EXPLORING CONVENTIONAL AND ADVANCED METHODS FOR SUSTAINABLE IRRIGATION IN INDIA

SIRISHA ADAMALA, CH. JYOTIPRAVA DASH, A.O. SHIRALE*, P.C. MOHARANA, R.K. NAITAM, H.L. KHARBIKAR, M.S. RAGHUWANSHI, H. BISWAS

ICAR-National Bureau of Soil Survey and Land Use Planning, Nagpur, Maharashtra, India

*Corresponding author, E-mail: abhay.shirale@icar.gov.in

Water is the life blood of crops and that makes availability of irrigation water a prerequisite for sustainable agriculture production. Proper irrigation systems are essential for all agriculture seasons since unpredictable weather pattern making water a scarce resource even in rainy season. In India, hardly 40% of the gross cultivated area is covered by irrigation, despite being world's largest irrigated region. Indian farmers own many techniques for storing as well as application of irrigation water in farm fields. Traditional irrigation methods (TIM) though economical and sustainable for rural populations their water use efficiency (WUE) is relatively low (35-40%) due to the huge conveyance and distribution losses. Advanced irrigation techniques offer best solutions to boost WUE in agriculture thus, to cover more area under irrigation i.e. to increase gross cropped area of the country. In contrast to TIM, modern or micro irrigation (MI) techniques utilizes emitters, nozzles, and pipe networks to enable the delivery of irrigation water at predetermined intervals and quantities. In order to mitigate groundwater depletion and maximize WUE in farming, it is high time to make use of sophisticated and computerized systems to plan for automated irrigation technologies (Smart irrigation).

IRRIGATION METHODS

Various types of irrigation methods differ in how the water obtained from the source is distributed within the field with a goal to supply the entire field uniformly with water, so that each plant has the amount of water it needs, neither too much nor too little. The different types of irrigation methods used in India are depicted in Fig. 1.

TRADITIONAL IRRIGATION METHODS

The design and structure of each local tradition irrigation method are decided by the terrain and rainfall pattern of the region (Debnath et al., 2020). Hence, irrigation in each eco-zone of India had unique techniques of traditional method. Table 1 highlights some of the representative local structures being practiced in different regions across the country.

Surface/Flood Irrigation: In this method, water moves over and across the land by simple gravity flow in order to wet it and to infiltrate into the soil.

Basin Irrigation*:* It is the most common method and, in this method, the field is divided into small units which

are surrounded by small levees or dikes to prevent runoff. This method is not suitable for all crops and soils, but it is generally favored by moderate to slow intake soils, deep-rooted, and closely spaced crops that are unaffected by standing water like rice for long periods. Trees can also be grown in basins are called as check basins. Level and graded basins are a variant of basin irrigation, where the field is divided into a number of terraced rectangular bays which are graded level or have no significant slope

