

UNIVERSITY OF AGRICULTURAL SCIENCES
GANDHI KRISHI VIDGNYAN KENDRA BENGALURU-560065
DEPARTMENT OF AGRICULTURAL EXTENSION



SEMINAR REPORT ON

**SMART AGRICULTURE -FOR RESOURCE
USE EFFICIENCY**

SUBMITTED TO THE SEMINAR TEACHERS:

- | | |
|----------------------------------|---------------------------------|
| 1. Dr. B. Krishnamurthy, | 2. Dr. S. Ganeshmoorthi |
| Professor & Head, | Associate professor |
| Dept. of Agricultural Extension, | Dept. of Agricultural Extension |
| UAS, Bengaluru-65. | UAS, Bengaluru-65. |

SUBMITTED BY:

MUTTEPPA CHIGADOLLI
PALB 8031
III Ph.D. (Agricultural Extension)
Dept. of Agricultural Extension

Index

Sl. No	Particulars	Page No
01	Introduction	1
02	Objectives	2
03	Concept of Smart Agriculture	2
04	Market estimates for Smart Agriculture	4
05	COVID-19 Impact on the Global Smart Agriculture Market	6
06	Top 10 technologies in smart agriculture	7
07	Transformative discoveries for smart agriculture	11-19
08	Deliberation of smart agricultural practices for higher Farm resource use efficiency a) Precision in Seed Sowing and Planting b) Precision in Nutrient Management c) Smart Agriculture Practices for Efficient Water Management d) Smart Agricultural Practices for Weed and Pest Management e) Smart Agriculture Resource conserving practices	20-28
09	Smart Agricultural Practices for Higher Productivity and Profitability	28-31
10	List of different smart agriculture practices	32
11	List of Smart Agriculture Practices for India	32
12	List of data driven tools with their key features for Smart agriculture	33
13	Pilot projects / initiatives of smart agriculture in India	33-36
13	Benefits and challenges of smart Agriculture	37-38
14	Role of extension in promoting smart agriculture	38
15	Review of related studies	38
14	Conclusion	40
15	References	40-41
15	Discussions	42-44
16	Synopsis	45-46

SMART AGRICULTURE - FOR RESOURCE USE EFFICIENCY

“It is not the quantity of water applied to a crop; it is the quantity of intelligence applied which determines the result -there is more due to intelligence than water in every case.”

-Alfred Deakin (1890)

INTRODUCTION:

Population growth is one major issue which is hindering development across the globe. World's population is expecting 2.4 billion increase by 2050 from 2015 and most of these additional 2.4 billion people will live in developing countries like India, Bangladesh, Ethiopia, Nigeria and other developing countries. At the same time, most of the people will be living in cities. Food and Agriculture Organisation (FAO) estimates that agricultural production will have to increase by 60 per cent by 2050 to satisfy the expected demands for food and feed. Agriculture must therefore transform itself if it is to feed a burgeoning global population and provide the basis for economic growth and poverty reduction. Apart from this the present-day agriculture system is facing the various problems like degradation of soil properties and fertility, soil erosion, shrinking of resources, pollution of resources, supply of spurious inputs, increasing cost of labours, labour scarcity, fragmented landholdings, stagnation and declining trends in productivity and changing climate has adversely impacts on agriculture with increased rate of natural calamities. All these are hindering the agricultural production therefore, agriculture needs to be transformed itself with new technologies, which seems very promising to move to the next level of farm productivity and profitability to overcome all difficulties and feed the increasing population. India has demonstrated a big transformation in the agriculture sector in the second half of the 20th century with the 'Green Revolution' but now we need to go for a 'Technology Revolution' to accelerate the growth in the agriculture sector. This technology revolution is nothing but smart agriculture which has got all the technological inputs that can steer us away from the problems of present-day agriculture. Smart agriculture has the potential to double the food production and reducing wastages and losses by 50 per cent by 2050 along with lesser impact on environment. Smart agriculture has been continuously evolving in the last few decades. It is the all-new agricultural production mode and ecosystem which is based on digital farming, smart farming and precision agriculture through use of

information and communication tools and technologies. With this background, the present study has been conceptualized with the following objectives.

OBJECTIVES:

1. To understand the concept of Smart Agriculture and Smart Agriculture Practices
2. To deliberate smart agricultural practices for higher farm resource use efficiency
3. To review the case studies/ research studies related to smart agriculture and their implications

I. CONCEPT OF SMART AGRICULTURE AND SMART AGRICULTURE PRACTICES:

Smart agriculture has been continuously evolving in the last few decades. It is the all-new agricultural production mode and ecosystem which is based on digital agriculture and precision agriculture. Digital agriculture digitizes the planning, process and result of agricultural production, such as big data, artificial intelligence, cloud computing and blockchain. Precision agriculture uses information technology to achieve precision management, such as drone, robot and intelligent irrigation. The recent developments, such as cloud computing, internet of things, big data, blockchain, robotics and artificial intelligence have taken the management of agricultural operations to a much higher level of efficiency through application of technologies. Thus, the Smart agriculture allowed for the integration of so far isolated lines of development into smart, connected system of systems. Integration of these technologies will help the agriculture to evolve in a data-driven, intelligent, agile and autonomously connected system of systems. The operations of each agricultural process will be automatically integrated in the food chain through the semantically active technologies right from production to final dissemination of produce to the consumers.

Smart Agriculture involves the integration of advanced technologies into existing farming practices in order to increase production efficiency and the quality of agricultural produce with lesser impact on environment.

Smart agriculture consists of applying inputs (what is needed) when and where it is needed

and has become the third wave of the modern agriculture revolution.

Transformation of Indian agriculture needs to be more productive through efficient use of inputs, sustainability in production, and needs more resilience towards **risks**, shocks and long-term climate variability. FAO defined climate-smart agriculture (CSA) as the three dimensions of sustainable development (**economic**, social and environmental) by jointly addressing food security and climate challenges. These three main pillars are as follows: a) Sustainably increasing agricultural productivity and income b) adapting and building resilience to climate change and c) reducing or removing greenhouse gases emissions, where ever possible. To address these three intertwined challenges, production systems need to become more efficient and resilient at the farm level. Resource conserving and Smart Agriculture practices should be more efficient in resource use: Use less land, water and inputs to produce more food sustainably and be more resilient to changes and shocks. These resource conserving technologies (RCTs) and Smart Agriculture practices are targeted at precise level with highest accuracy to achieve more precision in inputs application like seed, fertilizers, pesticides, irrigation etc. at farm level with information communication technologies (ICTs) and descision support system (DSS) which is considered as smart agriculture.

With the modernization of agriculture, the terms like smart agriculture, precision agriculture, smart farming and digital farming have been used interchangeably although they have subtle difference in their meanings. Let us understand these terms clearly one by one.

Precision farming or precision agriculture: Precision farming and precision agriculture are generally regarded as the same thing. However, the term precision agriculture, often abbreviated PA, is more widely used. In a 2016 report on how big data will revolutionize the global food chain, McKinsey & Company define precision agriculture as: “a technology-enabled approach to farming management that observes, measures, and analyzes the needs of individual fields and crops”. According to McKinsey, the development of precision agriculture is shaped by two trends: “big-data and advanced-analytics capabilities on the one hand, and robotics—aerial imagery, sensors, sophisticated local weather forecasts—on the other”. The European Parliament’s report on Precision agriculture and the future of farming in Europe defines **precision agriculture as: “a modern farming management concept using digital techniques to monitor and optimize agricultural production processes”**. The key point here is **optimization**. Instead of applying an

equal amount of fertilizers over an entire field, precision agriculture involves measuring the within-field soil variations and adapting the fertilizer strategy accordingly. This leads to **optimized fertilizer usage, saving costs, and reducing environmental impact.**

Smart farming: Smart farming is the application of information and data technologies for optimizing complex farming systems. Unlike with PA, the focus of smart farming is not on precise measurement or determining differences within the field or between individual animals. The focus is rather on access to data and the application of these data – how the collected information can be used in a smart way. **Smart farming involves not just individual machines but all farm operations.** Farmers can use mobile devices such as smartphones and tablets to access real-time data about the condition of soil and plants, terrain, climate, weather, resource usage, manpower, funding, etc. As a result, farmers have the information needed to **make informed decisions** based on concrete data, rather than their intuition.

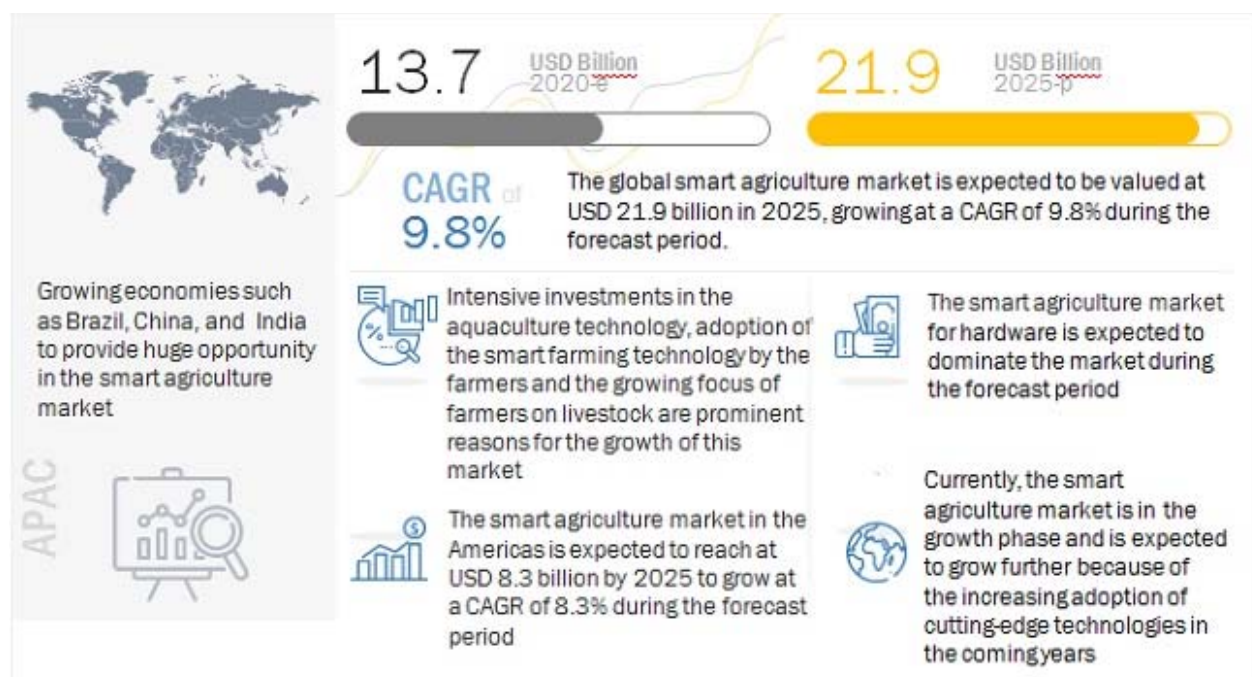
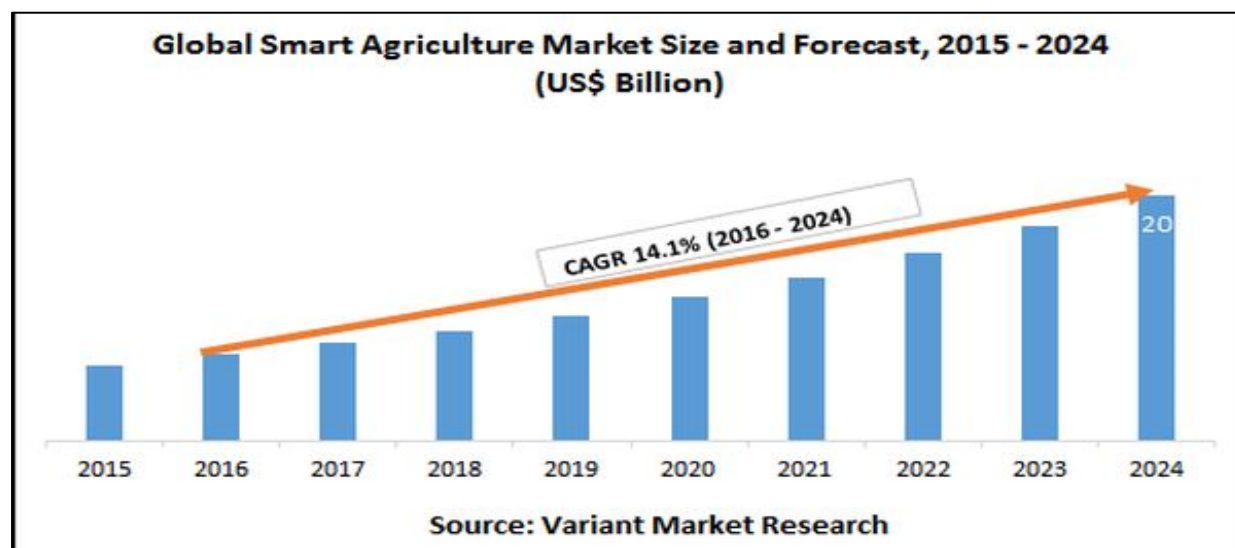
Digital farming: The essence of digital farming lies in **creating value from data.** Digital Farming means to go beyond the mere presence and availability of data and create actionable intelligence and meaningful added value from such data. Digital farming is **integrating both concepts – precision farming and smart farming.** According to a paper on Digital Agriculture by DLG (German Agricultural Society), digital farming is understood to mean “consistent application of the methods of precision farming and smart farming, internal and external networking of the farm and use of web-based data platforms together with Big Data analyses”.

