



NEW DEVELOPMENTS IN AGRICULTURE

In the previous lesson, you have learnt about the challenges faced by Indian farmers. Have you thought about any solution to these problems? One possible solution may be the use of advanced technologies in agriculture. Agricultural practices and agriculture businesses have evolved in recent years in a variety of ways. The main goal of all the improved technologies is utilizing the resources more efficiently, boosting the crop yields and minimizing the risks. Time-tested practices like crop rotation, integrated nutrient and pest management, conservation tillage combined with new agricultural technologies, such as monitoring field productivity with sensors and satellite images or special farming software, all contribute to the sustainable growth of agriculture.

Let's discuss some of these advanced technologies which can help to reduce the misery of farmers.



LEARNING OUTCOMES

After studying this lesson, the learner:

- explains about the recent advancements in Indian agriculture;
- describes the role of emerging technologies and precision agriculture in crop production;
- defines the farm automation;
- discovers modern practices of crop production; and
- states the role of Agri-tech startups and FPOs in agricultural revolution.

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4.1 EVOLUTION OF AGRICULTURE TECHNOLOGY

Technological advancement in agriculture is essentially needed to counter the huge number of challenges that Indian agriculture faces, right from seed sowing to crop harvesting and marketing of the produce. These technological developments have happened in different phases over the years. It was more evident for the first time during the ‘Green revolution’ period in mid-sixties when short duration crop varieties of rice and wheat were combined with chemical fertilizer and irrigation. The technological model of agricultural production until the early 20th century remained largely subsistence type characterized by poor productivity. This era is known as “**Agriculture 1.0**” marked by the widespread use of animal drafts.

Agriculture 2.0 started towards the end of the 19th century with the introduction of machinery, such as tractors. Later, agricultural technology underwent several transformations.

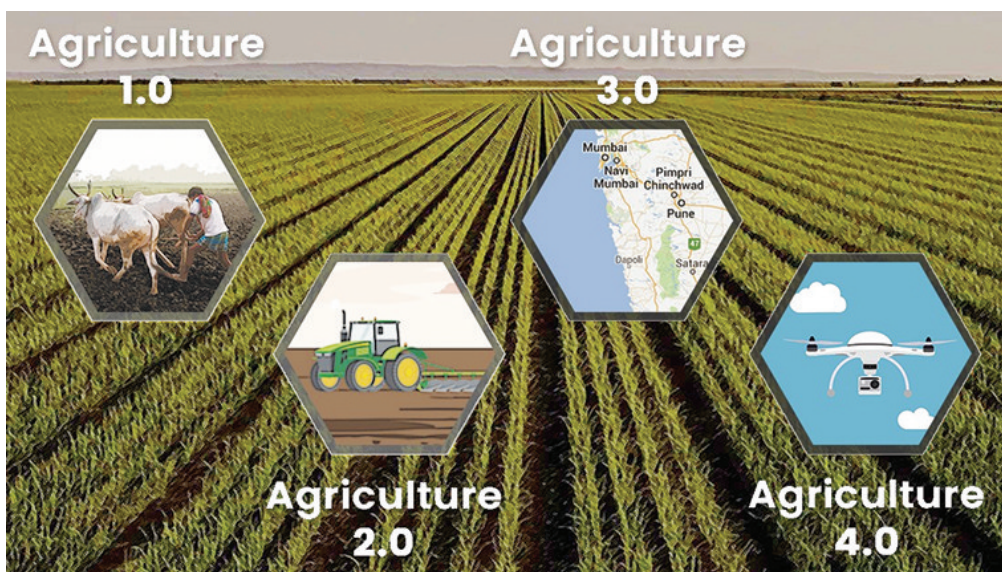


Fig 4.1: Evolution of Agriculture Technology

Agriculture 3.0 may be characterized by precision or smart farming, which evolved out of the need to track and manage all inputs into crop production more efficiently. The pursuit of precision agriculture and its associated agricultural technology have led to the development of new farming methods and tools. The Global Positioning System (GPS) came as the breakthrough technology that is transforming agriculture in a big way. Now, with further technological development, we are experiencing smart farming, in which all the information from the fields and surrounding environment are collected at real-time and decision making is done based on the facts and field-level evidence.

Agriculture 4.0 or **Digital agriculture** refers to the next generation of farming methods in which emerging digital tools are used for maximizing crop yields and other agricultural outcomes. Technologies like automatic machines, sensor-equipped robots, the Internet of Things (IoT), drones, and satellites are all part of the new agricultural environment, named Agriculture 4.0.

