies

Researchers used a model called LSM2 to predict how irrigation might expand in the future. The model shows:

- How much land will be equipped for irrigation over time?
- How different types of irrigation systems (such as surface, drip, or sprinkler) might be used in the future.

The logistic model predicts a faster growth of irrigated land than the FAO model. By 2050, the logistic model estimates approximately 381

million hectares, whereas the FAO model predicts 352 million hectares, a difference of 27 million hectares.

Impact of Micro-Organisms

Micro-irrigation technologies, such as drip and sprinkler irrigation, play an important role in modern agriculture because they offer multiple benefits for water management, food security, and rural income generation. One of the main advantages of micro-irrigation is that it helps to conserve water. Unlike traditional irrigation systems, which lose a lot of water through evaporation, runoff, or deep percolation, drip and sprinkler systems deliver water directly to plant roots in a controlled manner, reducing wastage. This makes them especially valuable in areas facing water shortages or droughts and helps farmers manage water efficiently during critical periods, such as the pre-monsoon season.

Micro-irrigation also helps increase farmers' income and reduce poverty. By enabling more land to be cultivated and increasing crop yields and quality, it reduces cultivation costs, particularly for irrigation, and allows crops to mature faster. These benefits result in higher farm incomes, which support rural households in improving their livelihoods. In addition, micro-irrigation improves food and nutritional security by allowing households to grow various crops, including vegetables and other high-value crops.

Another important benefit of micro-irrigation is that it allows water to be spread over a larger area, even under water-limited conditions, making it possible to cultivate more land during dry seasons or droughts and to increase overall crop production. Micro-irrigation also improves energy efficiency and crop performance.

Overall, micro-irrigation is a crucial technology for modern agriculture, as it helps conserve water,

increases income, reduces poverty, improves nutrition, and allows farmers to cultivate land more efficiently, making it a sustainable solution for meeting agricultural and water management challenges.



Fig: Micro irrigation in India

Prospects of Precision Irrigation Systems: Challenges and Solutions

Precision irrigation is a modern method of farming in which crops receive the right amount of water at the right place and time. Unlike traditional methods, where the entire field is watered equally, this system checks what the plants and soil actually need and then provides water accordingly. This helps save water, improve crop growth, and reduce waste. It can also make farming more profitable in the long term.

However, the use of precision irrigation is not simple. The biggest problem is cost. The machines, sensors, and controllers required are extremely expensive. Small farmers, who make up a large part of the farming community, usually cannot afford these technologies. In addition, these devices must be installed and removed repeatedly during the farming season, which requires additional time and labor. Even though the sensors provide correct readings, they usually

cover only a small area of the field. This means that they do not always show the real condition of the entire farm.

Another challenge is the technology and knowledge. Precision irrigation produces a large amount of information about soil, water, and crops. To use this information properly, farmers require training and technical skills. However, many farmers lack this knowledge. In addition, most systems require a good Internet connection and a steady electricity supply. However, in many rural areas, the Internet is weak and power cuts are common, so the system cannot run smoothly. Farmers are also concerned about data privacy because they are unsure how the information collected from their farms will be used.

Despite these problems, precision irrigation offers significant opportunities. New technologies, such as mobile applications and artificial intelligence, can guide farmers on when and how much to water. Governments can help farmers by providing financial support, training in local languages, and building better infrastructure, such as the Internet and electricity in villages. Companies can also create cheaper and simpler systems that are easier for farmers to adopt.

Literature Review:

1. Pavithra D. S, M. S. Srinath, the author explains about this paper, an automatic irrigation system that uses GSM technology and an Android mobile app to help farmers control watering easily. Sensors check soil moisture, temperature, humidity, and water level and send the data to a microcontroller. The system sends updates to the farmer's phone via SMS and allows for the remote control of the water pump. It automatically turns the motor on when the soil is dry and off when it is sufficiently moist. This saves water, power, and time. The system is low-cost, easy to use, and useful for farms, gardens, and greenhouses, thereby making agriculture more efficient and smarter.
2. Bharath M. N, R. Varun Baba explain that this paper presents a smart, solar-powered drip irrigation system designed to make farming easier and more efficient. It uses soil moisture sensors to detect when plants need water, and a microcontroller automatically opens and closes the valves to supply the right amount of water. The system includes a backup water storage tank to ensure that irrigation continues even if electricity is limited, and solar panels provide uninterrupted power. This automation reduces labor, prevents water wastage, and ensures healthier crop growth. Overall, it offers a low-cost, energy-efficient, and sustainable solution for the future of agriculture.
3. N.D. Pergad, Y.P. Patil, author, explains about this paper and a smart irrigation system to help Indian farmers deal with irregular rainfall. It uses soil moisture, temperature, and water level sensors to monitor field conditions. The ARM7 microcontroller processes this data and controls the irrigation motors automatically. A GSM module sends updates to the farmer's mobile, and an LCD shows real-time information in the field. This system helps save water, reduces labor, and ensures crops receive the right amount of irrigation. It combines modern technology and automation to make farming more efficient and reliable.
4. V. Bhamoriya, S. Mathew author explains about this paper. Efficient water use in agriculture is very important due to water scarcity. Traditional irrigation wastes water and reduces crop productivity. Modern techniques like drip and sprinkler irrigation deliver water directly to plants, saving water and increasing yields. These systems also reduce labor and energy costs. Sensors and automation can further improve irrigation efficiency. Despite their benefits, high initial costs and technical knowledge limit adoption by some farmers. Studies suggest that proper