Thus, the smart agriculture is the broader which includes the precision agriculture, smart farming and digital farming.

Smart Agriculture Practices: refers to the all the practices used in smart agriculture which may be tools, techniques, web applications, mobile apps, GIS, GPS, decision support system, expert system, implements handling techniques and other data driven tools which helps in increasing agricultural production, productivity with optimum resource utilization and lesser impact on environment.

Market estimates for Smart Agriculture: The smart agriculture market is estimated to be worth USD 13.7 billion in 2020 and is projected to reach USD 22.0 billion by 2025. It is expected to

grow at a CAGR of 9.8% from 2020 to 2025. The rising pressure on food supply system owing to rapidly growing population, surging use of modern technologies in agricultural products and growing focus of farmers on livestock monitoring and disease detection to fuel the growth of smart irrigation systems. Moreover, the rising investments in the agriculture technology sector have propelled the growth the growth for smart agriculture market.





COVID-19 Impact on the Global Smart Agriculture Market:

Smart agriculture market is expected to witness a marginal dip in 2020 due to the COVID-19 pandemic as the movement restriction and lockdowns has resulted in the disruptions in the supply chain, However the use of remote monitoring technology and farm management software tools could lead to higher adoption during post COVID-19 period. COVID-19 has disrupted the supply chain of different vertical of smart agriculture market, which included precision farming, livestock monitoring, aquaculture, greenhouse, and forestry. The companies are exploring new opportunities to interact with growers and farmers by leveraging advanced technologies.

The outbreak of the COVID-19 pandemic that originated in China, has become a serious health crisis worldwide. Demand for agriculture equipment and related technologies is likely to be reduced in the short term. Some recovery is expected by the first quarter of 2021, and the market might start picking momentum by the end of 2021 Major agricultural OEMs such as John Deere, and AGCO have reduced their sales guidance for the first half of financial year 2020 by 10 to 20%, mainly due to disruptions in the supply chain.

The effect of COVID-19 on the livestock sector is more noticeable as the access to the animal feed has reduced and diminished capacity of the slaughterhouses due to the logistical

constraints and labor shortages. The shutdown of businesses and quarantine measures is expected to have a negative impact on providers of livestock monitoring products. For instance, RFID tags, milking robots, and feeding systems may witness reduced demand due to the temporary shutdown of business activities in the US and western European countries. However, in medium to long term the demand for livestock monitoring products is expected to witness robust growth.

The precision aquaculture sector is facing a disruption in the supply chain of fresh fish due to the outbreak of Novel Coronavirus. As per the Alliance of Independent Press Councils of Europe, the precision aquaculture industry has been dealing with a combination of issues that had led to closures of production sites in the EU and loss of many small businesses, with severe consequences on the employment in coastal areas. Recirculating Aquaculture system (RAS)-based aquaculture projects will have a more significant impact due to reduced demand for aquaculture products.

The smart greenhouse market too has been affected but the COVID-19 pandemic. The consumer demand is not yet clear for the time being, but it is expected that the demand for commodities will face a decline in the short term as bulk demand from restaurants or hotels has stopped due to closures and lockdowns. With a shortage of raw materials, companies are unable to deliver end products on the promised dates.

The precision forestry is expected to see a reduction in demand for CTL-based harvesting equipment in 2020. The reason for the decline in the growth for forestry equipment is the temporary shutdown of manufacturing facilities in the Americas and Europe. Further, this segment does not exactly produce essential products; hence, the recovery in the precision forestry segment will be comparatively longer.

The study categorizes the smart agriculture market based on component, system type, application at the regional and global level. By Offering: Hardware, Software and Services. By Agriculture Type: Precision Farming, Precision Forestry, Livestock Monitoring, Smart Greenhouse, Smart Feeding Systems, Monitoring and Control Systems, Underwater Remotely Operated Vehicles, Precision Aquaculture.

By Application:

I. Precision Farming Application

- a) Yield Monitoring
- b) Field Mapping
- c) Drainage Mapping
- d) Crop Scouting
- e) Weather Tracking & Forecasting
- f) Variable Rate Technology
- g) Inventory Management
- h) Farm Labour Management
- i) Financial Management
- j) Others

II. Precision Forestry Application

- a) Genetics and nurseries
- b) Silviculture and fire management
- c) Harvesting management
- d) Inventory & logistics management

III. Livestock Monitoring Application

- a) Milk harvesting management
- b) Breeding management
- c) Feeding management
- d) Heat stress management

- e) Animal comfort management
- f) Behaviour monitoring and control
- g) Others

IV. Precision Aquaculture Application

- a) Feeding management
- b) Monitoring, control and surveillance
- c) Others

V. Smart Greenhouse Application

- a) HVAC management
- b) Yield monitoring and harvesting
- c) Water & fertilizer management
- d) Others

BY Farm Size

- a) Small Farm
- b) Medium Farm
- c) Large Farm

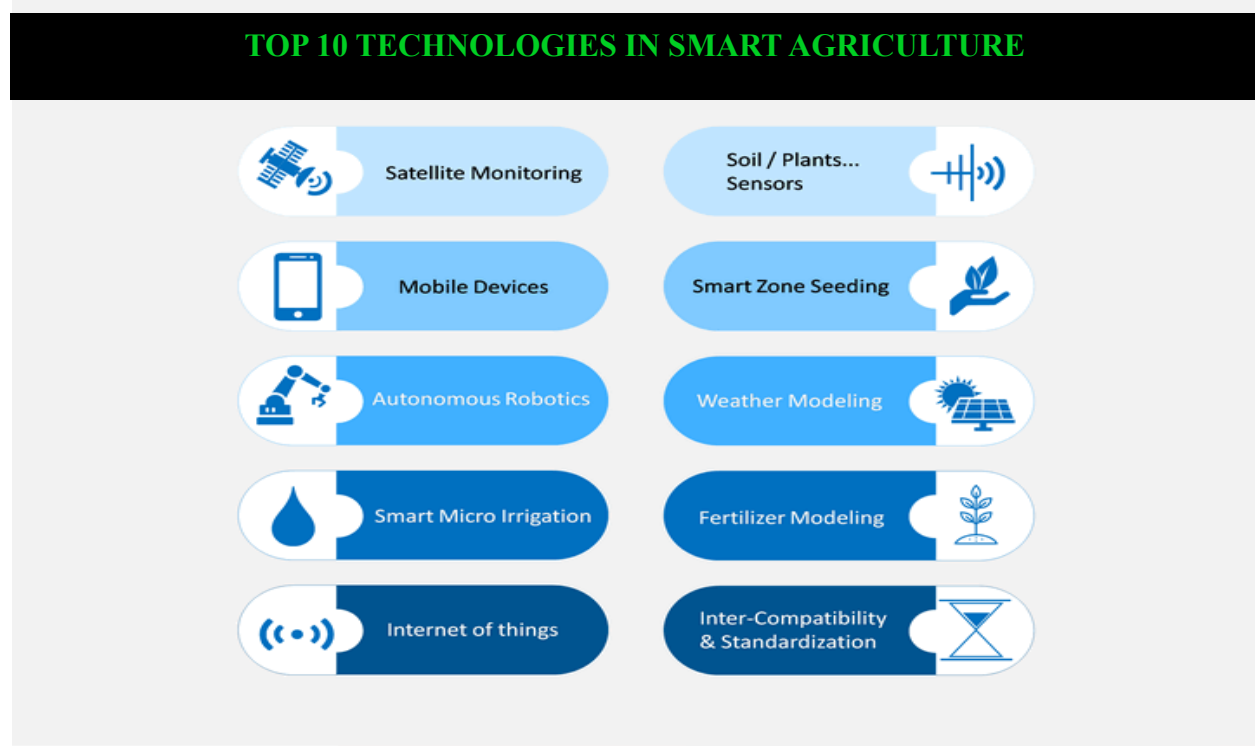
By Region

- a) Americas: North America & South America
- b) Europe
- c) Asia Pacific
- d) Rest of World

Recent Developments

- Deere & Company announced updates to its 19-1 software to enhance the automation, documentation, functionality, and security of Generation 4 4600 Command Center and 4640 Universal Displays. This latest software has a higher level of automation activation, which has enabled the company's Machine Sync harvest automation functionality on the Gen 4 platform for tractors.
- Trimble launched a new entry-level Trimble Ag Software subscription called Farmer Core, which enables farmers to connect all aspects of their farm operations.
- Topcon Agriculture launched the Topcon Agriculture Platform, a cloud-based farm workflow improvement tool, which integrates connectivity, cloud services, and data analytics for farmers.
- DeLaval collaborated with the Swedish University of Agricultural Sciences (SLU) to install DeLaval VMS V300 at Lövsta research and education center (Sweden). The company also gave access to the latest robotic technology and digital milk sampling equipment to SLU.
- Antelliq opened its new Allflex Livestock Intelligence office in South Africa. The increased demand for its products and services, which helps farmers collate and interpret animal health data, has resulted in its continued expansion.