Augmented Reality (AR) vs Virtual Reality (VR) and IoT

Augmented reality (AR) layers digital objects on top of your live view of the immediate physical surroundings via the camera on a smartphone or tablet. The user is immersed in a mix of the real world and a virtual world. Interacts simultaneously with both the worlds using smartphone or tablets. Virtual reality (VR) is a completely immersive experience that transforms your physical surroundings into a digital world via a head-mounted display. In this case, it is hard to differentiate between real and virtual world.

For example, one may introduce virtually a new harvesting machine in the picture of actual crop field using AR and see the effectiveness. In case of VR, we can have completely simulated environment of crop field and machine.

On the other hand, **IoT** or **Internet of Things** is a broad term given to every object that can relay information seamlessly when connected to the network. For example, by placing sensors, robots, and cameras inter-connected with smartphone, one may monitor and operate the farm even from a far away location.

4.2 FARM LEVEL MODERNIZATION

Laser Land Leveling

Laser leveling is a process of smoothing the land surface from its average elevation using laser equipped drag buckets. This practice uses high-power tractors and soil movers that are equipped with global positioning systems (GPS) and/or laser guided instrumentation so that the soil can be moved either by cutting or filling to create the desired slope/level. This technique is well known for achieving higher levels of accuracy in land leveling and offers great potential for water savings and higher grain yields. A laser transmitter transmits a laser beam, which is intercepted by the laser receiver mounted on the leveling bucket. The control panel mounted on the tractor interprets the signal from the receiver and opens or closes the hydraulically controlled bucket to collect and drop the soil where it is needed to make the field near absolute level.

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Benefits of Laser Land Levelling.

- A precisely leveled surface leads to uniform soil moisture distribution, resulting in good germination, enhanced input-use efficiency and improved crop stand and yield.
- Laser leveling allows for control of water distribution with negligible water losses.
- Laser leveling improves irrigation efficiency and reduces the potential for nutrient loss through better irrigation and runoff control.
- It facilitates uniformity in the placement of seedlings, helping to achieve higher yields.
- Land leveling reduces weed (improved water coverage reduces weeds up to 40%), pest, and disease problems.
- It results in 3 to 4% additional land recovery and improves operational efficiency (reducing operating time by 10-15%).
- It leads to reduced consumption of seeds, fertilizers, chemicals and fuel.
- It facilitates movement of agricultural machinery through the fields.



Fig. 4.2: Tractor-mounted laser land leveller

Precision Farming

Precision farming is about doing the right thing, in the right way and at the right time. With the help of precision farming, agricultural inputs such as seed, fertilizer, water, etc. are applied in the needed quantity whenever crops need these inputs to increase yield, quality, and profit. It is also an agricultural resource management strategy that collects, processes, and evaluates data and offers insights to help farmers optimize and increase soil quality and productivity.

New precision agriculture technologies allow the farmers to control every variable of crop farming, such as moisture levels, soil conditions, and soil nutrients. It may involve the use of sensor technology, AI (artificial intelligence), GIS, and IoT to collect and analyze data about the soil, plants, and animals. It allows for more targeted use of inputs, such as water, fertilizer, plant nutrients, pesticides, seeds, and labour.

Micro-irrigation

Micro-irrigation is a modern method of irrigation in which water is applied on the land's surface or below the surface using drippers, sprinklers, foggers, and other emitters. The major components of a micro-irrigation system include water supply, pumping devices (motor and pump), ball valves, fertigation equipment, filters, control valves, PVC joining accessories (main and sub-main) and emitters.

Types of Micro Irrigation

A. Sprinkler Irrigation

Sprinkler irrigation is a method of applying irrigation water like natural rainfall. Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air through sprinklers so that it breaks up into small water drops and falls on the standing crops. This kind of irrigation system helps uniform application of water in the field irrespective of field topography. The research conducted in different parts of the country measured water saving due to sprinkler system ranging from 16 to 70% over the traditional method with yield increase from 3 to 57 % in different crops and agro-climatic conditions. Sprinkler irrigation is suited mostly for field and tree crops grown in rows.



Fig 4.3: Sprinkler irrigation system



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Drip Irrigation

Drip irrigation is sometimes called trickle irrigation and involves dripping water onto the soil at very low rates (2-20 litres/hour) from a system of small diameter plastic pipes fitted with outlets called emitters or drippers. Water is applied close to plants so that only part of the soil in which the roots grow is wet, unlike surface and sprinkler irrigation, which involves wetting the whole soil profile. Crops suitable for drip irrigation system are orchard crops (e.g., mango, grapes), vegetables, plantation crops, wider row crops like sugarcane, maize, cotton, mustard, pigeonpea etc. Now the emphasis is being given on extending the use of drip irrigation to close growing crops like wheat, chickpea, soybean etc.