planning, crop selection, and management can make micro-irrigation highly effective. Overall, modern irrigation technologies are key to sustainable farming and better water management.

5. Hussain, M.A. and Guha, P. The author explains this paper. Floods are one of the major threats to agriculture in India, often causing heavy damage to cereal crops. Previous studies mostly examined local or farm-level impacts, leaving a gap in understanding state-wide effects. Hussain and Guha analyzed 17 Indian states from 1990 to 2017 to study how floods affect cereal production in irrigated and rainfed areas. Their research showed that while larger farming areas increase crop output, floods significantly reduce it. Rainfall intensity contributes to flooding, and irrigation systems sometimes help but can also worsen flood impacts if poorly managed. The study emphasizes the importance of better irrigation planning and flood management to safeguard cereal crop yields.
6. Reddy K.Y.V., Adamala S, and Harish Babu B. The author explains in this paper that Drip irrigation is a method that gives water directly to plant roots, saving water and boosting crop growth. It has been widely adopted in India through programs like APMIP to increase farm productivity and protect groundwater. Studies show that drip systems improve water and fertilizer efficiency, enhance yield and fruit quality, and lower farming costs. Field observations in Guntur District found most systems performed well, but some faced problems like uneven water flow or insufficient pump power. Overall, drip irrigation is an efficient and sustainable solution for modern farming.
7. Ahmed, Z., Gui, D., Murtaza, G., Yunfei, L., & Ali, S. The author explains in this paper how drylands face serious water shortages and low agricultural productivity. Traditional irrigation methods often cause over- or under-
- watering. Smart irrigation systems, using AI, drones, and predictive models, help deliver the right amount of water based on soil, climate, and crop needs. These technologies save water, improve crop yields, and make farming more efficient. They also support sustainable development and help ensure food security in water-scarce regions.
8. Patel A., Kushwaha N.L., Rajput J., & Gautam P.V. The author explains in this paper how micro-irrigation helps improve water use efficiency in dryland farming. It explains that agriculture, especially in India, faces major water scarcity problems affecting crop yield. The study highlights that drylands need advanced practices like drip and sprinkler irrigation, mulching, and crop residue management. These methods reduce water loss and improve soil moisture for crops. It also notes that such technologies can help farmers cope with climate change. Overall, micro-irrigation is seen as a key solution for sustainable farming in water-limited areas.
9. Askar A., Sunggat M., Maxat M., Nunzhigit S., Kanat Z., Ainur K., Arnay A., & Asset O. The author explains in this paper how ozone produced by the corona discharge method helps in cleaning and purifying water. It explains that ozonation effectively removes harmful substances like chromium, iron, petroleum products, and organic impurities. The process also improves the bacteriological quality of water but does not change minerals such as calcium, magnesium, or sulfates. The efficiency depends on proper ozone mixing, dissolution, and energy use. Overall, studies show that ozonation is a powerful, clean, and eco-friendly method for improving water quality.
10. Gagliardi, G., Lupia, M., Cario, G., Cicchello Gaccio, F., D'Angelo, V., Cosma, A.I., & Casavola, A. The author explains in this paper how the Internet of Things (IoT) supports smart agriculture by using sensors, drones, and data analysis to monitor crop

health. It focuses on the ENOTRIA TELLUS project, which developed a smart system for managing vineyards. The system collects real-time data on weather, soil, and plant conditions. Field tests showed that it helped farmers plan irrigation and harvesting more efficiently. Overall, IoT-based farming improves productivity, saves resources, and supports better decision-making.