Top 10 technologies in smart agriculture:



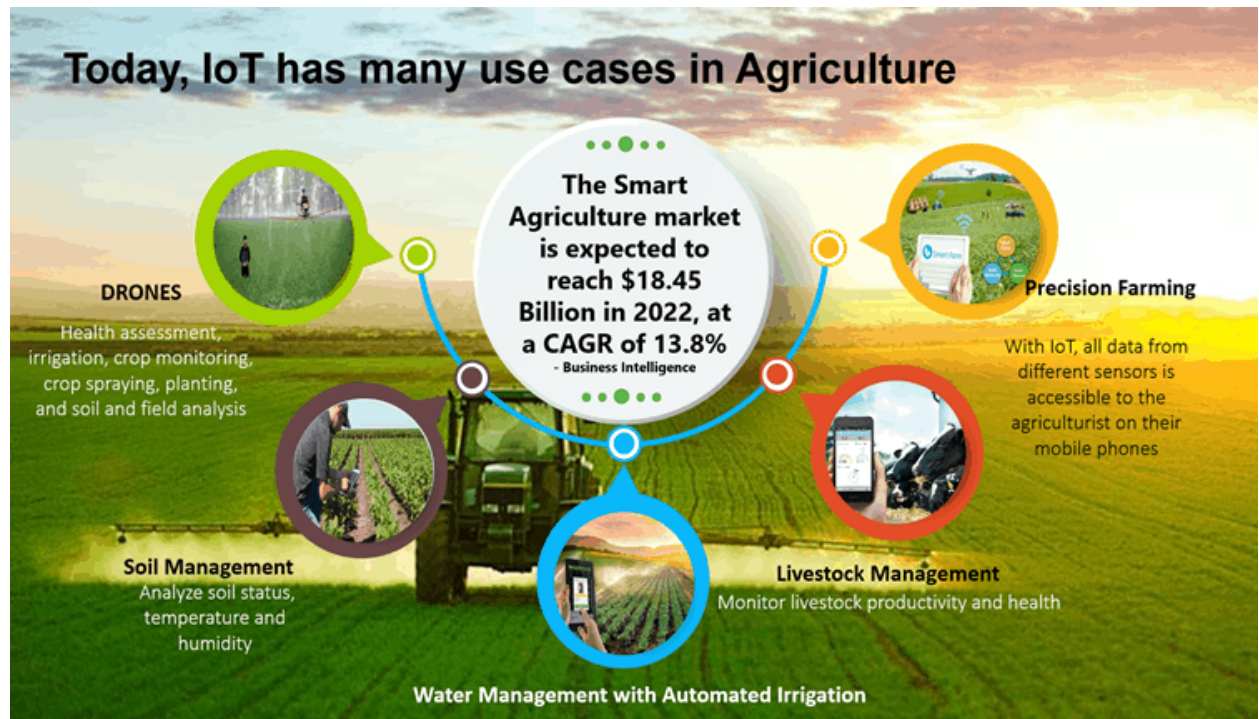
TRANSFORMATIVE DISCOVERIES FOR SMART AGRICULTURE

There is a basket of technologies and innovations that are enable production technology of smart agriculture. The concept, science and applications of such innovations are described below:

- 1) **Internet of Things (IoT):** IoT is described as a network of physical objects. These can be “things” that can be embedded with technologies, software or sensors which further helps in connecting or the exchange of data with other devices or systems via the internet or vice versa. In 2016, more than 5.5 million new “things” got connected every day, thus, creating the huge scope for Internet of Things. There are over 8.3 billion IoT devices connected today.



Global market for Internet of Things in



- 2) **Artificial Intelligence (AI):** It is the science of instilling intelligence in machines so that they are capable of doing tasks that traditionally required the human mind. The term AI is commonly used when a machine mimics cognitive functions such as planning, learning, reasoning, problem solving, knowledge representation, perception, motion, manipulation, social intelligence, and creativity. AI combines automation, robotics, and computer vision. Advances in statistics, faster computers, and access to large amounts of data have augmented the advances in AI, particularly in the field of Machine Learning where significant progress has been made in the areas of image and pattern recognition, natural language understanding, and robotics. Integration of AI and IoT devices further improves the growing and selling processes via predictive analytics. These programmes will help farmers determine which crops to grow and anticipate potential threats by combining historical information about weather patterns and crop performance with real-time data.



Global artificial intelligence market in agriculture industry



Key trend

Smart sensors
and precision
agriculture



Smart Driver

Maximizing
profits in farm
operations



Market Driver

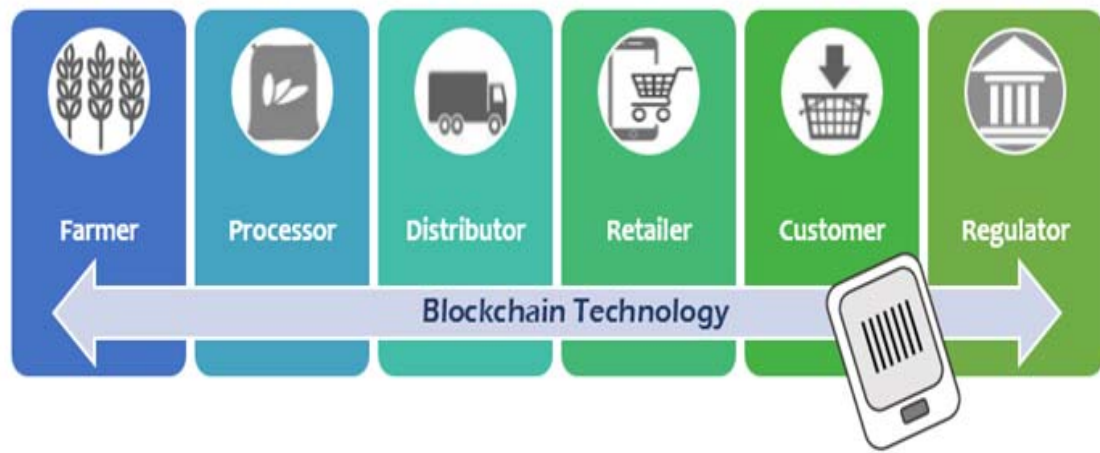
Higher adoption
of robots in
agriculture



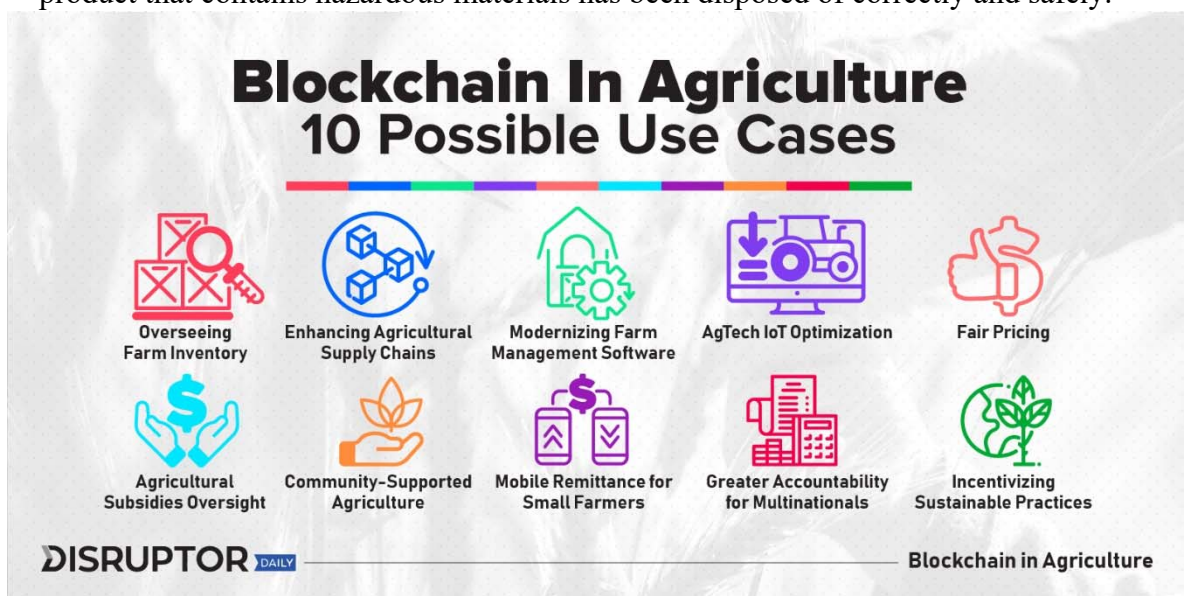
Forecast

The market is
expected to grow
at a CAGR of
22.38% by 2021

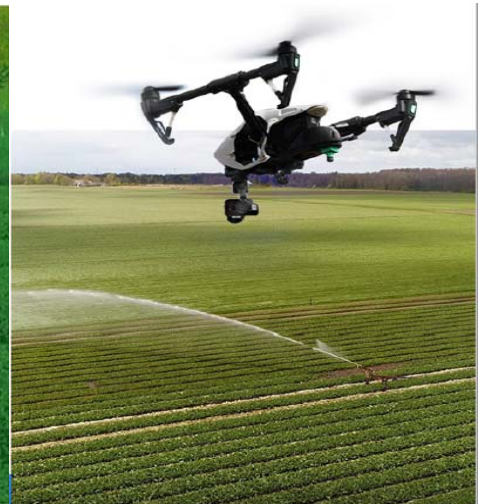
- 3) **Blockchain:** It is a recent technological advancement with potential for addressing the challenge of creating a more transparent, authentic, and trustworthy digital record of the journey that food and other physical products take across the supply chain. Blockchain works by mapping data and providing it to users along the value chain simply by scanning a barcode. These barcodes are applied and linked throughout the value chain automatically by grading and sorting robotics. This information not only provides the consumer with transparency, but also reduces risks for producers at the same time making available a cost-



effective supply chain analysis to optimize profits. When blockchain is integrated with IoT, it creates an immutable supply chain, ensuring that buyers are getting an authentic product that has not been damaged along the way. These technologies can also verify whether a product that contains hazardous materials has been disposed of correctly and safely.



