

Precision irrigation management:

An innovative technique for efficient water management

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Irrigation is the artificial application of watering the crops for their survival, growth and development. The need of irrigation for crop production is increasing due to rise in drought indices and quick population growth. Yet, there are a number of problems that irrigated agriculture needs to grapple with, which have led to subpar performance, wasteful water use and low water output. In order to make up for the short-comings of rainfall, freshwater is necessary for irrigation and the supply of nutrients for plant growth. Over 70% of the fresh water resources are used for agricultural purposes. The traditional approach of managing irrigation has issues including low water use efficiency and low production. Using a precision irrigation management technique that reduces water losses, balances supply and demand, and tracks performance is necessary to increase the efficiency of water used in crop production. It also handles the variability of land in terms of water stress through variable rate irrigation.

Keywords: EOSDA crop monitoring, Normalized difference moisture index, Precision irrigation management, Weather forecast

PRECISION irrigation provides a means for evaluating crop water requirement and applying the optimum quantity of water to crops in the right amount at the right time at the right place in the right manner. It is the principle that is adding the effective distribution of available water, which is based on the characterized procedure that influences the irrigation stages

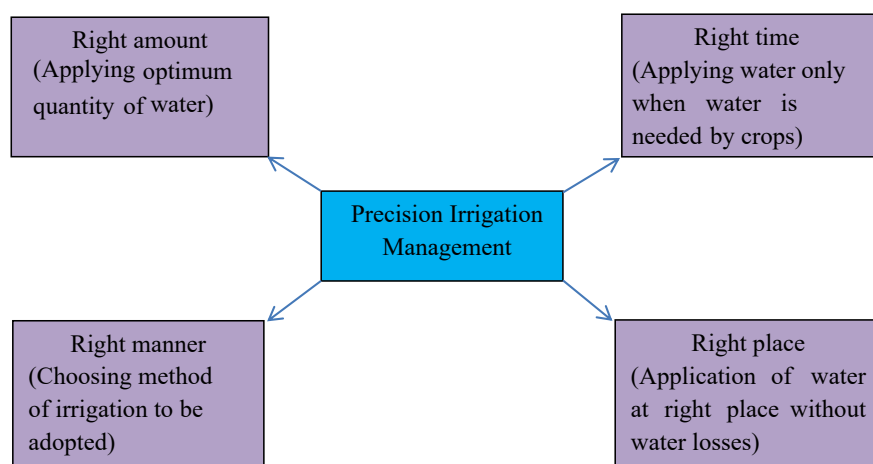
which help in the sustainability of agricultural production and management. It seeks to maximize crop yield, while using the least amount of water. It also means using water resources properly over the long term, which is more important in a world, where water is becoming scarce due to climate change. However, it is a highly needed feature for irrigation planning,

which involves knowing the advances of the water requirements, yield and soil moisture content to ensure better management. A paradigm shift from optimizing production/unit of land area to the maximum productivity/unit of water consumed is necessary due to the competition for the limited fresh water resources. Precision irrigation is regarded as a key technology for increasing water use effectiveness in both continuous and fixed irrigation systems.

Precision irrigation methods

Precision drip irrigation system:

In precision drip irrigation, moisture is delivered with tiny pipes placed in lines, also known as drip tape/drip line watering. The droplets are supply directed to the crop roots at low pressure, and a lack of water nearby hampers the development of weeds. Thus, it not only prevents plant starvation due to weeds, but greatly reduces the volume of





Point source drip irrigation



Drip irrigation

Source: Indiamart

necessary moisture, which is among the significant benefits of drip watering system. Unfortunately, drip tapes are delicate around machinery and are readily clogged with impermeable objects. Contrarily, soluble materials make it possible to combine fertilization and water delivery.

Precision mobile drip irrigation (PMDI): PMDI combines the effectiveness of a typical center pivot system with the more efficient drip irrigation application method. PMDI systems use the hanging drip nozzles in place of the usual spray nozzles, found on the standard center pivot system. It takes the efficiency of both, standard center pivot and drip irrigation system designs and combines them, providing an excellent solution for a number of common issues seen with the center pivot system.