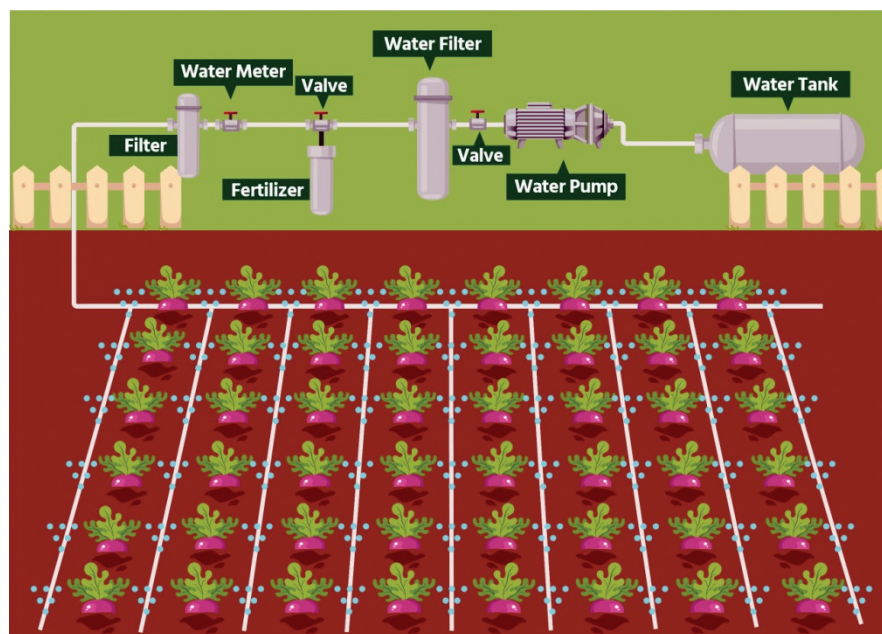


Fig 4.4: Drip irrigation system

Benefits of Drip Irrigation:

- Improvement in crop yield up to 200 %
- Water saving up to 70% compared to flood irrigation. Additional land can be irrigated with the water saved.
- Crop grows consistently, healthier and results in higher yield.
- Increase in fertilizer-use efficiency by 30%
- Expenditure on fertilizers and labour use reduces.

- Undulating terrains, sandy & hilly lands can also be brought under productive cultivation.
- Water-use efficiency can be as high as 90%.

**INTEXT QUESTIONS 4.1**

1. If you are having an undulating land where paddy is to be grown, which management practices will you adopt?
2. Land levelling reduces the operating time by

a. 5-10%	b. 10-15%
c. 15-20%	d. 20-30%
3. is a method of applying irrigation water which is similar to natural rainfall.
4. Water saving by sprinkler system is around

a. 16% to 70%	b. 30% to 50%
c. 60% to 75%	d. 70% to 90%

*Notes***4.3 FARM AUTOMATION**

Farm automation brings together agricultural machinery, computer systems, electronics, chemical sensors, and data management to improve equipment operation and decision-making, and ultimately, reduce human error. Reduced labor time, higher yields, and the efficient use of resources are driving the large-scale adoption of the technology. Farmers now use automated harvesters, drones, autonomous tractors, seeding, and weeding to transform how they cultivate their crops. Technology takes care of menial and recurring tasks, allowing them to focus on more critical functions. Automation can help employees save time, as the technology reduces the need for people to actively partake in a task. Thanks to automation, most farmers now spend more time with their families than before.

A. Modern Greenhouses

Greenhouse technology provides an opportunity to control the climate in which crops can be grown. With improvements in growing technology, greenhouse

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crop cultivation is witnessing a boom. One can regulate almost all the parameters needed for the crop growth like temperature, moisture, CO₂ level, light intensity, etc., depending upon the capital investment made in the greenhouse.



Fig 4.5: Crops cultivation inside a greenhouse

The entire global greenhouse market currently produces nearly US \$350 billion in vegetables annually. As the demand for high value crops is growing round the year, modern greenhouses are becoming increasingly tech-heavy, using LED lights and automated control systems to perfectly tailor the growing environment. Successful greenhouse companies are scaling up significantly and locating their growing facilities near urban hubs to capitalize on the ever-increasing demand for local food.