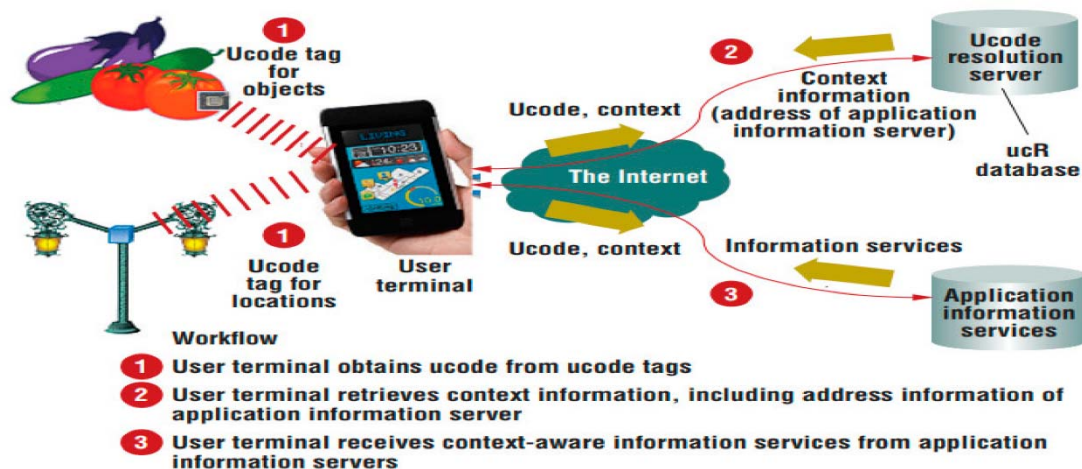
- 4) **Robotics:** Powered with advanced AI technology, robots will soon play a defining role in agriculture. Advanced computer vision is also transforming the way drones operate. Drones with AI-enabled vision processing capabilities are being used to assess the real situation on the condition of crops on ground. Autonomous drones and the data they provide can help in crop monitoring, soil assessment, plant emergence and population, fertility, crop protection, crop insurance reporting in real time, irrigation and drainage planning and harvest planning.



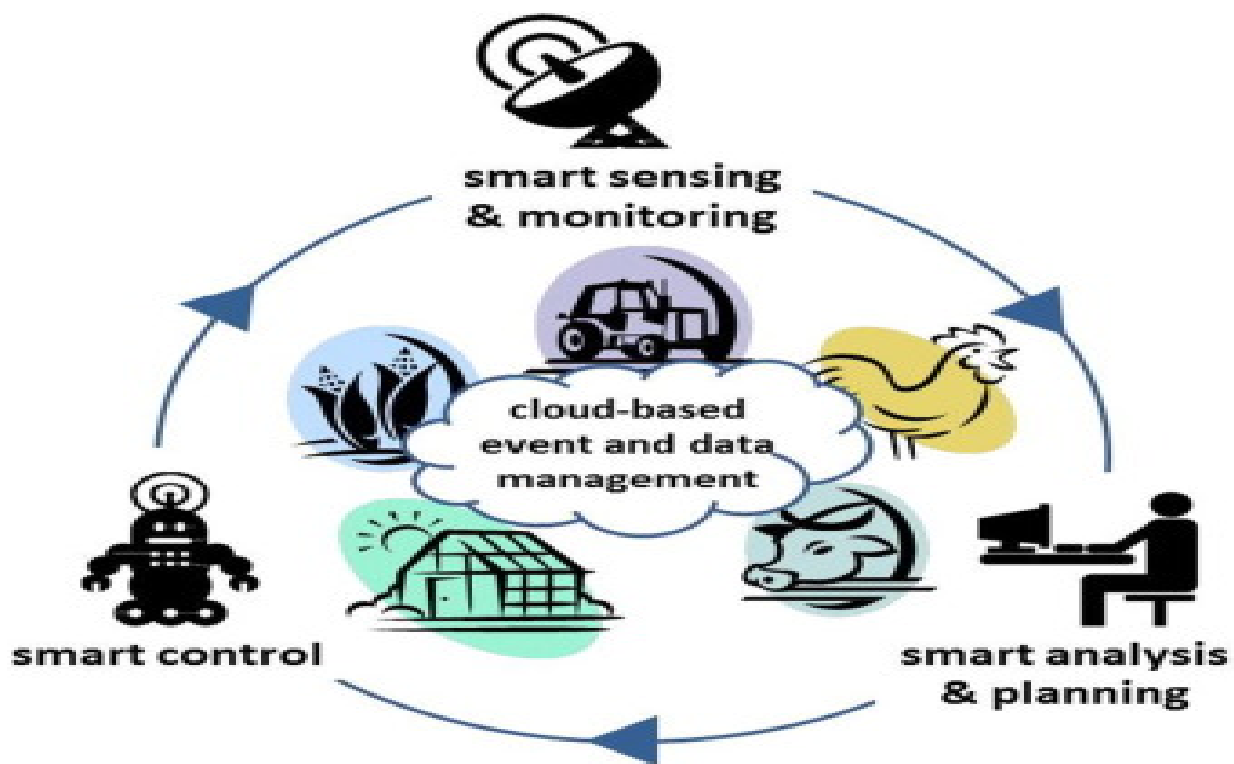
- 5) **Autonomous Swarms:** Autonomous swarms combine the technology of swarm robotics with a blockchain-based backend. Swarm robotics involves multiple copies of the same robot, working independently in parallel to achieve a goal too large for any one robot to accomplish. By leveraging the benefits of both swarm robotics and Blockchain, pesticide and fertilizer can be applied more sparingly and planting and harvesting can be done with individual attention to each plant, an impossible task with large-scale machinery. The new approach produces greater yields at reduced cost, while raising the quality of the crop.



- 6) **Artificial Intelligence of Things (AIoT):** Individually, the Internet of Things (IoT) and Artificial Intelligence (AI) are powerful technologies. AIoT is a combination of AI and IoT. AI can complete a set of tasks or learn from data in a way that seems intelligent. Devices empowered with the combination of AI and IoT can analyse data and make decisions and act on that data without involvement by humans



- 7) **Big Data:** It is a combination of technology and analytics that can collect and compile novel data and process it in a more useful and timely way to assist decision making. Data mining is the computing process of discovering patterns in large data sets involving methods at the intersection of artificial intelligence, machine learning statistics and database system. Big Data and analytics have the potential to add value across each step and can streamline food processing value chains such as selection of right agri-inputs, monitoring soil moisture, tracking prices of market, controlling irrigations, finding the right selling point and getting the right price.



Apart from the above technologies there are various technologies that will revolutionize the farming industry: Now is a time of innovation in the agricultural industries. Every day new technology is released onto the market and greeted with the open arms of eager precision farmers the world over. We have compiled a list of the 15 most exciting precision farm technologies that will reshape the agricultural landscape and improve farming practices overall.

Sensor Tech: Sensors can be used in a number of ways, most commonly they are used to detect inconsistencies or problem areas in crops. They can also detect moisture levels, soil nutrition and tell a farmer how much fertiliser to apply to his fields.

Innovation with Food: The global demand for affordable and nutritious food is unrelenting and farmers have often struggled to keep up with demand. With demand not likely to diminish any time soon, smart food is being created through researching existing crops and making them more plentiful when it comes to harvest.

Things are Becoming Automated: With driverless technology on the precipice for our everyday road going cars, the technology has been transferred to the agriculture industry. More and more farms are becoming fully automated, reducing human workload significantly and reducing costs at the same time.

Better Equipment: Engineering has improved in the last decade, with more robust materials available to farm tech developers, the new and unique machines they are creating as a result are truly magnificent. Don't believe us? Look at the functionality of today's tractors compared to one released 10 years ago!

Hardware Telematics and Warnings: It used to be that farmers would use their machinery until it stopped working, repair it and then repeat the process until the machinery was useless. Now with hardware telematics, machinery is telling farmers when things are likely to become a problem including warnings to reduce workload. By working in this way, the longevity of farm machinery has greatly increased, and farmers are making less and less costly repairs.

Livestock Tracking: Traditionally if you lost livestock whilst it was out grazing you would have to go in search of it, wasting time and energy in the process. Sometimes on large cattle ranches this search could take days and turn up nothing at all. Now animals can be tracked using inbuilt GPS in their collars, meaning if one strays from the other animals it can be quickly located and returned to where it should be.

Crop Analysis: Another traditional method that can be done away with now is the blanket use of fertiliser and herbicide. Farmers can now use tech to analyse the overall health in minute detail, even down to the individual plants. Meaning fertiliser and herbicide is only administered when required and costs are greatly reduced.

Genetically Designed Food: Further to the point of adapting existing crop species to produce more abundantly, scientists have been working hard in the lab to create genetically designed food types that are safe for human consumption. It may only be a matter of time before we have altogether new crop types to grow.

Variable Rate Management Systems: These systems work in tandem with the crop analysis, distributing fertiliser, herbicide and water in the exact quantity required and to the exact location it is needed. Never before has farming been such a precise art.

Agricultural Robots: These automated machines are often partnered with drones or other mapping technologies. They can distribute fertilizer, herbicide and also serve as personal weed eradicators. Many farms utilise these small automated bots to cut down on labour costs. They are particularly useful in fruit picking industries.

Drones: Providing famers with an unparalleled perspective of their land, drones are the precision agriculture heroes. Sometimes guided by human hands, but often unmanned, drones survey farms from the sky, collecting lots of important information in real time that allows farmers to troubleshoot problems as they arise rather than when it is too late.

Fertigation Systems: Working alongside variable rate application systems, fertigation systems can be installed to provide fertiliser and water to the nearest drop in the precise location that it is required, saving man hours and ensuring wastage is kept to an all-time low.

Vertical Cultivation: An innovation that has led to farming in the most unlikely of places, these box like pods house crops and can be stacked one on top of the other to create a farming solution in busy cities or urban environments. Already readily adopted in Asian countries like Japan, it won't be long before these boxes provide a farming solution the world over and help curb the pressure to keep up with the demand for food.

Mechanical Swarms: Currently in development and yet to be utilised in the field, the idea is to have robots conduct all farm work whilst interacting with each other and using drones and sensors to guide their actions. Perhaps it sounds like the stuff of science fiction but with continued investment this should one day be reality.

