CHAPTER IV
MODERNIZATION OF AGRICULTURE

4.1 Introduction
4.1.1 India has second highest agriculture land in the world. Majority of Indians depend for employment on agriculture. Water management is a big issue in this sector that affects productivity. Lower than expected rain and lack of water management affects agriculture adversely. Technology application is necessary to increase productivity and profitability of farmers. India needs to adopt world’s best agricultural practices to raise her production and productivity. Around 65% of Indian economy depends on agriculture. We need to modernize farming practices and enhance farmer’s income to ameliorate their pathetic condition. Traditional agricultural practices are consuming excessive quantity of water, energy, fertilizers and pesticides, etc with the result that fertility of land and ground water are decreasing every year. Occasional lack of rains and reduction in surface water is also creating problems for irrigation.

4.2 Background
4.2.1 Traditional methods of irrigation have inherent disadvantages and are inefficient in the use of water, energy, welfare use of fertilizers and other agricultural resources. They create soil erosion, water logging in fields and wastage of ground water. Micro or trickle irrigation methods, including drip irrigation and sprinkler irrigation have many advantages, such as conservation of energy, water & fertilizers and help achieve higher net yield and productivity. They are suitable for arid and semi-arid areas in hot tropical conditions. They can be operated in both manual & automatic modes and enable selection of irrigation methods based on different parameters.

4.2.2 Budget 2015-2016 has laid emphasis on “Pradhan Mantri Gram Sinchai Yojna” aimed at “Per drop More Crop” and Parampragat Krishi Vikas Yojna (Organic Farming) as the two most important programmes in the farm sector to enhance productivity and production. Allocation of Rs 5,300 crore was
made for micro irrigation watershed development and Sinchai yojna. Also, Rs 300 crore allocation was made to encourage organic farming in the country. State governments are expected to contribute more money for the same. Soil health card scheme has been introduced and a unified National Agriculture Market has been setup to increase farmers' incomes. National Skills Mission would also enable young farmers to use modern technologies, develop skills, innovate, create and ideate for boosting crop production per drop of water using innovations and creativity.

4.3 **Surface Irrigation**

4.3.1 There are three types of surface irrigation methods, such as level basin, furrow basin and border strip basin. In surface irrigation, entire field is filled with water. In level basin, water is applied in the entire field and end parts of the field are linked with small ponds and extra water goes waste as deep percolation, soil evaporation and run off to ponds. In furrow basin, furrows are made along contours and are filled with water. In border strip basin, a water channel is provided between two adjacent rows of beds. This method is not suitable for all types of soils and around twenty percent water is actually used by plants. It is suitable for uneven land, where leveling cost is high.

- **Level Basin** - This technique is suitable, where the size of plot to be irrigated is small.

![Figure-4.1: Level Basin Flood Irrigation](image)
Furrow Irrigation Basin

Furrow irrigation method is mostly used for row crops, such as potatoes, cotton, sugarcane, vegetables, etc. In this technique, whole field is not filled by water, rather water is filled in furrows. It is suitable for slopy lands, so that water can be runoff, where the furrows are made along contours.

![Figure-4.2: Furrow Irrigation](image1)

- **Border Strip Irrigation Basin**

  Border strip irrigation is also known as bay strip irrigation. In border strip irrigation, first all the field is leveled. Field is divided into small beds, which are surrounded by 15 to 30 cm high bunds. A water channel is provided between two adjacent rows of beds.

![Figure-4.3: Showing Border Strip Irrigation](image2)
There are many disadvantages of conventional irrigation methods. Conventional irrigation requires large work force and maintenance cost is high. Here, the plants utilize only 20 to 40% water. Due to over irrigation, water moves below the roots of plants and results in raising the water table. If the field is not leveled, initial cost may be high. Lack of subsurface drainage may restrict the leaching of salts from the soil.

4.4 **Drip Irrigation**

4.4.1 Drip irrigation system employs an extensive network of pipes, which is operated at low pressure. Low volume water is applied at high frequency range for 1 to 4 days. Water and fertilizers are used efficiently under the farm conditions. Different types of micro irrigation systems can be used on the basis of type of crop and amount of water available for irrigation. This system provides more crop for every drop of water alongwith early maturity, better quality & higher yield of crop. It saves labor cost, yield increases up to 230% and water is saved upto 70%.