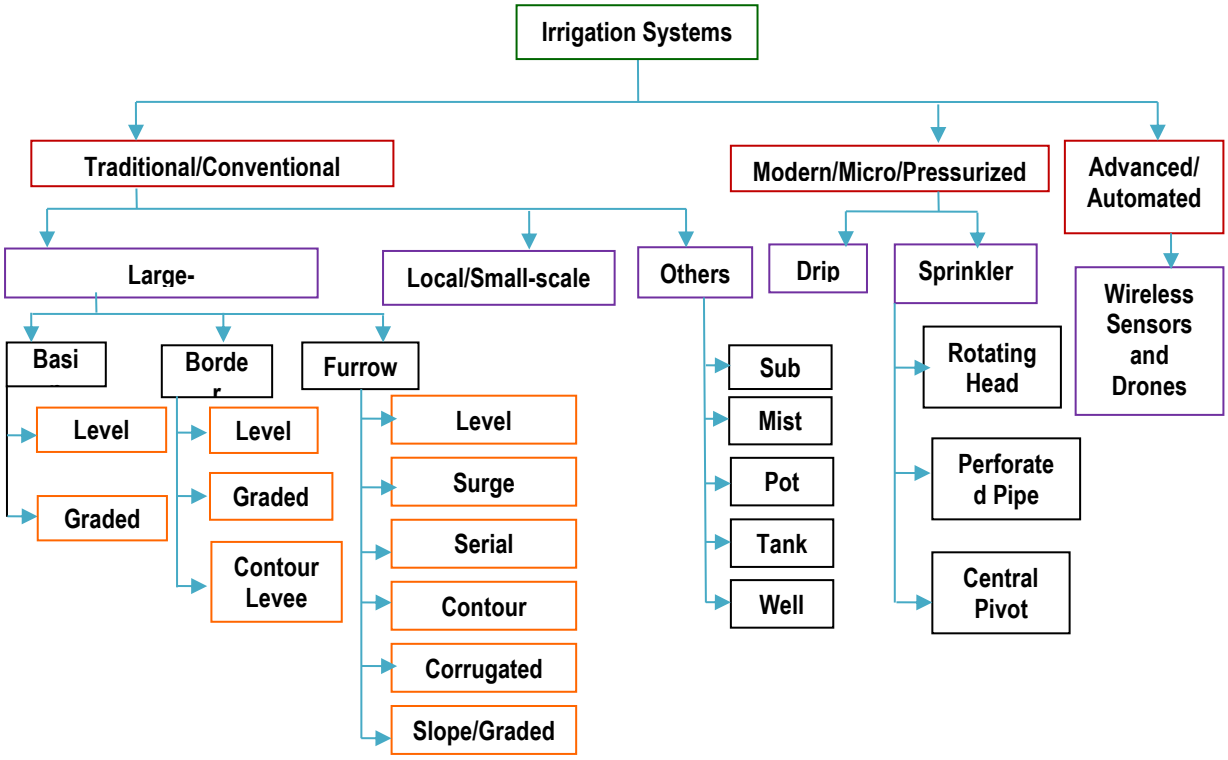

Figure. 1 Different types of irrigation methods in India

Table 1 Traditional irrigation methods in India according to terrain

ECO-ZONE	STRUCTURES
Trans Himalayan	Water from melting snow and ice is the only source of water
Western Himalayas	Canals to collect water from hill streams, springs, and melted snow
Eastern Himalayas	Bamboo pipes are used to divert the streams water for irrigation
Northeastern Hill Ranges	Rainfall & groundwater are main sources of water in natural springs
Brahmaputra Valley	Floodwaters accumulate in natural depressions are used
Indo-Gangetic Plains	Rivers and their floodwaters are the main source of water
Thar Desert	Rainwater was captured and stored in ponds and underground tanks
Central Highlands	Irrigation by wells and tanks is very common in this region
Deccan Plateau	Wells, embankments across rivers & streams, reservoirs and tanks
Western Ghats	Horizontal well in hard laterite rock formations
Western Coastal Plains	Shallow wells in low depressions to yield sweet potable freshwater
Eastern Coastal Plains	Ponds in areas of waterlogging, floods or saltwater ingress
Islands	Wooden bunds to collect water in the pits through split bamboos

Border Irrigation: This method is an extension of the basin irrigation to sloping, long rectangular or contoured field shapes, with free draining conditions at the lower end. Irrigation water can be fed to the border in several ways: opening up the channel bank, using small outlets or gates or by means of siphons or spiles. A sheet of water flows down the slope of the border, guided by the bunds on either side.

Furrow Irrigation: In this technique, irrigation water is channelled along the primary direction of the field using *furrows*, *creases*, or *corrugations*. Water infiltrated through the wetted perimeter spreads horizontally and vertically to fill the soil reservoir (Adamala et al., 2014). Here, crop is usually grown on the ridges between the furrows hence, this irrigation method is ideal for all crops that can be grown in rows. In different situations, different furrow methods are used such as slope, levelled, contour, serial, and corrugated. Surge Irrigation is a variant of furrow irrigation where water supply is pulsed as on and off mode in planned time periods.