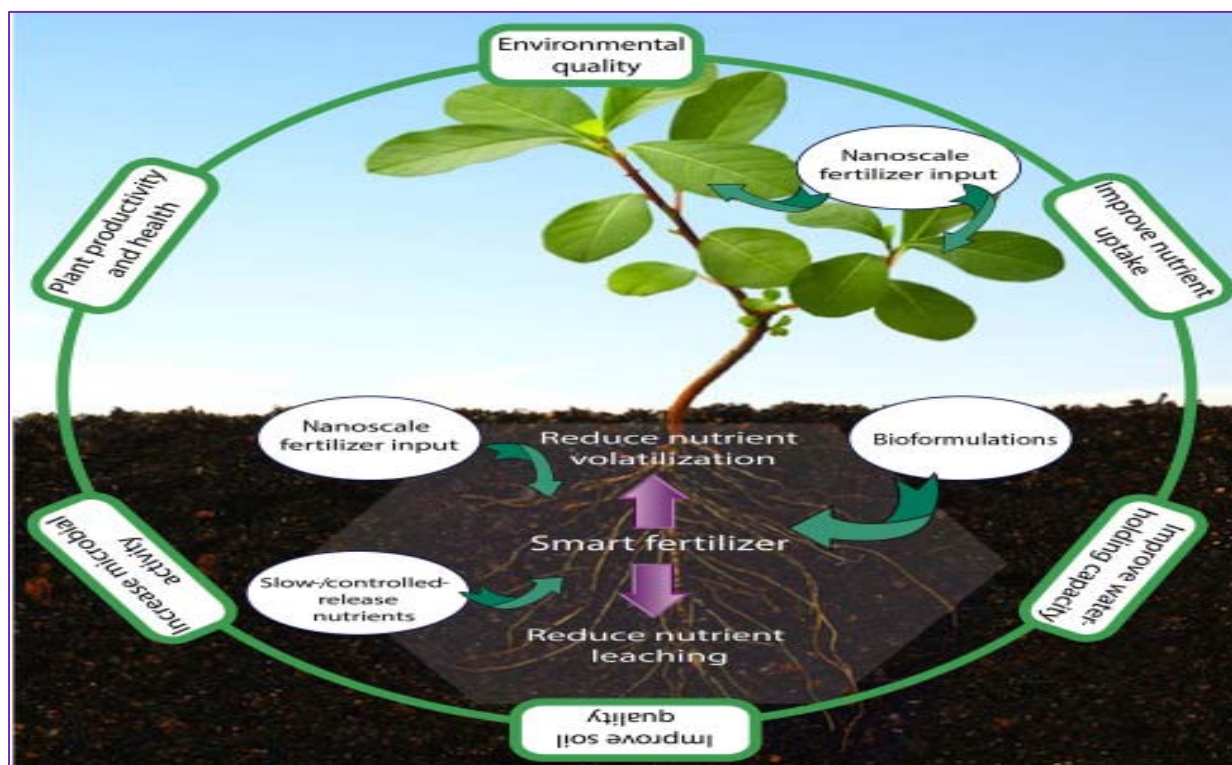
II. DELIBERATION OF SMART AGRICULTURAL PRACTICES FOR HIGHER FARM RESOURCE USE EFFICIENCY

1. Precision in Seed Sowing and Planting: Seed sowing at right place and right amount is very tedious in fields. Effective seeding requires control over two variables: planting seeds at the correct depth, and spacing plant at the appropriate distance apart to allow for optimal growth. Precision seeding equipments are designed to maximise these variables every time. Combining geo-mapping and sensor data detailing soil quality, density, and moisture and nutrient levels takes a lot of the guesswork out of the seeding process. Seeds have the best chance to sprout and grow and the overall crop will have a greater harvest. In future, existing precision seeders will come together with autonomous tractors and ICT- enabled systems that feed information back to the farmers. Prototype drones are being built and tested for use in seeding and planting. These drones can use compressed air to fire capsules containing seed pods with fertiliser and nutrients directly into the ground.

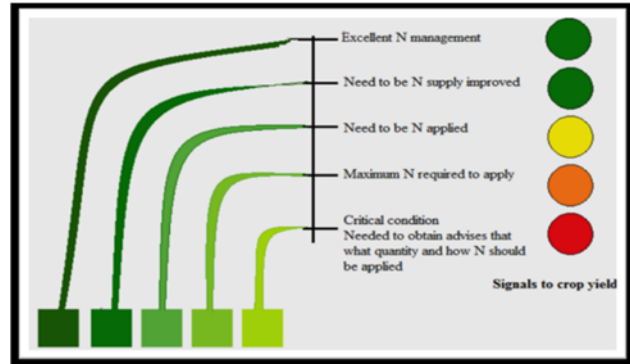


2. Precision in Nutrient Management: The approach of site-specific nutrient management (SSNM), a systematic approach to provide sound knowledge on ‘feeding crop’ with nutrients as and when needed to make synergy between nutrient demand and supply under different field crops production system, is the solution to manage special variability of nutrients and better nutrient use efficiency.

A. Smart Fertilisers: Smart fertilisers are new type of fertilisers which are formulated based on micro-organisms and nano-materials. Nanotechnology based smart fertilisers development with an emphasis on controlled- release and/or carrier/delivery systems will synchronise nutrient availability with the plant demands thereby reducing nutrient losses. Increased nutrient use efficiency has reduced dose of phosphate by half to one fourth and increased yields by 10 percent. For smart micronutrients the reduction in dose was up to 90 percent. Due to less investment, farmers' income can be raised by 15-20 percent. Bio-stimulants have direct hormonal effect on plants that positively affect root growth, root efficiency, nutrient uptake and characters that are beneficial in shifting from chemical to organic fertilisation regime. Major groups of bio-stimulants are humic substances, protein hydrolysate and amino acid stimulants, seaweed extract and PGPR. Bio-fertiliser on the other hand have an indirect effect on nutrient availability without itself supplying nutrients. They are live microbial formulations that aid in nutrient availability and uptake.

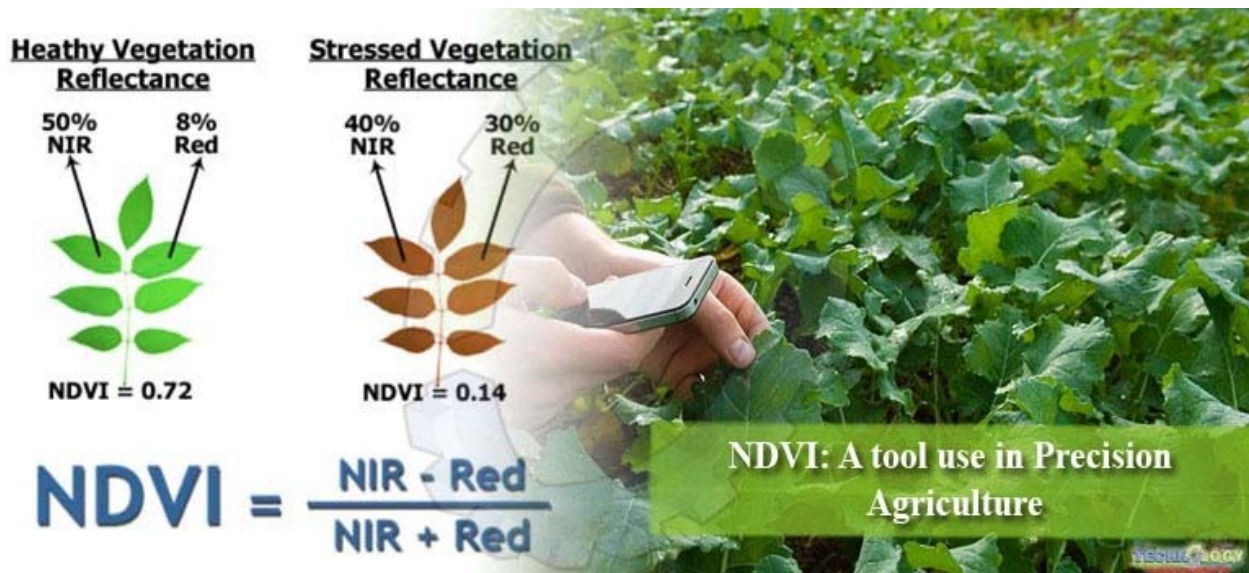


B. Leaf colour chart: Leaf colour is a fairly good indicator of the nitrogen status of plant. Nitrogen use can optimise by matching its supply to the crop demand as observed change in the leaf chlorophyll content and leaf colour. The leaf colour chart developed by International Rice Research Institute, Phillipines can help the farmers because the leaf colour intensity relates to leaf nitrogen status in rice plant. The monitoring helps in the determination of right time of nitrogen application.



Use of leaf colour chart is simple, easy and cheap under all situations. The studies indicate that nitrogen can be saved from 10-15 percent using the leaf colour chart.

C. NDVI Sensors: Studies in wheat as well as in rice crops have shown that need based nitrogen application using remote sensing based Normalised Difference Vegetation Index (NDVI) sensors can save 15-20 percent nitrogen without any yield penalty (Bijay- Singh et al., 2015) leading to improved profit margins to the farmers.



D. SPAD Value: SPAD (Soil-Plant Analysis Development) is a simple, quick and portable diagnostic tool for monitoring leaf nitrogen (N) status and improving the time of N topdressing in rice. SPAD is low-cost chlorophyll meter and affordable by farmers. It is possible to monitor leaf N status using the SPAD thresholds and guide fertilizer-N timing on irrigated rice. Measuring SPAD readings of the uppermost fully expanded leaf to reveal the plant N status has been accepted as a common practice, although it was found that leaves in lower positions could be more suitable to serve as testing sample for N status diagnosis, as the lower leaves were much better than upper leaves in separating N level, in case the total N was used as an indicator. SPAD meter-based N management appeared to be more efficient and smarter N management.



E. Nutrient Expert (NE): NE is the recently developed precision nutrient management technology guided by decision-support system software for improving crop yields, environmental-quality and overall agricultural sustainability. International Plant Nutrition Institute (IPNI) in collaboration with CIMMYT has developed a Nutrient Expert (NE), a nutrient decision support system, based on site-specific nutrient management (SSNM) principles. NE *provides* fertiliser recommendations by considering yield responses and targeted agronomic efficiencies along with contribution of nutrients from indigenous sources. This system follows systematic approach of capturing site-specific information that is important for developing a location-specific recommendation. NE has been successfully used to provide fertilizer recommendations in major maize growing agro-ecologies of country and also increased yield and farm profitability over existing fertilizer recommendations.

F. Urea Deep Placement (UDP): UDP technique, developed by the International Fertilizer Development Center (IFDC), Is a good example of a climate-smart solution for rice systems. The usual technique for applying urea, the main nitrogen fertilizer for rice, is through a broadcast application which is a very inefficient practice, with 60-70 per cent nitrogen losses contributing to GHG emissions and water pollution. In the UDP technique, urea is made into “briquettes” of 1 to 3 grams that are placed at 7 to 10 cm soil depth after the paddy is transplanted. This technique decreases nitrogen losses by 40 percent and increases urea efficiency by 50 per cent. It increases yields by 25 percent with an average 25 percent decrease in urea use (Singh et al 2010).

3. Smart Agriculture Practices for Efficient Water Management

Water is the most critical natural resource for human survival and sustainable development as its availability is decreasing day by day. The total projected demand of water for irrigation sector will be more than the present level, so there will be three major challenges viz., (i) “more crop per drop of water” by efficient and productive use of available water resources in irrigated areas, (ii) increased productivity of sub-productive challenged ecosystems i.e., rainfed and waterlogged areas, and (iii) making use of grey water (waste water) for agriculture production. It is possible only through efficient irrigation management when and how much required by the crop.