4.4.2 The head part consists of a pump or motor to lift water. Water pressure can be adjusted and then distributed through nozzles. Fertilizer and nutrient loss is very less due to localized application. Basin leveling is not necessary and soil type is not important in drip irrigation. Water and evaporation losses are minimized. The amount of water supply to field can be adjusted. It facilitates application of water and fertilizer at the plant root system. It saves water up to 35 to 65%. It increases the crop yield & enhances plant growth. It is easy to install and labor cost is low. However, initial cost and maintenance cost is high. Sun can decrease the usable life of supply tubes. Water and evaporation losses are minimized.

4.4.3 For water to trickle down 8 to 10 cm deep in the soil, we need 1 lakh litres of water in drip irrigation to irrigate one hectare area of farm. Cost per hectare depends mainly on spacing of crop. Economic considerations limit the use of drip irrigation technique to orchards and vegetables in water scarcity areas. Laterals may be designed to operate under pressures as low as
0.15 to 0.2 kg/cm\(^2\) and as high as 1 to 1.75 kg/cm\(^2\). A pressure drop of 1 to 1.75 kg/cm\(^2\) in the head of the drip system (including filter) may be anticipated.

4.5 **Sprinkler Irrigation**

4.5.1 In sprinkler irrigation (Fig.4.4) a pressurized pipe network is used for delivery of water through pipe to nozzles of the sprinkler, which is similar to natural rainfall. Water comes with high pressure into sprinklers such that sprinklers move in a circle and are driven by a ball & gear drive mechanism called impact mechanism. This system is adaptable to any farmable slope. It is also adaptable for any type of irrigable field. It is best suited for sandy soils. It is highly efficient due to uniform water distribution.

4.5.2 Sprinkler method usually requires the highest initial investment as compared to surface irrigation methodology, except where extensive land leveling is necessary for surface irrigation. Power requirements are usually high, since sprinklers operate with pressures greater than 0.5 to more than 10 kg/cm\(^2\). They include rotating head systems and perforated pipe system. Rotating head systems are classified according to pressure ranges of operation and
their position in relation to irrigated crops. Central pivot system is used for automatic movement of sprinklers.

4.5.3 This system can be used for almost all types of crops except paddy & jute. It can eliminate surface run off irrigation water and can protect the crop against frost & high temperature. It reduces labor cost for irrigation as compared with surface method. It saves fertilizer & water. Land leveling is not necessary for sprinkle irrigation. It provides higher water use efficiency. Sprinklers provide efficient coverage for small to large areas and are suitable for use on all types of properties. They are adaptable to all types of irrigable soils, since sprinklers are available in a wide range of discharge capacity. Sprinkler is designed to ensure maximum water saving combining high quality, affordability and ease of installation.

4.5.4 However, it is not suitable for very fine texture soil (<4mm/hec). There is an uneven distribution of water due to distortion by high pressure water. Evaporation losses are high. It requires clean water, which is free from debris, sand slit & clay particles. Initial cost of installation of sprinkler system is high. It requires high operating power and has some limitations, such as higher initial cost. It requires continuous energy for operation. Under high wind and high temperature conditions, water distribution & application efficiency is poor.

4.6 Sensing Devices

4.6.1 Mechanical, electrical, electronic and bio- sensors are being increasingly used in different applications in agriculture, environmental surveillance, disaster management, space technology, remote sensing, hydrology, etc. Simple soil moisture sensors that do not require power are being used by gardeners for checking, whether plants have sufficient moisture to thrive or not. After inserting the soil moisture probe for around 60 seconds, a meter indicates whether soil is dry, moist or wet for plants.

4.6.2 Soil moisture sensors are designed to calculate soil volumetric water content based on the dielectric constant of the soil. The dielectric constant of soil
increases, when the water content of the soil increases. The dielectric constant of water is much larger than air and other soil components. Therefore, measurement of dielectric constant gives a predictable calculation of water content.

4.6.3 There are three portable units including, base station, valve system and sensor network. Sensor system collects data from soil moisture sensor and sends it to the base station. Base station system receives the moisture data from sensor sensor network and controls the valve system. Low noise wireless system is used as communication channel between sensors system and base station. By using this method, farmers can raise productivity by predicting the raw value of need of water requirement for the crop.

4.6.4 Soil moisture probe is made up of multiple soil moisture sensors. This sensor measures soil properties, such as electrical resistance, dielectric resistance or interaction with neutrons as a proxy for moisture content of soil. The relation between measured property and moisture must be calibrated periodically, since it may vary depending on the type of soil. The reflected microwave radiation property is affected by soil moisture and is being used for remote sensing in hydrology and agriculture.