B. Artificial Intelligence (AI)

Artificial intelligence (AI) is a branch of computer science that focuses on building and managing technology that can learn to autonomously make decisions and carry out actions on behalf of a human being. These can monitor plant health, soil conditions, temperature, humidity, and more. The idea is to give farmers a better understanding of what's happening on the ground through advanced technology that can tell them more than a naked eye can see. Not only is it more accurate, it's also faster. The goal is to enable farmers to use this artificial intelligence to make better decisions in the field, thereby achieving their goals of better harvests.

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Artificial intelligence is going to bring the next revolution in agriculture. Right from sowing the seeds to nutrients and irrigation management to pests' predictions, AI will enable farmers to get the best results for their hardwork. This will also contribute in determining the best practices; be it choices of seeds, fertilizers or pesticides or the technique deployed at a particular stage of farming. Similarly, IoT (Internet of Things) is used as a smart farming solution for monitoring the crop field from anywhere. This technology connects different electronic devices and shares the information seamlessly in real time. This technology is being used in several on-farm and off-farm operations. Farmers are now able to operate irrigation pumps from anywhere, as the field level irrigation information can be shared on his smartphone.

C. Mobile Technology in Agriculture

Mobile applications related to agriculture are now gaining importance. With a specific application, one can see the entire field map on the mobile. Crop monitoring mobile app allows you to keep eyes on a field's vegetation from anywhere. One can track the weather in the field, plan and manage scouting tasks, and get updates on the current situation all from the convenience of his mobile device.

D. Robotics in Agriculture

Use of robots in agriculture is still in preliminary stage in India. However, with the rising cost of human labour, we may expect wide application of robots in near future. In 2022, the global market size of agricultural robotics was nearly \$5 billion. Many farming activities performed by humans can be done by these robots or agribots. Though at pilot stage, these agribots are being used in seed planting, crop harvesting, weeding, sorting and packaging, livestock management, etc. The autonomous performance of such robots allows for continuous field management and improves agricultural productivity. Several new agri-entrepreneurs are venturing into this field to provide the services of agribots in India.

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Fig. 4.7: Application of robotics in agriculture

E. Remote Sensing Technology in Agriculture

The use of satellites in agriculture started long back for collecting crop data and monitoring the crops at large scale. Satellite sensors monitor, measure, and record the electromagnetic radiation reflected or emitted by the crops on earth for further analysis and data extraction. With this technology, one can track crop growth throughout the season even in vast, inaccessible areas. This information is beneficial for various purposes, including crop forecasting and policy making.

- a) **Satellite Imaging:** India is planning to have dedicated satellites for agriculture, which will help in continuous monitoring of farm-related activities like crop forecasting, pesticide application, irrigation, soil data, and generation of critical data related to drought. It would allow real-time crop imagery. Crop imagery lets a farmer examine crops as if he or she were standing there without being present in field. Even reviewing images on a weekly basis can save a farmer's considerable amount of time and money. Additionally, this technology can be integrated with crop, soil and water sensors so as to help the farmers make critical decisions.

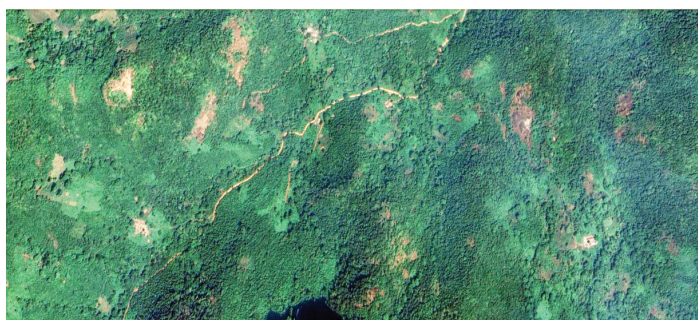


Fig. 4.8: Vegetation monitoring using satellite imagery

- b) **Geographic Information Systems (GIS)** are essential for the storage, analysis, and visualization of spatial data for precision agriculture needs. One of the most important ways that GIS-based agriculture technology is used in farming is to gather information about a region's crops, soil, climate, and topography by using satellites and drones. In livestock rearing, GIS software monitors the movement of animals. This, in turn, will help farmers track animals' health, fertility, or nutrition.

Furthermore, GIS in agriculture enables the use of applications in conjunction with smart tools to optimize the spreading of fertilizer and pesticides. By using these maps, it's easy to pinpoint the most productive parts of your field, as well as low-yielding places that would benefit from additional fertilizer or other methods to boost field productivity.