11. Levitow, L.; Zaccaria, D.; Maia, R.; Vivas, E.; Todorovic, M.; Scardigno, A. The author explains in this paper how innovative irrigation methods can improve water efficiency and support sustainable farming. It highlights that many farmers lack knowledge and guidance to use these technologies effectively. The study shows that poor information exchange and low motivation hinder progress. Farmers often depend on external water sources instead of improving efficiency. The authors suggest better knowledge-sharing among farmers and experts. Overall, cooperation and awareness are essential for efficient water management.
12. Balasundram, S.K.; Shamshiri, R.R.; Sridhara, S.; Rizan, N. The author explains in this paper how digital agriculture helps reduce climate change impacts and improve food security. It explains that changing weather and rising temperatures harm crop yields and livestock growth. The study highlights that smart farming tools can enhance productivity and cut greenhouse gas emissions. It also focuses on promoting sustainable and fair food systems. The authors stress the need for cooperation among farmers, researchers, and policymakers. Overall, digital agriculture supports climate resilience and sustainable food production.
13. Venot J-P, Zwarteveen M, Kuper M, Boesveld H, Bossenbroek L, Kooij SVD, Wanvoeke J, Benouniche M, Errahj M, Fraiture CD, Verma S. The author explains in this paper how drip irrigation is often presented as a modern and efficient solution to solve problems of water shortage, food production, and poverty. However, it explains that the success of drip irrigation does not only come from the technology itself but also from how different people and institutions use and promote it. Farmers, engineers, and policymakers all play important roles in shaping how this technology is understood and applied. The study points out that the real impact of drip irrigation depends on local conditions, social factors, and farming practices. It concludes that drip irrigation works best when technology and people's needs are well connected, rather than seeing it as a one-size-fits-all solution.
14. Absanto, G., Mkunda, J., & Nyangarika, A. The author explains in this paper how micro-irrigation systems like drip and sprinkler irrigation help small farmers who face water shortages. It shows that these systems save water, increase crop production, and lower farming costs. The review studied 184 papers and found that farmers earn more and their farms become more sustainable. It also helps protect the soil and environment. Overall, micro-irrigation improves food security, reduces poverty, and supports better living for rural farmers.
15. Arulmani, K., Srinivasan, G., & Jayasankar, R. The author explains in this paper how drip irrigation helps tomato farmers save water and earn more profit. It was done in Tamil Nadu with 50 farmers using drip systems. The study found that even with high setup costs, farmers got higher yields and better income. Drip irrigation made tomato farming more efficient and profitable. It also helped save water and reduce farming costs. The study suggests giving farmers training and support to maintain the system well.
16. Bhardwaj, A. K., Pandiaraj, T., Soman, P., Bhardwaj, R. K., & Singh, T. C. The author explains in this paper how drip irrigation improves rice farming in the Indo-Gangetic Plains, where water scarcity is a big challenge.

The research was done in Uttarakhand on direct-seeded Basmati rice. It found that drip irrigation at 100% CPE every two days gave the best results. Farmers got 45% higher yield compared to traditional flooded farming. The method also saved water and improved fertilizer use. Overall, drip irrigation made rice farming more profitable, efficient, and climate-resilient.

17. Abric, S., Sonou, M., Augeard, B., Onimus, F., Durlin, D., Soumaila, A., and Gadelle, F. The author explains in this paper how small farmers in West Africa use private irrigation to grow better and more valuable crops. The study found that using simple and cheap tools like pumps and wells helps farmers earn more and produce good yields. However, many farmers still face problems like a lack of training and limited money. The paper suggests giving more support and investment to improve irrigation systems. Overall, private irrigation helps farmers improve their farms and livelihoods.
18. Arunjyoti S, S CS, Sirisha A, the author explains in this paper that this study finds the best pipe size to save money in pressurized irrigation systems. Small pipes cost less but use more power, while big pipes cost more but save energy. The researchers made simple math models using six types of pipes to find the right balance. They compared prices, flow rate, and electricity costs. The study helps choose the best pipe that is both cheap and efficient for irrigation.
19. Mannschatz T, Wolf T, Hülsemann S. The author explains in this paper how managing water, soil, and waste together is important for sustainable development. Many old models study only one part, making it hard to choose the right tool for combined analysis. The authors made the Nexus Tools Platform (NTP), a website to compare different environmental models. It lets users filter, view, and choose models easily. The platform includes 73 models related to water, soil, and

waste. It helps researchers and planners pick the best model for their studies.

20. Okasha, A.M.; Ibrahim, H.G.; Elmetwalli, A.H.; Khedher, K.M.; Yaseen, Z.M.; Elsayed, S. The author explains in this paper that this research developed a low-cost soil moisture sensor to help farmers manage irrigation efficiently. The sensor works using solar power and accurately measures soil moisture levels. It was tested in both laboratory and greenhouse conditions, showing a strong match between the sensor readings and the actual soil moisture content. The device performed reliably with stable and consistent results. It also helps in saving water and reducing costs for farmers. Overall, this solar-powered sensor is an affordable, accurate, and eco-friendly solution for smart irrigation management in greenhouses.
21. Atanasov, S author explains in this paper how plants can be used as natural sensors by observing the color of their leaves to check soil moisture. It uses image processing and mathematical models to predict when crops need water. The system takes photos of plants, studies their color changes, and relates them to soil moisture and temperature. An automatic irrigation system has been developed that starts watering when the plants show signs of dryness. The model predicts soil moisture with very high accuracy, around 98%. This smart method helps farmers save water and reduce manual work by using plants themselves as indicators for irrigation needs.
22. Mushtaq S, Maraseni TN, Reardon-Smith K The author explains in this paper how modern irrigation systems can help Australia deal with water shortages caused by climate change. It found that while these systems save water, they also use more energy and release more greenhouse gases. Researchers tested five irrigation methods to find the right balance between saving water and using energy. Drip irrigation was found to be very