4.6.5 Heat dissipation soil moisture sensors rely on effective conductivity of soil. Additional water content conducts heat more readily than dry soil. Heat dissipation soil moisture sensor, which has a porous intermediate water holding element is subject to errors upto 30% wet and dry cycles. Tensiometer is used to measure how hard the root system of the plant must work to extract water for its need from the soil. It directly measures the soil matric potential, which is the force which the root system must overcome to free water from the grip of soil particles. Light texture soil needs water application at tensiometer reading of 20 centibars (1 bar=100 centibars) and heavy textured soil requires water application at 60 centibars reading during wet and dry cycles.
4.6.6 Soil moisture sensors enable farmers to use lesser water quantity to grow crops, increase crop yield and obtain better quality crop by soil moisture management during critical plant growth stages. Today, soil moisture sensors are being used increasingly in golf courses to increase efficiency of irrigation system to prevent over watering, leaching of fertilizers and other chemicals at the site.

4.7 New Developments

4.7.1 Today, technology is advancing at an accelerated pace as never before. Theoretical knowledge is necessary to explain and predict situations and practical aspects of research and development. ICT & WSN application in agriculture requires multi-disciplinary and inter-disciplinary approach. WSNs are the real world examples of pervasive, smart sensing and computing devices. Farmers need awareness and information about emerging technologies, which have potential to save labour, costs and raise productivity in agriculture operations.

4.7.2 Magnetized water is being used in farms to increase crop growth. Agriculturists across the globe are using micro air vehicles and sensors to gain insights for assessing requirements of growing plants and maximise value for the farmers. Technology application helps achieve reduction in environmental impact and wastage of critical resources through precision agriculture.

4.8 Crop Modeling & Simulation

4.8.1 Different crop modeling methods are being used in agriculture to calculate the growth of crops and monitor various environmental constraints like moisture, nutrients, water etc. Decision Support System for Agro Technology Transfer (DSSAT) model is used to observe growth, development and crop yield. Also, Agricultural Production System Simulator (APSIM) is being used to integrate all the information derived by different researchers for analysis and future use.
4.8.2 Two types of simulation models are being used for crop modeling in agriculture. Decision Support System Simulator (DSSS) is being used for agro technology transfer to estimate the growth and development of plants. And Agriculture Production System Simulator (APSS) is being used for production estimation.

4.8.3 Both drip irrigation and sprinkler irrigation systems can be controlled and monitored by wireless sensor network technology. Sensor part can be an electronic, electrical or mechanical. Each sensor works as a node in the field. Data can be sent from one node to another node through wireless sensor links. Nodes perform minimal data processing to find the shortest path for exchange of information. Nodes are connected with each other using different topologies, such as tree or mesh topology. All wireless devices are connected with a single monitoring device, such as computer or mobile through the network. Drip irrigation can be controlled by using different electronic devices, like zigbee communication, soil moisture sensor, GSM-Bluetooth or comparator.

4.9 Prediction of Crop Water Requirement

4.9.1 There are three main sources of water for irrigation that include, rainfall, ground water and streams or ponds. If water is provided according to plant requirement, it enhances productivity. Farmers lack resources to predict water requirement to increase quality and quantity of crops. Wireless sensor network can be installed in the ground to measure soil moisture and to calculate approximate value of water requirement in the field. If wireless sensor network is connected with a wireless module, information can be sent to control and monitor the field from the main station.

4.10 Evolving Farming Practices

4.10.1 Farming and agriculture provide essential food and fuel to society for its survival. Availability of agriculture land, water, energy and labour resources are decreasing continuously. Farmers have been using inefficient irrigation techniques, hand held tools and animal driven implements based on their experience, since ages. Agricultural practices are still evolving in India.
Many farmers have started using tractor driven machinery to improve their labour productivity, but tractors have many disadvantages, including soil compaction and limited capabilities.

4.10.2 Agricultural scientists and engineers are trying hard to replace tractor driven mechanization with robotic agriculture. Robotic agriculture has huge potential and it can ensure food security for the burgeoning population. It is essential to increase agriculture productivity to meet the present food deficit situation in India, by using advancements in science and technology. Global population has crossed the seven billion mark, out of which around 15% of population is going hungry everyday. Droughts in the Horn of Africa have created numerous problems for the population. Difference between demand and supply of food is increasing disproportionately today and food prices are increasing year on year. Productivity can be raised by using hybrid or high yield variety of seeds & saplings, fertilizers, world’s best irrigation practices, pesticides, deweeding chemicals, higher plant density and mechanical farming methodologies.