F. Weather Tracking

Although we depend on local weather experts/meteorologists for weather information, the truth is that computerized weather modeling is becoming more popular. There are online weather services that focus exclusively on agriculture, and farmers can access these services on their smartphone. This technology can give farmers enough advanced notification about hailstorm and other weather events so that they can take precautions to protect the crops or at least minimize the losses to a significant extent. Some agri-tech startup companies provide a farm-specific micro-climate forecast for the next 14 days to keep you well prepared for weather risks of the future.



Fig 4.10: Sensors installed in the field for weather forecast

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G. Livestock Farming Technology

Emerging livestock technologies provide farmers with data-driven insights, allowing them to streamline farm management, improve animal care, and boost productivity. Here are some of the many innovations redefining livestock farming:

- **Automated dairy installations** milk cows automatically without human intervention.
- **Automated cleaning systems** remove waste, enabling cleaner and disease-free environment.
- **Automated feeder systems** provide animals with feeding mixtures tailored to their specific needs and in the right amount.
- **Digital monitoring of animals:** Every animal wears an electronic device attached to the collar. It is a battery-powered microcontroller device equipped with low-power inertial sensors (accelerometer and magnetometer) and wireless communication. This technology can enhance the welfare and management of animals. This 'connected cow' concept is the result of equipping herds with sensors to monitor their health and increase productivity. By attaching individual wearable sensors to cows, producers can keep track of daily activity and health-related issues and make operational decisions quickly and easily.

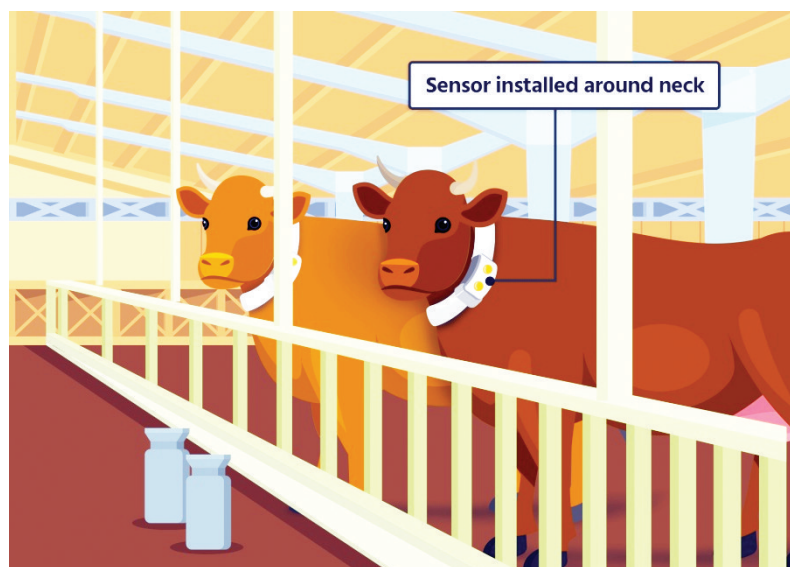


Fig. 4.11: Digital monitoring of animals through sensors



H. Farm Management Software

It is an integrated platform that provides real-time data and information, like a digital checklist, to assist farmers in tracking daily activities. With this monitoring and reporting software, farmers can improve decision-making throughout all operations. There are some enterprise resource planning solution available in the market that allow farms to streamline their processes and enables seamless collaborations. It lets users manage procurement, supply chain, finances, and processing from a single hub. This innovation in agriculture technology will continue to advance as internet-enabled devices become ubiquitous in future.

I. Drone Technology in Agriculture

Drones, also known as unmanned aerial vehicles (UAVs), are becoming quite common in the agricultural industry. Drones are being used for different purposes. Equipped with different technology-based sensors, drones can be used in precision agriculture – monitoring crop health, weed and pest detection, crop scouting, analysis of soil health, irrigation management, monitor field temperature, and spray pesticides or fertilizers at desired locations on the field.

In animal husbandry, drones are used to observe grasslands and track animal movements on big ranches. Some drones have thermal imaging cameras to detect sick animals with high body temperatures. The inherent benefits and the rise of drones in farm operations lie in their ability to help farmers acquire comprehensive data to make timely decisions.



Fig. 4.12: Spraying of pesticide through drones

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1. The role of Global Positioning System (GPS) is
 - a. Soil testing
 - b. Soil sampling
 - c. Nutrient analysis
 - d. All of the above
2. Which of the following is used in seed planting, crop harvesting, weeding, and sorting?
 - a. GIS
 - b. GPS
 - c. Agribots
 - d. None of the above
3. The drones can be used in precision agriculture for
 - a. Monitoring crop health
 - b. Spray pesticides or fertilizers
 - c. Crop scouting
 - d. All of the above
4. If your father is having 10 acres of paddy crop, which method will you suggest him to spray pesticides during the period of labour shortage?
5. Which method can be used to examine the crops without actually standing there?