- A. Automation Irrigation System:** Pressurised irrigation systems like sprinkler, drip and subsurface drip irrigation are already prevalent irrigation methods that allow farmers to control when and how much water their crops receive. By pairing these irrigation systems with increasingly sophisticated IoT-enabled sensors to continuously monitor moisture levels and plant health, farmers will be able to intervene only when necessary, otherwise allowing the system to operate autonomously. While pressurized systems are not exactly robotic, they could operate completely autonomously. In a smart farm context, relying on data from sensors deployed around the fields perform irrigation as needed.
- B. On-farm Reservoir (OFR):** Rainwater harvesting and efficient water use are inevitable options to sustain rainfed agriculture in future. Different states have initiated special programmes for OFR to ensure the sustainability and to improve livelihoods of people.



C. Deficit Irrigation Supplies: Under limited water availability condition, irrigation strategies based on meeting the partial crop water requirements should be adopted for more effective and rational use of water. The adoption of deficit irrigation such as regulated deficit irrigation and controlled late season deficit irrigation are becoming an accepted strategy for water conservation and to reduce the amount of water used for crop production.

Analog irrigation systems have been used in commercial agriculture for some time and they operate on pre-programmed schedules and timers. As we do not take in to account the data on daily weather conditions, this often leaves farmers unprepared for sudden weather changes and can lead to significant overwatering and waste. Smart irrigation systems are more inclusive to such risks and are equipped with self-governing capabilities that result in more precise watering schedules that reflect the actual conditions of the grow site.

Smart irrigation comprises specialised hardware devices, software and services used to obtain real time data to help farmers make effective decisions pertaining to their farms. The combination of IoT and AI technologies, such as Machine Learning, computer vision and

predictive analytics, further allow farmers to analyse real-time data of weather conditions, temperature, soil moisture and plant health.

According to the Alliance for Water Efficiency, most smart irrigation technologies fall under two classifications:

1. Sensor-based Control: This method leverages real-time measurements from locally installed sensors to automatically adjust irrigation timing to the exact temperature, rainfall, humidity and soil moisture present in a given environment. This data is also supplemented with historic weather information to ensure farmers are able to anticipate unfavourable conditions.

2. Signal-based Control: Unlike sensor-based controls, these smart irrigation systems rely on weather updates transmitted by radio, telephone or web-based applications. These signals are typically sent from local weather stations to update the “evapotranspiration rate” of the irrigation controller.

4. Smart Agricultural Practices for Weed and Pest Management

A. New Generation Herbicides: Recently some post emergence new generation herbicides are available in the market with the assurance of selective effective control of weeds in field crops. These herbicides are required in very low doses and these are very easy in handling and transportation. Few post-emergence herbicides like imazethapyr, fenoxaprop-p-ethyl, cyhalofop butyl, quizalofop ethyl and clodinafop-propargyl in pulses and oilseeds: tembotrione in maize, pyrazosulfuron ethyl, chlorimuronethyl + metsulfuron methyl in rice; clodinafop + metsulfuron methyl in wheat are found very effective to control both broad leaved and grassy weeds.

B. Herbicide Resistant crops (HRCs): Herbicide resistant crops are genetically modified (GM) crops engineered to resist specific broad –spectrum herbicides, which kill the surrounding weeds, but leave the cultivated crop intact. These HRCs comprised 83 percent of the total GM crop area, equating to just fewer than eight percent of the arable land worldwide. Most herbicide resistant GM crops (maize, soyabean, cotton) have been engineered for glyphosate tolerance but now GM crops are evolved resistance against 2, 4- D, dicamba, glufosinate, sulfonylurea, mesotrione and isxaflutole. If government of India allows growing herbicide resistant GM crops then weed management will be more efficient.

C. Artificial Intelligence and Automation in Weed Management: Weeds and pests management are the most critical aspects of plant growth and development can be perfectly managed through autonomous robots. A few prototypes are already being developed to monitor the crops and simultaneously control the weeds. Similarly, automated cultivator can be used to control the weeds. With advanced machine learning, or even artificial intelligence (AI) being integrated in the future, machines such as this could entirely replace the need for humans to manually weed or monitor crops.

There are also drones currently available and in development for crop spraying applications, offering the chance to automate yet another labour-intensive task. Using a combination of GPS, laser measurement and ultrasonic positioning; crop spraying drones can adapt to altitude and location easily, adjusting for variables such as wind speed, topography and geography. This enables the drones to perform crop spraying herbicides, fertilisers and pesticides more efficiently, and with greater accuracy and less waste.

These robots designed for weeding, with the same base machine can be equipped with sensors, cameras and sprayers to identify pests and application of insecticides. These robots, and others like them, will not be operating in isolation on farms of the future. They will be connected to autonomous tractors and the IoT, enabling the whole operation to practically run itself.

5. Smart Agriculture Resource conserving practices

i) Laser land levelling: Precision land levelling is another resource conservation technology, which using laser guided system, helps in obtaining a perfectly levelled field. Yield advantage in both direct seeded rice (DSR) and transplanted rice (TPR) and saving of 20-25 percent of irrigation water apart from several other benefits like better crop establishment, nutrient use efficiency, uniform irrigation etc. have been reported with laser land levelling.

ii) Raised-bed Planting: Raised-bed planting refers to growing of crops (wheat, maize, pigeon pea and horticultural crops) in row geometry and on raised beds with furrow irrigation arrangements using a multi-crop raised bed planter. Helps in saving irrigation water by 30- 40 percent, furrows act as drainage channel in case of heavy rains and hence save crops from excess moisture. This provides excellent opportunity for intercropping operations and crop diversification.

iii) Conservation Tillage: Conservation tillage practices range from zero tillage (No-till), reduced (minimum) tillage, mulch tillage, ridge tillage to contour tillage. Conservation tillage farming is a way of growing crops without disturbing the soil through tillage using zero-till planter/drill. It increases the amount of water that infiltrates into the soil and increases organic matter retention and cycling of nutrient in the soil. Conservation tillage improves soil properties, making it more resilient. It helps in timely planting, reduce cost, improve soil health, increase profits, help in adapting to terminal heat stress and reduce environmental foot prints.

Smart Agricultural Practices for Higher Productivity and Profitability:

i) Crop diversification: Crop diversification is the most important agricultural activity providing employment and food security to millions of people in the country. It can be practiced in two ways i.e., temporal/horizontal/crop rotational diversification and spatial/vertical diversification. The component crops which are less productive or need more inputs is substituted with more remunerative, less inputs requiring and which sustain the soil fertility. Rice-wheat cropping system is most dominating cropping system and nearly contributes 42 percent to the total food grains production. The growth in crop productivity of component crops is either stagnating (Wheat) or declining (rice) despite the use of higher yielding cultivars. Thus, substitution of rice which require more water with maize or cash crops like sugarcane and cotton will not only reduce water requirement but also enhance the system productivity which leads to increase farmers income.

ii) Integrated Farming System: IFS is adoption and integration of wide ranges of resource saving package of practices, which ensures acceptable levels of profits/ income, make whole system economically sustainable, ecologically renewable, socially acceptable, minimize the negative impacts of intensive farming and preserve as well as improve the environment. In IFS approach emphasis is given on diversification of cropping systems in general and farming systems as a whole has been found successful to bring improvement in economic conditions of small-farm families. This could be possible by intervening most appropriate cost-effective technologies for narrowing yield gaps and through integration of less-input requiring enterprises for holistic development of farms and ensuring livelihood and nutritional security as well. The approach applied on small land holdings varying from 0.4 to 1.5 ha of land has been successful to meet household food, fodder, feed, fuel requirements of a family, and achieve other goals including reduced production cost,

increased profits, nutritional security, more employment opportunity, regular income and environmental safety. Horticultural crops mainly fruits and vegetables and dairy and goatry are among promising enterprises which integrate with existing farming systems to enhance income manifold.

iii) Conservation Agriculture (CA): CA is a concept for optimising crop yield, economics and environmental benefits. The key features of CA are 3 basic principles: 1. Minimum soil disturbance, 2) Maximum soil cover by leaving and managing the crop residues on the soil surface, 3) Crop diversification. The main advantages of CA are reduction in cost of production, reduced incidence of weeds, saving in water and nutrients, increased yields, environmental benefits, crop diversification opportunities, improvement in resource-use efficiency, etc.

iv) Organic Farming: Organic farming in India has been reinvented and getting more popular with each passing day. Farmers, entrepreneurs, researchers, administrators, policy makers and of course consumers are showing increasingly greater interest in promotion and development of organic farming in the country. Organic food products are considered to be much safer and nutritious than the products produced by conventional farming. Organic farming also helps to restore the soil health, protect environment, enhance biodiversity, sustain crop productivity and enhance farmers' income. Organic produces are being sold at premium price which increase farmers income. Seeing the long-term benefits of organic farming, the Government of India has taken many important steps for its promotion in the country. With the support of all kinds of stakeholders and the Government, the scope of organic farming movement has widened tremendously in India.

Based on the above-mentioned discussion, it may be concluded that Smart Agriculture approaches will find their due for smart agricultural practices, increased productivity, resource use efficiency and profit to the farmers and environmental safety.

Multilayer Farming: Multilayer farming can be scientifically defined as an integrated agricultural system in which we plant (4-5) different types of crops on same land and at same time which matures at different height and in different time. Actually-It is a type of intercropping which is at growing trend these days. [Akash Chaurasia](#) has develop the concept of multilayer farming. He started cultivating the crops by forming different layers and by the application of this technique he has proved of getting heck lot of higher production. Many people confuse on multi-tier, multi-

storied and multilayer cropping system. All of them are same. In **multilayer farming**, the crops grown have different germination time. So, they are sown at different depth of soil. The first crop sown at deepest layer of soil should germinate less So that-The middle layer and Upper layer of soil can be utilized to grow early maturing crops.

Principles of Multilayer Farming: **Multilayer Farming** is based on the principle of-High Density Planting-Making the ultimate and efficient use of manure, water, land and vertical space.

Other Principles includes: Maximum use of available resources of land, labour and capital. Minimization of production cost and input used. Development of organic and sustainable farming mitigating the use of chemicals agriculture. Ensuring the food and nutritional security to household.

Example of Multilayer Farming: Colocasia, Potato, Leafy Vegetable like coriander and papaya.

Crops	Planting time	Germination time	Depth of sowing	Maturity time
Colocasia	January	2-3 months	25-30 cm	7-8 months
Potato		20-30 days	10-15 cm	2-3 months
Leafy vegetables		5-8 days	3-6 cm	15-25 days
Papaya		7-8 months for fruit setting	15-20cm	9-11 months

VERTICAL FARMING AND HYDROPONICS:

Vertical farming is the practice of growing crops in vertically stacked layers. It often incorporates controlled-environment agriculture, which aims to optimize plant growth, and soilless farming techniques such as hydroponics, aquaponics, and aeroponics.

Hydroponics: Soil is replaced by a water solution that is rich in macronutrients like nitrogen, potassium, phosphorous, calcium nitrate and micronutrients like manganese, zinc etc. A ‘grow system’ controls the balance of nutrition, humidity and temperature, uses less water than soil-based farming and increases yield without chemicals or pesticides.