good for saving water, but it increased energy use. Replacing old, inefficient systems gave the best results for both water and energy savings. The study suggests making balanced policies to support both water conservation and climate protection.

23. Namara, R. E., Nagar, R. K., & Upadhyay, B. The author explains in this paper how micro-irrigation technologies help improve farming in India by increasing crop production and income. Even with government and NGO support, very few farmers are using these systems. The main reasons for adoption are access to groundwater, crop type, education, and financial ability. The study found that richer farmers adopt micro-irrigation more than poorer ones. It also shows how farmers use the saved water to affect groundwater levels. Overall, the research highlights that micro-irrigation is useful and efficient but needs better promotion among small and poor farmers.

24. V. Ramachandran, R. Ramalakshmi, and Seshadhri Srinivasan. The author explains in this paper an automatic irrigation system that uses IoT and cloud technology to make farming more efficient. It uses low-cost sensors to measure soil moisture, pH, and weather conditions. The data collected is sent to the cloud through Wi-Fi or GSM for easy monitoring. An optimization model then decides how much water the plants need. A solenoid valve automatically controls the water flow based on these calculations. Overall, the system helps farmers save water and makes irrigation smarter and easier to manage.

25. Shweta S. Patil, Ashwini V. Malviya. The author explains in this paper how modern technology can help farmers monitor their fields easily. Earlier studies show that using sensors to check soil moisture, temperature, humidity, and water levels helps improve crop growth. The ARM processor is useful for fast

data handling with less power use. Wireless tools like Zigbee and GSM send real-time updates to farmers' phones. This helps them take quick action when conditions change. Such systems reduce manual work, save water, and make farming more efficient and smarter

Conclusion: This review paper explains that water is becoming very limited, and since farming depends on water, saving it has become a serious problem. Agriculture is important for human life, so it is necessary to find smart ways to use water carefully and avoid waste.

To solve this problem, new types of automatic irrigation systems have been created using modern technologies like Wireless Sensor Networks (WSN), GSM, and the Internet of Things (IoT). These systems help farmers control and monitor their irrigation through mobile phones or computers. This means farmers do not have to be in the field all the time to water the crops.

These systems are easy to use, even for people who don't have much technical knowledge. They also need very little maintenance and are affordable for most farmers. Most importantly, they help use water in the best possible way — giving each crop the right amount it needs. This not only saves water but also improves the quality and quantity of crops.

Such modern irrigation systems are also useful for farms in distant areas where people cannot visit regularly. They can even be used in greenhouses to control water levels and plant growth.

In short, these modern irrigation technologies make farming smarter, save water, and help produce better crops. They are a simple, effective, and sustainable solution for the growing problem of water scarcity in agriculture. Irrigation

technology is changing very fast all around the world. Earlier, the focus was mainly on increasing the total area of land that could be irrigated. But now, the goal has shifted toward using better technology to get more crops with less water. This means that instead of expanding horizontally, we are improving vertically.

Traditional flood irrigation, where water is allowed to flow freely over fields, is slowly being replaced by more modern systems such as sprinkler and drip irrigation. These methods use water more carefully and reduce wastage. According to this study, this change is expected to continue in the future. Among all the irrigation methods, drip irrigation is expected to grow the fastest.

In the past, most farmers used traditional irrigation methods, where they would go to their fields, look at the soil and plants, and decide when to water based on their personal experience. Although this method worked for many years, it takes a lot of time, effort, and water.

Today, irrigation is becoming modern and smart. New systems use advanced technologies like sensors, data collection devices, and automatic controllers. These tools help farmers understand the exact needs of their crops and the condition of the soil in real time. The system collects data such as soil moisture, humidity, and weather patterns, and then automatically decides when and how much to irrigate. This is called precision irrigation or smart irrigation.

Smart irrigation systems help farmers make better decisions without needing to check the field manually all the time. The use of smart irrigation not only saves water but also increases crop growth and yield. Since the plants receive just the right amount of water, they grow healthier and stronger. Overall, this research shows that switching from traditional to modern irrigation methods is an important step toward sustainable agriculture.

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