4.4 MODERN PRACTICES IN AGRICULTURE**Indoor Vertical Farming**

Vertical farming has been a science fiction topic in the 1950s and later, but now it's not only scientifically possible but also becoming financially viable. Vertical farming, a component of urban agriculture is the practice of growing crops in vertically stacked layers. This offers many advantages like

- Perhaps the most obvious is the ability to grow crops in land constrained environments.
- Indoor vertical farms enable growers to control variables such as light, temperature, humidity, water, and sometimes, carbon dioxide levels, allowing them to get healthier and better yields throughout the year.



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- Vertical farms use up to 70% less water than traditional farms.

Quite often, the stacked layers don't require soil to grow plants. Based on type of technology used, they're either hydroponic or aeroponics system.

- I. **Hydroponics** is a type of indoor vertical farming where plants grow in water and nutrient solutions.
- II. **Aeroponics:** Here roots of the crops are suspended in the air. Water and nutrients are sprayed intermittently in the form of mist with help of emitters.

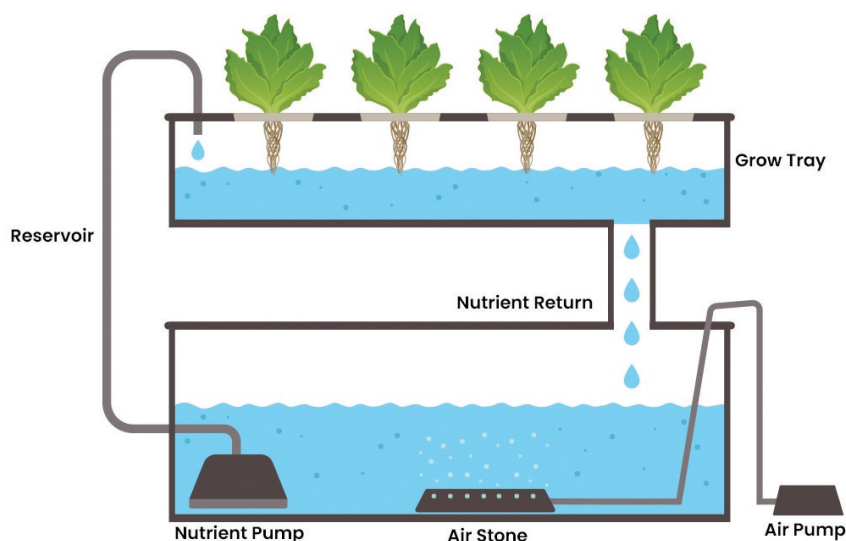


Fig. 4.13: Hydroponics

Genetically Modified Crops

Genetically modified crops or GM crops are the special type of plants used in agriculture, whose genetical make up has been modified using genetic engineering techniques. GM crops are created mostly with the aim of

- Introducing a new character (e.g. resistance to certain pests, diseases, environmental conditions, herbicides) in the plant which does not occur naturally in the species. For example, Bt-cotton in India.
- To increase nutritional value and for other purposes like production of pharmaceutical agents, biofuels etc. For example, Vitamin A enriched golden rice variety.

At present, the only genetically modified crop that is under cultivation in India is Bt-cotton which was grown over 11.9 million hectares in 2022. Bt cotton was first used in India in 2002, which is resistant to one of the most damaging insects of the crop viz. bollworm.

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**INTEXT QUESTIONS 4.3**

1. and are the methods of growing plants without soil.
2. The genetically modified crop which is being cultivated in India
 - a. Rice
 - b. Wheat
 - c. Sugarcane
 - d. Cotton
3. In hydroponics system, plant roots are suspended in air (True/False).

4.5 AGRITECH STARTUPS AND FPOS

In India, more than 86% of farmers are smallholders who have little understanding of modern farming methods and techniques. Several types of startups in agriculture and allied sectors have come up in the last decade that are filling the gaps in the food value chains. Innovation based agri-startups are basically working in six areas:

- 1) Those providing output market linkages
- 2) Those facilitating input supply
- 3) Enabling mechanisation, irrigation control and financial support
- 4) Helping in quality maintenance, monitoring, traceability and output predictions
- 5) Post-harvest management and farming as a service
- 6) Those supporting animal husbandry farmers

Connecting small and marginal farmers with these entrepreneurs can build a more equitable and sustainable food system for India. But how can it be achieved? The solution to this question lies in the establishment of Farmer Producer Organisations (FPOs).