SOIL MOISTURE AND PH METER: It is a 3 in 1 soil tester which measures soil's **moisture, pH and light** by just plugging in the probe based on reading you can decide when to water, control pH level, determine if plant getting adequate light. Simply insert probe of the meter into the soil to remaining about 10mm outsider, switch to the setting you want to measure and read the scale. For example: Choosing the MOIST, scale of 1-3 (red parts) means needing watering, 4-7(green parts) means suitable, 8-10 (blue parts) means that too wet.

INFOSYS MODEL OF SMART AGRICULTURE: Infosys explains how an enterprise can become a Live enterprise. One that is sensing, responding and evolving with the needs of the time. We do this by deploying the right technology capabilities and solutions. One such example is in our own Smart farm in Hyderabad, India. See how Infosys is using drones and other new technologies to navigate the farm of the future through this URL

<https://youtu.be/0WR4BeFcLks>



LIST OF DIFFERENT SMART AGRICULTURE PRACTICES

Sl. No	Technologies	Mobile/Web Applications	Devices	Methods
1.	Artificial intelligence	Plantix	Urea Deep placement	Conservation agriculture
2.	Blockchain	Kisan Suvidha	SPAD Meter	Hydroponics
3.	Internet of Things	Pusa Krishi	Plant injector	Multilayer farming
4.	GIS, GPS	Expert Systems	Leaf color chart	Organic farming
5	Smart fertilizers	DSS	Pneumatic planter	Mulching
6.	Sensors	M-kisaan portal	Deep thunder	Vertical farming
7.	AIOT, Big data	Websites	Kisan raja-Motor controller	IFS
8.	Robots, Drones, Swarms	Plant doctor	Soil moisture & pH meter	Raised bed planting

List of Smart Agriculture Practices for India

Soil moisture & pH meter	Kisan Raja-motor controller	Grid Sampling
Pressurized Irrigation (Smart Irrigation)	Mulching	Smart fertilizers
Leaf color chart	Multilayer farming	Mobile & Web based applications
Pneumatic planter	Smart agronomic practices	

List of data driven tools with their key features for Smart agriculture

TOOLS	FEATURES
Global positioning system	<ul style="list-style-type: none">• Location of soil samples and the laboratory results can be compared to a soil map.• Fertilizer and pesticides can be prescribed to fit soil properties and soil conditions• One can monitor and record yield data as one goes across the field.
Global information system	Spatially referenced Geographical Information
Grid sampling	Determination of precise nutrient doses
Variable rate Technology	Precisely control the rate of application of crop inputs that can be varied in their application commonly include tillage, fertilizer, weed control, insect control, plant population and irrigation.
Yield Monitoring	Yield data from the monitor is recorded and stored at regular intervals along with positional data received from GPS unit.
Remote sensing	Crop Production Forecasting, Soil Mapping, Wasteland Mapping, Water Stress, Insect Detection and Nutrient Stress
Auto-Guidance Systems	Allows more precise automated application of inputs
Proximate guidance systems	Proximate sensors can be used to measure soil (N and pH) and crop properties as the tractor passes over the field.

PILOT PROJECTS / INITIATIVES OF SMART AGRICULTURE IN INDIA

All the global IT majors are here simultaneously, NITI Aayog, the government's think tank, has been working with major global technology giants such as IBM, Microsoft, SAP and others to harness the power of artificial intelligence, data analytics, satellite imaging, the internet of things (IoT) and machine learning to improve yields, increase predictability and raise incomes of Indian farmers.

Start-ups, foreign investors are also present: Many start-ups have also sprung up in this space and are doing good work in using these technologies to help farmers. According to Invest India, the government's foreign investment promotion agency, there are more than 450 agri-tech

start-ups in India – that means one out of every nine start-ups in this space is Indian. The leading ones include Intello Labs, Stellops, Gobasco, Ninjacart, Cropin, Jumbotail and Agrostar, among others. Foreign and domestic investors have also spotted the opportunity here. Large fund houses such as Omnivore, Accel and Ankur Capital have invested in many early-stage start-ups, which, according to IT industry body Nasscom, have raised about \$250 million (till June last year).

Agriculture industry is a matter of concern for the government as lot of factors such as climate change, population growth and food security concerns have driven the sector to seek more innovative approaches to improve production, productivity and quality in major crops. NITI Aayog came up with a National Strategy for Artificial Intelligence in India, which is aimed at focusing on economic growth and social inclusion.

1. **The Government signed an MOU with IBM** to use AI to secure the farming capabilities of Indian farmers. The pilot study will be conducted in states like Madhya Pradesh, Gujarat and Maharashtra. After the pilot study, IBM's Watson decision platform will provide a farm-level solution for improving the agriculture sector. It will provide weather forecast and soil moisture information to farmers to take pre-informed decisions regarding better management of water, soil and crop. This initiative was aimed at improving the future of farming by harnessing multiple data points and combine predictive analytics, AI, satellite data, and IoT sensors to give farmers insights on ploughing, choosing crops, spraying pesticides, and harvesting.

2. **AGRI-UDAAN:** In a bid to push innovative technologies in agriculture secure, the government of India has also launched another initiative — AGRI-UDAAN – Food & Agribusiness accelerator 2.0 to mentor 40 agricultural startups from cities like Chandigarh, Ahmedabad, Pune, Bengaluru, Kolkata and Hyderabad, and enable them to connect with potential investors. This initiative is a six-month-programme in which shortlisted Agri startups with innovative business models will be mentored and guided to improve their operations, enhance commercialisation, improve product validation and business plan preparation, risk analysis, customer engagement, finance management, and fundraising. These shortlisted startups will also stand a chance of receiving \$40,000 as funding assistance.

3. **Maha Agri Tech Project in Maharashtra** is another such project which seeks to use innovative technologies to address various risks related to cultivation such as poor rains, pest attacks, etc., and to accurately predict crop yielding. The project will also use this data to inform

farmers about several policy requirements including pricing, warehousing and crop insurance. The first phase of the project uses satellite images and the data analysis done by Maharashtra Remote Sensing Application Centre (MRSAC) and the National Remote Sensing Centre (NRSC) to assess the area of land, and the conditions of select crops in select talukas. However, the second phase includes an analysis of the data collected to build a seamless framework for agriculture modelling and a geospatial database of soil nutrients, rainfall, and moisture stress to facilitate location-specific advisories to farmers.

4. **Government of Karnataka with Microsoft:** The government of Karnataka has also recently signed an MOU with a tech giant — Microsoft to empower smallholder farmers with AI-based solutions to help them increase income and price forecasting practices. Microsoft with guidance from Karnataka Agricultural Price Commission (KAPC) is aiming to use digital tools to develop a multivariate agricultural commodity price forecasting model considering the following parameters — sowing area, production time, yielding time, weather datasets, and other relevant datasets.

5. **Government of Karnataka:** Farmers across Karnataka in India will now be able to combat crop diseases with the touch of a screen. Plantix, an Android smartphone app that can detect pests, diseases and also identify nutrient deficiencies, was launched in the local language Kannada on Monday.

6. **Nokia and Vodafone India Foundation, the CSR arm of Vi, announced that they have deployed a Smart Agriculture solution that aims to improve the productivity of farmers in India:** The pilot of Vodafone India Foundation's SmartAgri project is being implemented in 100 locations in the states of Madhya Pradesh and Maharashtra and will benefit over 50,000 farmers in the region by enhancing their productivity and income. The smart agriculture-as-a-service solution, which utilizes Nokia's Worldwide IoT Network Grid (WING) solution, will ensure that precise and practical data is sent to farmers enabling them to enhance productivity.

Over 400 sensors have been deployed over 100,000 hectares of farmland to collect various data points which are then analysed by a cloud-based and localized Smart Agriculture app. The app provides local language support as well as weather forecast and irrigation management information. The sensors generate insights that helps to improve soy and cotton crop yields. Crop management through WING can include smart irrigation, smart pesticide control, proactive

information sharing frameworks on crops and weather, as well as a platform for commodity exchange. The use case can also employ Remotely Piloted Aircraft System (RPAS) technology or drones instead of traditional sensors for crop management.

7. **Kerala partners with Cisco to support farming communities:** Software major Cisco signed a Memorandum of Understanding (MoU) with the Kerala State IT Mission (KSITM) to bring the benefits of digital technology and data science to farming communities in Kerala, as part of its Country Digitization Acceleration (CDA) programme. The first phase of this initiative will be rolled out in 15 panchayats across Kannur, the home district. Cisco will build an Agri-Digital Infrastructure (ADI) Platform and set up Village Knowledge Centres (VKCs) for knowledge delivery and provide access to e-learning and advisory services to the farming and fishing communities in Kannur. The comprehensive ADI Platform will provide access to a datastore with complete farming data of paddy and prawns farms in the region along with land and farmer profile databases. This datastore will run Cisco's robust analytics and computer engines to extract insights on crop yields, weather patterns, plant disease patterns, soil quality, moisture content, forecasting and other data, and make it available to farmers and government officials through the VKCs. This Cisco ADI Platform will be supplemented by a custom-built Smart Agricultural Platform that uses IoT sensors, Non-IoT databases, and satellite/UAV images to gather and relay real-time intelligence on soil content, moisture, weather conditions and other parameters. This platform will become a centralised knowledge hub which will provide data-based recommendations and insights to improve agriculture planning, reduce the risk of crop mortality and overall operational costs. Through VKCs, farmers can also access essential information on government policy updates, crop advisory services, market trends, rates and best practice videos. Farmers will also gain accessibility to government-provisioned financing on a Content Management System through a mobile application and web portal.

8. **Microsoft collaborated with ICRISAT** (International Crops Research Institute for Semi Arid Tropics) developing a predictive analytics app that **calculated the best crop sowing date for maximizing the yield**. As a test case, farmers across seven villages were sent text messages with dates for sowing and other advice. Despite meagre rainfall, **farmers that used the app boosted their yields by 30 percent**. When other farmers witnessed the results, they were also more likely to use the app themselves.