Micro-sprinklers: Similar to drip irrigation, micro-sprinklers are made for small areas. They can be used in orchards or row crops and spray water in a circular pattern.

Precision sprinkler irrigation: A machine or manually controlled tool that can be put temporarily/permanently, travel forward or rotates, sprays water through it. Depending on their guns and nozzles, sprinklers have varying pressures and droplet sizes. This precision irrigation method is only suitable for some crops, as big drops and high pressure can damage them. Additionally, any insoluble particles that get lodged inside the system will render the device inoperable. Another problem is that the winds have a significant impact on moisture distribution.

Precision surface irrigation: In accordance with the law of gravity, water distributes naturally throughout the area. It is acceptable when soil penetration is poor because it doesn't use any cutting-edge technologies but requires a lot of water. This precision irrigation method is suitable for clay soils, but will be difficult to implement in sandy ones. The surface method is performed in the following ways:

- The basin technique limits the area with bunds and floods it.
- The water stays there for a long time.
- This is a common method for cultivating rice and is also applicable to wheat.
- The technique is used on flat terrain with optional further levelling.
- The furrow technique entails digging large, water-filled ditches called furrows.
- The water drains naturally through syphon tubes or gates or through furrows that are higher than the crop rows.
- The border method provides water in the spaces between stretches of land.

Precision irrigation techniques

Precision irrigation management using EOS data analytics crop monitoring: EOSDA crop monitoring helps farmers to manage their fields by saving time, reducing costs and improving the yield's of crops. Precision irrigation management requires reliable information about the current weather forecast, that will help to determine the need for additional soil moisture supply. It is advised to undertake accurate irrigation, that is, to watering the

crops only when necessary, because doing so can save money and prevent damage from excessive moisture.

Precision irrigation management using normalized difference moisture index (NDMI): NDMI is used to determine vegetation water content. It is calculated as a ratio between the near-infrared (NIR) and short-wave infrared (SWIR) in traditional fashion. It is an accurate predictor of crop water stress. NDMI can detect water stress at an early stage before the problem has gone out of hand.

$$NDMI = (NIR - SWIR) / (NIR + SWIR).$$

The NIR and SWIR bands were selected for the NDMI and equation, to mitigate the effects of illumination and atmosphere. The short-wave infrared is sensitive to the vegetation, water content and the mesophyll structure of the leaves. On the other hand, the near-infrared picks up the bright reflectance of the leaf internal structure and the leaf's dry matter content. When combined, measurements of the water content of the vegetation are substantially more accurate. NDMI can also be used for precision variable rate irrigation, which saves resources by watering only those plants that lack moisture.

Precision irrigation management using soil moisture data: Soil moisture data can be obtained in several ways; viz. sensors-based soil moisture data in the field or satellite-based images. The use of sensors involves ongoing maintenance expenditures and equipment management. On the other hand, regardless of cloud covers satellite photography, it is a trustworthy method for gathering data on soil moisture. The EOSDA crop monitoring contains data on root zone and surface soil moisture, collected by satellite spectral sensors. Any field, anywhere in the world can have its soil moisture data checked, both, current and historical. Precipitation data and normalized difference vegetation index (NDVI) will allow tracking of the correlation between rainfall and moisture levels in the field.

Precision irrigation management using weather forecast: EOSDA monitoring provides a weather forecast for each field during the next 14 days. Accurate weather predictions assist in determining, when watering activities are required to maintain the proper soil moisture for the crops. Farmers will conserve resources by delaying watering activities in anticipation of the impending down-pours. Moreover, EOSDA crop monitoring automatically notifies changes in field such as adjustments to the vegetation indices or impending weather anomalies (cold and heat stress). By executing tasks in the field, the automatic notifications assist in preventing key moments from being missed.

Farmer-friendly mobile app-based operation: Precision irrigation water management is being quickly adopted in India, because of recent advancements in digital farming systems. The majority of Indian farmers use android-based smartphones, which means that in the future, widespread adoption of mobile-based automation and sensor-based precision irrigation is possible. The mobile app integrated smart irrigator and the blink app is effective examples of mobile app and web app applications in India that irrigation aid in remote monitoring and control of irrigation.