Equipping FPOs with Entrepreneurial Innovations

FPOs (Farmer Producer Organisations) are farmers' organisations that bring farmers together, make them more efficient buyers of agricultural inputs, and more effective sellers of their products. By pooling resources, they can also help farmers access new technologies that can improve their yields over the long run. FPOs work in every agriculture field of India, from field crops, horticultural crops, dairies, fisheries and poultry. Currently, there are more than 25,000 FPOs registered in different forms in India.

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With typical holdings of less than one hectare, farmers individually cannot afford to invest in mechanization or technology to enhance productivity, procure key inputs at a low price, or directly access buyers. Aggregation through FPOs is the only feasible option left for farmers to enhance their bargaining power and accrue more value. Here is where start-ups can come in. Young businesses with the ambition to scale up and provide reliable real-time support to small farmers can benefit massively from working with FPOs. They can build socio-economic resilience into agricultural supply chains, improve food and nutritional security, and build strong businesses that create wealth in rural areas. In coming years, we may expect that agri-startups and FPOs work hand-in-hand for sustainable development of agriculture and ensuring remunerative incomes for the farmers.

**INTEXT QUESTIONS 4.4**

1. FPO stands for
2. The areas where agri-startups operate in India are
3. What is the feasible option available for farmers to enhance their bargaining power?

**WHAT YOU HAVE LEARNT**

Feeding the rapidly increasing global population amid the climate crisis is a big challenge. Traditional farming cannot provide food at the speed and accuracy to feed this population. The technology delivers solution to such problem. New innovations in agriculture have shown us how technology can help us build more sustainable food systems and improve food security. Over the past five decades, digitization has resulted in the radical transformation of agriculture by improving its speed, scale, and productivity globally. Agriculture 4.0, the fourth agricultural revolution, has provided agri-stakeholders with a broad range of technological options to choose from to help them achieve their goals, be it remote sensing and GPS technologies, artificial intelligence, connected sensors, IoTs, or many other emerging technologies. Mounting pressures on the environment are also redirecting scientists' approach to the way we farm today. The road to sustainable farming requires significant investments in infrastructure and technology infusion, but its success can ensure that the current and future generations can live comfortably with the resources available.

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1. Enlist the recent advanced technologies in agriculture.
2. Discuss about laser land leveling and its benefits.
3. Define precision farming and micro-irrigation. Mention the types of micro-irrigation.
4. Discuss the methods that are used to produce off-season crops.
5. Write a short note on controlled environment agriculture.
6. Discuss the role of AI in agriculture.
7. Discuss livestock farming technology and its areas of innovation.
8. Give a detailed note on the remote sensing technology in agriculture.
9. Explain the greenhouse technology.
10. Discuss how FPOs and Agritech Startups help marginal farmers?

**ANSWERS TO INTEXT QUESTIONS****4.1**

1. Laser land leveling
2. 10-15% (Option b)
3. Sprinkler irrigation
4. 16-70% (Option a)

4.2

1. Soil sampling (Option b)
2. Agribots (Option c)
3. All of the above (Option d)
4. Drone technology
5. Satellite imaging

**4.3**

1. Hydroponics and aeroponics
2. Cotton (option d)
3. False

4.4

1. Farmer producer organization
2. Agriculture, Dairies, non-timber forest produce, poultry, honey production
3. Aggregation through FPOs

GLOSSARY

Augmented reality (AR): It is an interactive experience that enhances the real world with computer-generated perceptual information

Dry land farming: Cultivation of crops in areas receiving rainfall above 750 mm but less than 1150 mm is known as dryland farming.

Genetically modified crops: GM crops are the special type of plants whose genetical make up has been modified using genetic engineering techniques.

Marginal farmer: The farmer who has less than 1 hectare of agricultural land where he carries on agricultural activities as a proprietor, sharecropper, or tenant.

Precision farming: It is combination of information technology (IT), information communication technology (ICT) and sound agronomic practices intended for improving crop productivity, resource use efficiency and preventing harm to environment.

The Internet of Things (IoT): It is defined as the use of synched data on various platforms to exchange necessary information in real-time using the internet.

Vertical farming: It is an agricultural technique which involves growing crops in layers that are stacked vertically.