Sub-Irrigation: Sub-irrigation or seepage irrigation is a method of artificially raising the water table to allow the soil to be moistened from below the plants' root zone. This method is usually used for field crops, in lowlands or river valleys, combined with drainage infrastructure.

Mist Irrigation: This type of irrigation is a prerequisite for tissue culture plants during the primary hardening stage, where plants used to be tender and require high humidity to overcome heating. Misting water helps to delay maturing, arrest over-sweetening, overcome heat stress, and retains the freshness.

Pot Irrigation: This method is more suitable for areas having scanty rainfall and saline areas, where surface irrigation is not suited. An earthen pitcher is used in this method. Holes are made in the pitcher and water is filled in it so that seepage of water through the holes keeps the nearby soil moist. This method can be considered as an alternative of drip irrigation method.

Tank Irrigation: Tanks are small reservoirs with earthen walls, used for storing water diverted from a stream or runoff during the unpredictable monsoon rains having a wide diversity of distribution.

Well Irrigation: Well irrigation is popular in areas where groundwater resources are plenty. Traditionally, water is lifted from wells using 'Rahat' (known as Persian wheel). Traditional water lifting methods are almost vanished from Indian villages since most of the people prefer adopting less laborious modern water lifting methods.

MODERN OR MICRO-IRRIGATION

Micro irrigation allows frequent application of water in required and measured quantity, directly on or below the soil surface. Here, water is applied as continuous drops, tiny streams, or fine spray through emitters placed along a low-pressure delivery system. Such system provides water precisely to plants near the root zone that helps to mainten ideal moisture conditions for plant growth. It is one of the efficient methods of water utilization with 70-75% WUE (Krishna Reddy et al., 2017).

Basic types of micro irrigation system are as follows:

Surface System: It is the system in which emitters and laterals are laid on the ground surface along the rows of crops. The emitting devices are placed near the root zone of the crops.

Subsurface System: It is a system in which water is applied slowly below the land surface through emitters.

Bubbler System*:* In this system the water is applied to the soil surface in a small stream or fountain. These are suitable in situations where large amounts of water need to be applied in a short period of time and suitable for irrigating trees with wide root zones.

Micro and Mini Sprinklers: These are small plastic sprinklers with rotating spinners. The spinners rotate with water pressure and sprinkle the water.

Pulse: This system uses high discharge rate emitters therefore, has short water application time. Primary advantage of this system is a possible reduction in the clogging problem.

Biwall: It is an extruded dual chamber micro-irrigation tubing made out of linear low-density polyethylene. This system is suitable for all closely spaced row crops.

ADVANCED OR AUTOMATED IRRIGATION

The main aim of using advanced or automated irrigation systems is to make precise irrigation by optimizing water use in agriculture. In this system, different transmitters (sensors, Bluetooth, radio-frequency identification (RFID), wireless local area network (WLAN), *3rd Generation Partnership Project* (3GPP), WiMAX (Worldwide Interoperability for Microwave Access), and ZigBee) sense the in-field soil moisture, temperature, and various climate data and send them to the base station (BS). In addition to above, researchers have begun using the nano-based bio-sensors, drone technology, and unmanned aerial vehicles (UAVs) technologies to monitor their fields as well as aiding precision agriculture programs. However, transfer of this innovative research into practice is really challenging.

CONCLUSION

The less water use efficiency of conventional irrigation methods not only results high water use in agriculture but also cause wastage of water and create water logging and salinity problems in many regions. Judicious use of water is vital to achieve higher productivity in a sustainable manner. Modern irrigation systems such as micro irrigation and smart irrigation make use of wireless sensor networks for enhancing water use efficiency and productivity without affecting soil health. Ultimate success in farming especially under resource scarce conditions always depends upon farmer's wise decision in choosing the appropriate irrigation method.

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