4.10.3 Agriculture research organizations, scientists and engineers are making efforts to develop low-cost affordable machinery for large, medium and marginal farmers. Today, all types of machinery items are available in the market for land leveling, land preparation, seeding and planting, weeding, interculture, plant protection and harvesting purposes. However, these machines lack versatility, dexterity, intelligence, precision, multi-functionality capability and ease of affordability. We need to develop such machines, which are affordable and can work like human beings. Machines should be able to deal with individual plants and facilitate farmers work.

4.11 Wireless Sensor Network

4.11.1 Wireless sensor network is a group of spatially dispersed and dedicated sensors, which can be used to monitor and record physical condition of environment and organize this data at a central location. WSN’s can measure environmental parameters, like temperature, sound, pollution levels, humidity, wind speed, direction and pressure for use in agriculture. WSNs
system incorporates a gateway, that provides wireless connectivity back to the wired world and distributed nodes. All collected data is sent to the sink node or gateway node. Placement of sink node has great impact on energy consumption and lifetime of WSNs.

4.11.2 Multi-hop network for use in agriculture consists of hundreds of sensor nodes. These sensor nodes are capable of finding the route towards the sink for data transmission. All sensor nodes transmit data either directly to the sink, or they relay data through their neighboring nodes. Nodes which are located near the sink transmit more data than other nodes. An energy-efficient routing consumes less energy for transmission of messages.

![Figure-4.5: Wireless Sensor Network](image)

4.11.3 Wireless sensor networks represent an enabling technology for low-power wireless technology that can be used for measurement and control applications. WSN technology provides access to real-time data from a remote site, for analysis and taking necessary action. Negative weather conditions do not affect the working condition. This low-maintenance system can identify soil type, planting period, seed cutting and storage requirements. WSN is an automated system used to monitor physical condition parameters like temperature, pressure, sound etc. and passes collected data to the main station. All sensors are connected to each other. A sensor node has several parts, like radio transceiver, an antenna with a microcontroller, battery or an embedded source of energy harvesting.
4.11.4 Sensors can be used in dry or wet places to provide useful information about soil and weather. All sensors have transceivers, which pass signals to the gateway and pass the signal to the end user via internet connection. This automated WSN system can achieve water savings up to 90% (as compared to traditional irrigation practices) in the agricultural zone. Valve control hardware and software compatible with a commercial wireless sensor node needs to be used. Wireless sensor networks provide an enabling technology and elimination of lead wires achieve significant cost savings & improved reliability for long term monitoring application. Instrumenting spaces to be observed or controlled with wireless networks, enables long-term data transmission at scales and resolutions that are difficult to obtain otherwise.

4.11.5 Wireless Sensor Network (WSN) technology is being used to provide efficient precision agriculture. Wireless sensor network devices comprise wirelessly connected sensor devices, which are spread in the environment to manage and monitor it. WSNs were initially designed for military applications, but today wireless networks are being used in many industrial and consumer applications, such as industrial process monitoring and control and machine health monitoring. WSN architecture follows the OSI model. Wireless sensor network applications require five layers including, application layer, transport layer, network layer, data link layer and physical layer. After deployment in the physical world, even factory-calibrated sensors develop numerous faults that can corrupt sensor data. Salinity sensors are especially susceptible to biofouling. Gradually, sensor response quality of sensors gets degraded and corrupts critical data.

4.12 Precision Agriculture

4.12.1 Precision agriculture is one of the most important applications of WSNs. Developed countries are using micro air vehicles and sensors to assess the requirement of nutrients and water in growing plants to maximise value for the farmer & minimise environmental impact to reduce wastage of water and critical resources through Precision Agriculture. About 88% of available water resource is being consumed in agriculture, therefore participatory
irrigation management approach should be adopted for efficient use of water and reduction of conflicts among the farmers.

4.12.2 For example, in a potato research project, harvesting sensors were used to check soil moisture, temperature, humidity and protection of the field from fungal diseases. Farms, free from diseases and harmful fungi were achieved in both old used land reclamation and new land cases. In order to improve storage of potato seed tubers and crops, irrigation scheduling, fertilization scheduling and other planting practices were used. Use of WSN technology helped in improving the potato crop, saving of input resources and preventing or detecting harmful diseases.