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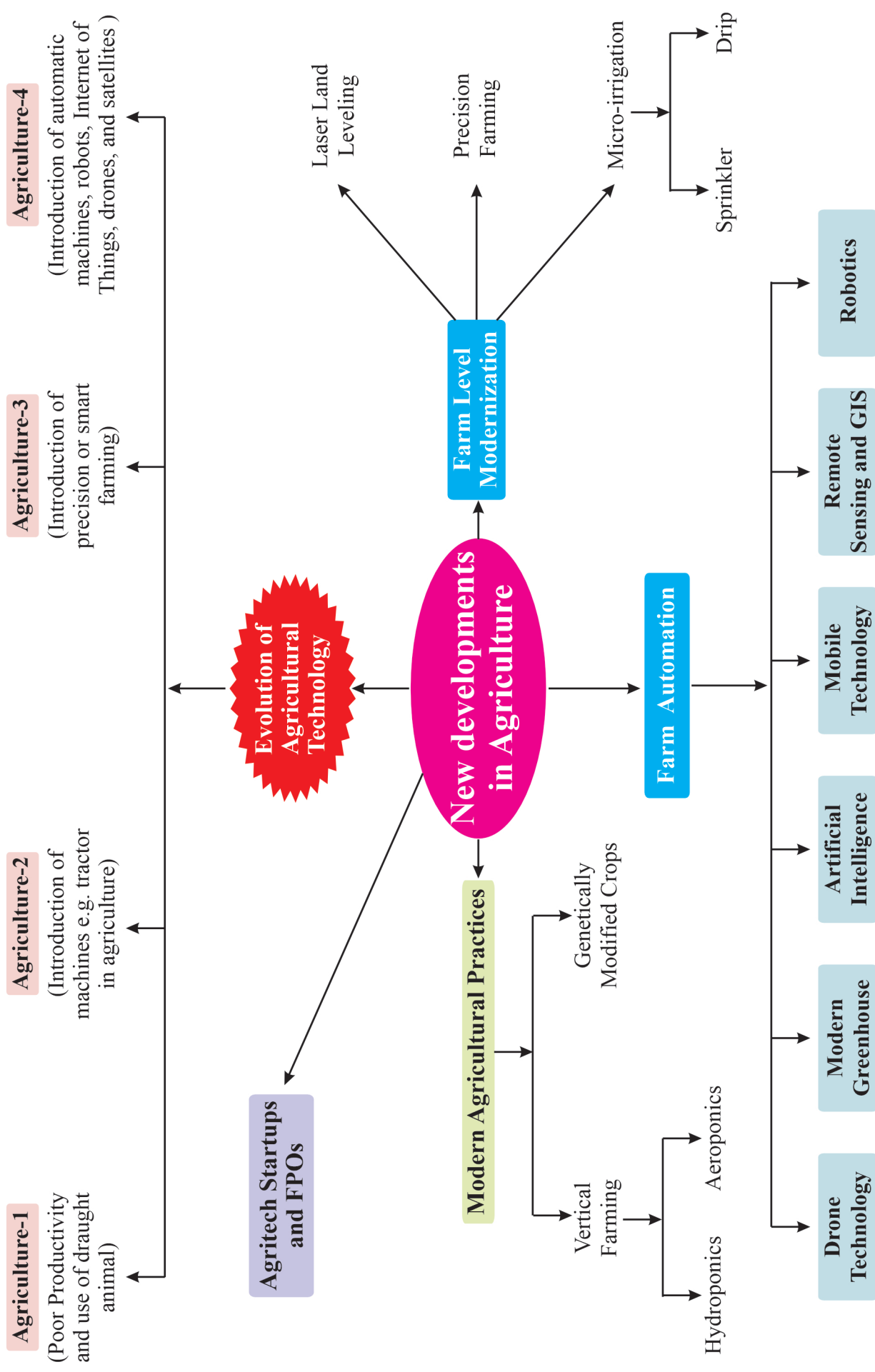


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2. Dass, A., Choudhary, A. K., Sudhishri, S. and Rajanna, G. (2019). *Precision crop and resource management*, ICAR-IARI, New Delhi.
3. Kumar, S., Saravaiya, S. N. and Pandey, A. K. (2022). *Precision Farming and Protected Cultivation: Concepts and Applications*, Narendra Publishing House, Delhi.

WHAT YOU HAVE LEARNT



MODULE -2

Crop Production Practices

5. New Developments in Agriculture
6. Crops, Cropping System and Crop Establishment
7. Nutrient, Water and Weed Management
8. Plant Protection and Harvesting
9. Fundamentals of Horticulture and Fruit Production
10. Vegetable Crops
11. Flower Crops