Benefits of smart Agriculture:

1. Simplified and automation of farming processes with minimal effort and a great degree of accuracy.
2. More Cost-Efficient Farming: Advanced cultivation methods reduce costs on inputs
3. Higher Yields and More Profitability: because of use of improved growing practices and they are able to sell more produce at the end of the season as a result. They also have less man hours to expend as technology is filling gaps that workers would have previously filled.
4. Better Quality Produce: Implementing better growing processes is providing produce that is of a higher quality. This is done in many ways such as actively monitoring the nutrients in soil, strip tilling and irrigating plants correctly and when irrigation is needed. Again; this not only boosts yields, but it also boosts profit margins further as when it comes to taking the crop to market, precision farmers are able to negotiate a higher price for the improved quality in the produce.
5. Less Waste: Lost crop is a nightmare for farmers, and over a growing season there is expectation that a certain number of plants will not see the season through. Making this worse is that historically storage practices inevitably resulted in further spoilage. With streamlined growing processes and healthier plants that crops have a much better chance of surviving and growing seasons are becoming more sustainable. Furthermore, improvements in storage by technological means has greatly reduced crop spoilage in the storage stage as well.
6. Higher Quality of Life: The growth seen across the globe in both yield and distribution of farmed goods has been staggering and this will continue to grow as more farmers realise that they can have simpler and more productive lives. Have you adopted precision farm techniques? What personal benefits have you seen on your farm? Let us know your how precision farming has changed your life in the comments.
7. Lesser impact on environment
8. Practices sustainable production methods
9. Improved monitoring, scouting and control
10. Accurate data collection
11. Precise analytics for prompt actions
12. Improved return on investment
13. Increase in yield quality and quantity

Challenges for smart agriculture:

1. High setup and maintenance cost
2. Flight time limitations and coverage
3. Weather dependency/climate dependency
4. Laws and regulations
5. Fragmented lands limit the smart agriculture
6. Needs expertise in handling devices
7. Complete dependency on data/electricity

Role of Extension In smart agriculture

1. Conducting field days
2. Conducting Demonstrations
3. Field Exposure visits
4. Trainings to farmers
5. Organizing farmer field schools
6. Collective/ Cooperative farming
7. Facilitating collaboration of technological institutes with agricultural institutes

Review of related case/ research studies:

1. Anonymous (2014) reported that among 64 districts covered in 13 states, indicated that micro-irrigation has benefited farmers significantly by reducing electricity consumption by about 31 per cent, the irrigation cost has also decreased by an average of 32.3 per cent. Furthermore, about 28 per cent reduction in total fertilizer consumption. It also enhanced the average productivity of fruits and vegetables by about 42.3 per cent and 52.8 per cent, respectively and increase in farmers' income in the range of 20 per cent to 68 per cent with an average increase of 48.5 per cent.
2. Anonymous (2017) reported that Microsoft, in partnership with ICRISAT initiated a pilot project in Devanakonda Mandal in the Kurnool district of AP. The pilot had a sample base of 175 farmers who were alerted on their mobile phones about suitable cropping dates, land preparation, and soil test-based fertilizer utilization. This helped increase crop output by around 30%. In 2017, this project was expanded to cater to approximately 3,000 farmers in

Karnataka and Andhra Pradesh during the *Kharif* cycle for a host of crops like groundnut, *ragi*, maize, rice, and cotton, among others. The increase in crop yield following the AI intervention ranged from 10-30% across all crops (2017).

3. Anonymous (2018) reported that in Andhra Pradesh, Vijay Bhaskar Reddy, a software engineer, has developed an IoT based autonomous irrigation solution, Mobile Motor Controller Device- Kisan Raja which helps farmers monitor, control and utilise water judiciously. This device has helped more than 34,200 farmers across ten states namely Telangana, Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu, Haryana, Punjab, Rajasthan, Madhya Pradesh and West Bengal. According to research company Markets and Markets, the smart irrigation market was valued at USD 0.83 billion in 2018 and is expected to reach USD 1.76 billion by 2023, at a CAGR of 16.30 percent.
4. Kapoor (2020) conducted study on Agribot: Saving Water and Spraying Pesticides and reported that it would not be surprising if you see drones deputed in the country's agricultural land spraying pesticides. Trials are being conducted in the fields with Agribot drones. Spraying of pesticides with limited amount of water is one of the great features of the Agribot drone. Where up to 400 litres of water is used for spraying pesticides in one-acre field, the Agribot can spray it in 8 litres of water. Pesticides are sprayed about 10 times a year per acre. Accordingly, around 3920 litres of water is saved per acre in a year. There are about 39 crore acres of cultivated land in India. If pesticide spraying is made mandatory by drone, about 1.5 lakh crore litres of water can be saved. Agribot drones are also being used to control grasshoppers. Amidst the terror of the locust attack, in January 2020, the drone sprayed over 500 hectares of land in 16 days and freed the area from locusts. The spray from the drone on the locust crew starts at 5 am and is repeated again in the evening. It takes about three to five minutes for a drone to spray on one acre of land. Around 99 percent of grasshoppers pile up in about 10 minutes. The Agribot drone can cover 50 acres a day with additional batteries. They are also able to operate in inaccessible areas and mountains. In the middle and later stages of the crop the drone can enter the fields for spraying pesticides, whereas this is not possible with heavy equipment. Along with saving water, the use of pesticides is 15 to 35 percent higher efficient with drones than the conventional methods as the amount of chemical is scientifically determined. By spraying pesticides with drones, farmers stay away from chemicals and they do not have any side effects on their health.

Conclusion:

Smart agriculture has the potential to double the food production along with reducing the losses and wastage. It is estimated that the smart agriculture has the potential to increase agricultural productivity by 70 per cent by 2050. There is a need to develop an infrastructure in our agricultural institutions to have scientific understanding for such technologies so that the farmers can be trained to use of such technologies and equipments in the field. There is a need for convergence of available institutional resources in the country for increasing the resource use efficiency through smart agriculture technologies. There is a need to develop an infrastructure in our agricultural institutions to have scientific understanding for such technologies so that the farmers can be trained to use of such technologies and equipments in the field. There is a need for convergence of available institutional resources in the country. We have best technology institutions of the world like Indian Institutes of Technology, National Institutes of Technology, Indian Institute of Science, etc. Our immediate need is to rope in these institutions with our top agricultural intuitions like Indian Agricultural Research Institute, Indian Veterinary Research Institute, National Dairy Research Institute, Indian Institute of Horticultural Research for testing and validation of the suitable technologies in commercially important crops in different parts of the country. In the long run, there should be a collaboration in these technology and agricultural institutions for the development of such technologies for sustaining smart agriculture in the country. There is a need to remember the visionary water administrator and second Prime Minister of Australia, Alfred Deakin who said in 1890 that “It is not the quantity of water applied to a crop, it is the quantity of intelligence applied which determines the result - there is more due to intelligence than water in every case.”

REFERENCES:

- ANONYMOUS, 2014, Impact evaluation study of National Mission on Micro-irrigation, *GoI Report*, Ministry of Agriculture.
- ANONYMOUS, 2014. ‘Measures for Improving the Water Use Efficiency’, *Guidelines for Improving Water Use Efficiency in Irrigation, Domestic & Industrial Sectors*. pp. 4.

ANONYMOUS, 2017. 'AGRI UDAAN- Food and Agribusiness Accelerator 2.0'. Press India Bureau (3 August). Available at: <https://pib.gov.in/newsite/printrelease.aspx?relid=169569>

ANONYMOUS, 2017, Digital Agriculture: Farmers in India are using AI to increase crop yields Available at <https://news.microsoft.com/en-in/features/ai-agriculture-icrisat-upl-india>

ANONYMOUS, 2018, Impact evaluation study of National Mission on Micro-irrigation, *GoI Report*, Ministry of Agriculture.

BIJAY SINGH, VARINDERPAL-SINGH, AND PURBA, J. 2015, Site-specific fertilizer nitrogen management in irrigated transplanted rice (*Oryza sativa*) using an optical sensor. *Precision Agric* (16): 455–475.

<http://www.fao.org/aquastat/en/overview/methodology/water-use>

<http://www.fao.org/water/en/>

<https://www.deloitte.com/us/en/insights/deloitte-review/issue-18/second-green-revolutionand-internet-of-things.html>

KAPOOR, N., 2020, Agribot: Saving Water and Spraying Pesticides, *Vigyan Prasar, Kurukshetra*, 58 (8):18.

MARIANI, JOE AND JUNKO KAJI.2016. 'From Dirt to Data: The Second Green Revolution and Internet of Things', *Deloitte Review* (18).

SINGH, A. K. 2013. Water management: Issues and strategies, *FAI Annual Seminar Papers*. New Delhi.

Discussions:

Q1: With all these advancement in smart agriculture still the disaster has adversely affected the agriculture, what is the reason for that?

Ans: We cannot avoid disasters but we can reduce its impact on agriculture and lives of by forecast and early warning systems. At present in Karnataka KSNDMC is started since 2008 which is providing forecasts at panchayat level. But the major reason is negligence by people about the forecasts due to inconsistencies in predictions and negligence by officials in conveying messages to the concerned.

Q2: Which are your strategies in promoting smart agriculture technologies in Indian context?

Ans: Major problems with respect to adoption of smart agriculture technologies in India are Fragmented landholdings, Diversified Cropping pattern, Illiteracy of farmers and Initial high costs, High cost of maintenance. Hence the organizing farmers in to associations/Groups will help farmers in sharing of costs between farmers and accessing smart inputs and technologies, training of farmers is needed with respect to technology/ devices handling skills. Apart from this, mobile based applications and technologies are most useful as they are penetrating nook and corner of rural areas, low-cost farmer friendly technologies can be developed by SAUs in collaboration with technological inputs and technologies can be provided to the farmers at incentivized/subsidized rates by government.

Q3: With respect to some of the technologies there are legal issues with respect to their application in our country especially with robots what is that?

Ans: Yes, there is an issue with respect to the robots/ drones with their licenses for use in agriculture field.

Q4: The technologies are advancing and delay in adoption of technologies in such way that by the time of application of one technology, another superior technology has entered the market making previous one an outdated one. What might be the strategies to overcome?

Ans: As one of the saying, 'Everything is changing except change', changing/evolution is important for progression. Strategies might be: to overcome delay in adoption, government should

take immediate actions to make sure that the technologies should be adopted as soon as possible to reap its benefits, organizing farmers, low cost and location specific technologies can be developed.

Q5: Is there any strategy other than organizing farmers to access smart agricultural technologies especially small and marginal farmers?

Ans: Just like custom hiring centers, Government should start the smart equipments/technologies/devices hiring centers on minimal costs so that all farmers can access to them. Government can provide them on subsidized rates just like micro-irrigation and green houses. Research and development should focus towards the development of low cost and small and marginal farmer friendly technologies.

Q6: Is the genetically modified crops are permitted for growing in India?

Ans: Till now only approved GM crop is Bt Cotton but farmers in Rajasthan, Madhya Pradesh and Haryana are growing GM crops like Maize, Soyabean and Sesamum which are not approved for cultivation in India.

Q7: The Kisan Raja works on internet or network?

Ans: It works on GSM network through the phone calls and messages. It also provides information related to the dry runs, current fluctuations and wire cuts, the motor will automatically offs and sends message to the farmer.

Q8: Is it possible for use of drones and other tools in Indian conditions?

Ans: Yes, it is possible with some initiatives and has been used by farmers of Punjab, Haryana and other states.

Q9: What is e-NAM portal?

Ans: It is an online trading platform which connects all the regulated markets across India. Through this portal farmers can sell their produce from their APMC to the buyers who are located at distant places.

Q10: What are the technologies developed by the Agricultural Engineering Colleges and SAUs in Karnataka?

Ans: With respect to SAUs, UAS Raichur has developed the e-SAP for detection of pest and diseases. Most of SAUs have their own portals, blogs and websites in which package of practices are provided and some have developed apps like UASB developed Fertilizer Calculator. With respect to engineering colleges, one person from UAS Raichur has increased the carrying capacity (pave load) of drones and in association with private bodies developed micro-irrigation models, various equipments, models of technologies.