4.12.3 Shaswat Yogic Agriculture (SYA) practices were used in Pantnagar Agriculture University (U.P), research farms for two to three years using organic manure and biotic pesticides. Positive vibrations were given to seeds in store, during plantation and during growth period of crops. Research has proved that productivity increases incrementally every year without any use of chemical fertilisers and pesticides. SYA saves the farmland from degradation, saves resources and increases farmers income.

4.12.4 Magnetized water can potentially increase crop growth. Unmanned aerial vehicles fitted with wireless sensing devices can be used to monitor and control agricultural activities. Such practices should be promoted by scientists, farmers and government agencies.

4.13 Use of GSM- Bluetooth for Real Time Monitoring of Crops

4.13.1 Automatic plant irrigator application is playing a vital role in enhancing productivity and monitoring of environmental parameters. This technique is economical and is based on wireless sensor interfaced with GSM, BLUETOOTH for irrigation control and real time monitoring of agriculture. Real time monitoring sensors for crops are controlled via SMS using a GSM module. SMS is shared by Bluetooth or GSM technique interfaced with the main microcontroller chip, which controls operations on the farm land. Information about rise in temperature, concentration of carbon dioxide level
in the soil and soil moisture content on the field is communicated to the farmer’s mobile phone using GSM BLUETOOTH module and farmers can take an appropriate corrective action. This system includes an ATMEGA 64 eight bit microcontroller chip, GSM and BLUETOOTH module RS 232 interface. Microcontroller is interfaced with different sensors to monitor the crop. ADC is used to convert analog data of sensors into digital data. EPROM records data obtained by the sensors, microcontroller analyses it and sends the information to the farmer through GSM (for distance control) and BLUETOOTH (for nearest control). Measured values of data collected by the sensors is stored in EEPROM is sent to the farmer on his request using SMS, via GSM module.

4.14 **Automated Plant Irrigator using 8085 Microprocessor and IC 8255**

4.14.1 In drip irrigation, Automatic Plant Irrigator employs 8085 microprocessor and IC 8255. Drip irrigation technology is water efficient and supplies necessary quantity of water at the root zone of the plants. It employs an extensive network of narrow tubing, valves and pump motor to supply water at low pressure using drop by drop process, that conserves water, energy and other input resources. Low volume of water is applied at high frequency. This system is comprised of sensors and employs op-amp LM324 electronic device that serves as comparator. Two stiff copper wires are used here to sense soil moisture on the farm. The whole system is controlled by a microprocessor, which monitors the sensors through IC 8255. Whenever the soil becomes dry, microprocessor switches ON the pump motor. When soil becomes wet, the pump motor is switched OFF.

4.15 **pH Value Tester**

4.15.1 Different devices are required to test fertility or pH value of different types of soil samples. Knowledge of soil properties enables farmers to obtain better crop growth and enhance productivity using appropriate quantities of fertilizers/nutrition and water. Before applying micro irrigation and WSN technologies, farmers must determine pH value of soil with the help of soil fertility meter. Meter two metal prongs, which are inserted into a soaking oil wet soil sample. This meter indicates electric behavior and is designed to
measure pH value or overall fertility of soil. It is easy to use and shows quick results on the dial. The pH value tester works against a buffer reference solution. It tests the soil according to the prescribed value of pH.

Farmers need to determine the percentage of important ingredients, like phosphorous, nitrogen and potassium present in the soil to achieve better growth of crops and productivity enhancement. For instance, in Bundelkhand U.P area, it was found that the main reason for the adversity of farmers lies in the negligible presence of phosphorous, nitrogen and potassium in the soil.

4.16 Measurement of pH Value

4.16.1 pH value of soil holds crucial importance in agriculture. It affects availability of soil nutrients for crop growth. If soil pH value does not lie within an acceptable range, crop growth is curtailed and soil erosion potential increases. The ability of soil to provide adequate nutrition to plants depends, firstly on the presence of requisite amount of essential elements like N, P, K, Mb, Fe, Mn, Zn, etc in the soil. Secondly, on the nature of combination of different elements present in the soil. Thirdly, on the process in which these elements are available in the soil and fourthly, on the soil solution and pH value.