Drone-based water stress monitoring: There is a huge scope for drone-based irrigation monitoring and identification of variable plant stress zones. Similar to this, drones are also being used to detect mechanical issues with canal operation and maintenance, which may result in the development of sustainable water resources. This has the potential to cover a bigger area, while cutting down on inspection time, which will aid in canal maintenance and repair. Though at this moment the use of drones for precision irrigation is very low, but there is a scope for their enhancement. For precise irrigation water management in canal commands, India can use this method.

Precision irrigation using FAO CROPWAT model: A computer model called CROPWAT was created by the FAO to assist crop water and irrigation needs from climatic and crop data. It also enables the determination of the scheme's water requirements for the entire region, as well as the formulation of irrigation schedules for various management situations. The model is based on water balance, where the soil moisture state is assessed daily using inputs for rainfall and computed evapo-transpiration. The software uses climate information, such as maximum and minimum temperatures, relative humidity, wind speed, sunlight hours and rainfall data. It calculates the evapo-transpiration rate using the Penman Monteith method.

Scope for transition from nascent stage utilizing advances in information technology

Although precision irrigation water management is still in its infancy in India, there is enormous potential for it to be adopted more widely over time while making full use of current developments in machine learning, digital farming solutions, etc. The automation and real-time data monitoring under the precision irrigation system will get further reinforced with the introduction of new emerging approaches in the field of information technology at both the worldwide and national levels.

Benefits of precision irrigation

Precision irrigation systems are designed to deliver water to specific locations on the farm in a controlled manner, which can help you optimize yields and improve profit. These systems offer many benefits to farmers, including:

- **Less water use:** Crops are harmed by excessive water use, which is terrible for the environment. They are deprived of the nutrients, needed to grow when there is little water. According to statistics, precision irrigation can cut agricultural water use by up to 25%.
- **Easy installation:** Easy

installation of precision irrigation systems and the possibility of automated control.

- **Direct supply of water to plant:** Direct distribution of water to the plant ensures the best possible support of plant water needs.
- **Increasing productivity:** It has been observed that precise watering increases yield by 8%. Precision irrigation delivers water straight to the plant's roots, whereas standard irrigation spreads it out around the plant, depriving the roots of the majority of it. Farmers can water their crops year-round in this way.
- **Watering the plant precisely when and how much it need:** Every crop has varying water requirements, which also depend on the stage of plant development. Understanding the plant's irrigation requirements at any given time, results in best produce, a longer storage time and better disease management, etc.
- **Enhanced quality yields:** The specific requirements of a crop at each stage of growth are met by precision irrigation. By doing this, the fruit improves in quality and may be preserved for a longer period of time without going bad.
- **Helps with environmental policies compliance:** Sustainable farming practices are required by new environmental regulations to save water while improving yields to feed the world's expanding population. By exhibiting sustainable practices and, with the correct technology, being able to precisely report on water use, precision irrigation helps the agriculture sector to meet both objectives.
- **Reducing manual labour:** In large farms, automated precision irrigation reduces the need for additional labour. For instance, flow sensors eliminate the need for manual inspections and can notify operators for maintenance.

- **Effective in weed management:** It reduces the emergence of weeds because the soil is watered only around the plant, and unwanted vegetation doesn't get enough moisture.

SUMMARY

To combat the issues of shortage and quality against the back-drop of climate change, we must use water resources more efficiently. The management of scarce irrigation water plays a big part in improving water usage effectiveness. Precision irrigation has been demonstrated as one of these innovations; however, at the moment there is the little

economic benefit to be had from using this technique for field-scale agricultural production. While precision irrigation has achieved significant advancements in some advanced countries, it is still in its infancy in India. Factors including small land holding size, expensive investment requirements and field heterogeneity in terms of water and nutrient stress, limits precision irrigation system adoption. It is anticipated that both farmers and users would benefit greatly from the integration of machine learning techniques and mobile and web solutions. Anyone who is interested in the digitization of the

farming process, including farmers, researchers and generalists, will find this study useful. Future research will address the environmental issues connected to automated farm's use of digital irrigation management technology. It goes without saying that the idea of managing irrigation water with precision is excellent and has many benefits. Yet, moving from the concept stage to field, acceptance takes significant resources, including both, human and capital infrastructure, as well as government policy assistance.

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