4.16.2 Soil is graded as alkaline/acidic as per pH value, as shown in the table 4.1.

<table>
<thead>
<tr>
<th>Acidic</th>
<th>Alkaline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly acidic upto pH=5.0</td>
<td>Strongly alkaline upto pH=9.0</td>
</tr>
<tr>
<td>Medium + slightly acidic upto pH = 6.0</td>
<td>slightly alkaline upto pH = 8.0</td>
</tr>
<tr>
<td>Very slightly acidic upto pH = 7.0</td>
<td>Very slightly alkaline pH = 7.0</td>
</tr>
</tbody>
</table>

Iron, Manganese and Zinc becomes less available, when pH value rises from 6.5 to 7.5-8.0. Phosphorous and Molybdenum availability increases at higher pH value.
4.16.3 Electronic sensing devices and testing devices should be calibrated with reference to readings obtained from manually operated methodologies. Average of three readings should be taken for better results. Soil chemistry, pH value and soil ingredients like P, N, Fe, Mn, Zn, Mb etc keep changing with time. We need to develop sensors to measure the growth of crops/fruit at various stages of ripening and colour change, sweetness etc in non-invasive ways.

4.17 Sensor Topology

4.17.1 Wireless sensor networks are being used to estimate water requirement of plants, automatic switching on/off the pump motor on the basis of farm requirement and status of irrigation system. Micro irrigation system can be connected to wireless sensor networks (WSN) to monitor status of the system. Wireless sensor networks are being used to monitor physical and environmental conditions. They have many military, industrial and consumer applications, such as control and monitoring of industrial processes & health monitoring of machinery.[69,111]

4.17.2 Different sensor devices are used for sensing parameters like, water level, soil moisture, humidity, temperature, etc. To record these parameters, large number of sensors are used to cover the entire field. These sensors are wirelessly connected through the network to a remote station. Each sensor serves as a node. All nodes perform minimal data processing and send data to base station. Routing between initial node and destination node is shown in figure in which shortest path between nodes is searched by minimal data processing. Nodes can be connected with each other using different topologies like tree topology and mesh topology.

4.17.3 Sensor deployment using spatial arrangement of permanent crop. Water is one of the most important resources for crop irrigation which consumes maximum water. Therefore, there is a need of water management in arid and semi arid regions of India. Efficient water management methods include aligning cropping pattern, micro irrigation, irrigation automation etc.

4.17.4 This system consists of different sensors, microcontroller, base station and irrigation control module. Different sensors in this system including climate
sensor, GPS sensor, weather sensor and soil moisture sensor. Soil moisture sensors are being used for measuring water requirement of plants.

4.17.5 Microcontroller 8051, PIC Zigbee is being used as a communication device along with microcontroller, central base station and irrigation control module. Irrigation control module is used for controlling water supply and start/stop the irrigation process on demand basis. The success of network depends on the deployment pattern of sensors in the field. It is necessary to provide an appropriate spacing pattern for permanent crops. Conventional patterns being followed include horizontal and linear row farming. In precision irrigation, hexagonal spacing pattern increases the coverage area of deployed sensors.

4.17.6 Sensor deployment can be Deterministic or Random.

- In deterministic deployment, it is necessary to maintain minimum number of sensors to keep the deployment cost low. Researchers have developed algorithms for deployment pattern of sensors, such as triangle pattern, diamond pattern, square pattern and double strip pattern in deterministic sensor deployment to achieve full coverage and connectivity.

4.17.7 In random deployment, sensor location is not known as priori. This type of deployment is used, where the resources are limited, networks are large & dense and topology is dynamic. More sensors are used in random deployment and cost is high. Random deployment requires more complex algorithms that consume more power for requisite coverage and connectivity. It is a challenging task to reduce coverage and connectivity area of wireless sensor networks in deployment of sensors. Two types of spacing patterns are being used in agriculture, namely Row pattern spacing and Hexagonal pattern spacing.

4.17.8 Both drip irrigation and sprinkler system can be controlled and monitored by wireless sensor networks. Sensor part can be an electronic, electrical or mechanical. Each sensor in the field works as a node. Data can be sent from
one node to another node via wireless sensor link. Nodes perform minimal
data processing to find a shortest path for exchange of information. Nodes
are connected with each other using different topologies such as tree or
mesh etc. All wireless devices are connected with a single monitoring device
such as computer or mobile through the network. Drip irrigation can be
controlled by using different electronic devices like zigbee communication
device, soil moisture sensor, GSM-Bluetooth device or comparator LM324.
For controlling and monitoring sprinkler irrigation system, sensor setup can
be designed using silver wires, comparator and power supply, where
wireless device is connected with the sensor to transmit field information to
the remote station.

4.18 ZIGBEE Technique

4.18.1 This system is used to produce more crop per drop of water and is based on
soil identification system that employs zigbee module for communication
purposes. Three soil moisture sensors are used to sense the soil moisture.
Three or more layers of soil at different depths e.g. 7.5cm, 15cm, 30cm,
45cm. The output of sensor is recorded by the microcontroller and an action
signal is generated by the microcontroller. If the value of soil moisture is
high, then the value unit remains closed. If it is low and soil is dry, then the
value unit remains open. An indicator displays, weather the soil is dry or is
having the requisite moisture content.

4.18.2 Microcontroller controls the pump motor and sends this data to a computer
through Zigbee module. Zigbee module uses low power and employs
wireless mesh network standard. Low power use results in longer life.
Integrated radio and microcontroller Zigbee chips, having flash memory of
60-256 kb are available in the market. Zigbee network layer supports, star,
tree and generic mesh network.

4.18.3 Zigbee operates in industrial, scientific, medical and radio band width of
915 MHz in USA and Australia and 2.4 GHz in most jurisdictions across the
globe. Zigbee technique is one of the newer techniques being used for drip
irrigation in agriculture. This is a modern real time feedback control system that monitors the moisture content of soil.

**Figure-4.6: Networking of Agrobots**

4.19 **Agrobots**

4.19.1 An agrobot has a movable physical structure, actuator system, sensor system, power supply system and computer. An agrobot involves use of sensors, microcontrollers, image processing algorithms, communication software and GPS, etc as shown in Fig4.6. Building a reliable robust and affordable agrobot is a challenging task. Agrobots are most suitable to perform repetitive labour-intensive agriculture activites, like seeding, spraying, planting, picking, watering, etc. Agrobots, provide smart and multifunctional capabilities to the farmer. Deployment of agrobots is highly beneficial to the farming community.

4.19.2 Agrobots are classified into harvesting or picking, planting, deweeding, pest control or plant maintenanceagrobots. Recent advancements in the development of agrobots using distributed sensor networks, promise to create same or even greater crop production as compared with traditional farming methods. Either a number of robots are deployed or a number of task- specific sensors are placed in a farmland. These sensors or robots can communicate with each other through the monitoring base station. They can perform tasks like, monitoring, surveillance and control activities. They can monitor growth of fruits/flowers on the basis of their colour, shape & size, health, produce of plants and growth of weeds. They can provide an estimate of produce and send alerts of trespassing of farmland to ensure safety of crops. They can also perform control and actuation activities, like watering of plants, plucking and deweeding.
4.19.3 Agrobots are being designed and built for performing specific-task based activities, like weeding robot, distributed home garden mobile robot, mobile weeding robot, multifunctional robot (which can be fitted with different end effectors), spray robot, coconut harvester robot, berry harvester robot, milking cow robot, etc.. These robots are using GPS and sensors for navigation. Robots are most suitable for repetitive tasks. Automation is the best solution for reduction of manual activities in labour-intensive repetitive tasks for which robots are found most suitable.

4.19.4 Concerted research efforts are continuing to develop multi-functional robots, which are capable of moving on uneven terrain & perform drilling, seeding, fertilizer application and spraying functions in an automated mode. Block diagram of a multifunctional robot is given below.

![Figure-4.7: Block Diagram of Multi-functional robot used for manipulation of soft fruit and flowers by End Effector](image)

4.20 Conclusion

4.20.1 Traditional methods of irrigation have inherent disadvantages and are inefficient in the use of water, energy, welfare use of fertilizers and other agricultural resources. They create soil erosion, water logging in fields and wastage of ground water. Micro or trickle irrigation methods, including drip irrigation and sprinkler irrigation have many advantages, such as conservation of energy, water & fertilizers and help achieve higher net yield and productivity. They are suitable for arid and semi-arid areas in hot tropical conditions. They can be operated in both manual & automatic
modes and enable selection of irrigation methods based on different parameters.

4.2.0.2 Wireless Sensor Network technology has the potential to increase crop growth and productivity in agriculture. Theoretical knowledge is necessary to explain and predict situations and practical aspects of research. Application of wireless sensor technology in micro irrigation projects raises productivity per unit of water, minimizes consumption of water, energy, reduces manual labor and other input resources being used in agriculture.