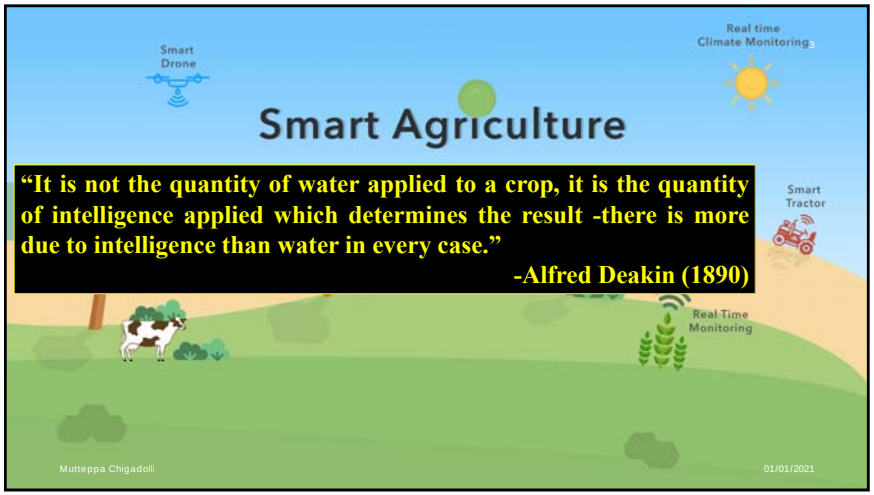

OUTLINE

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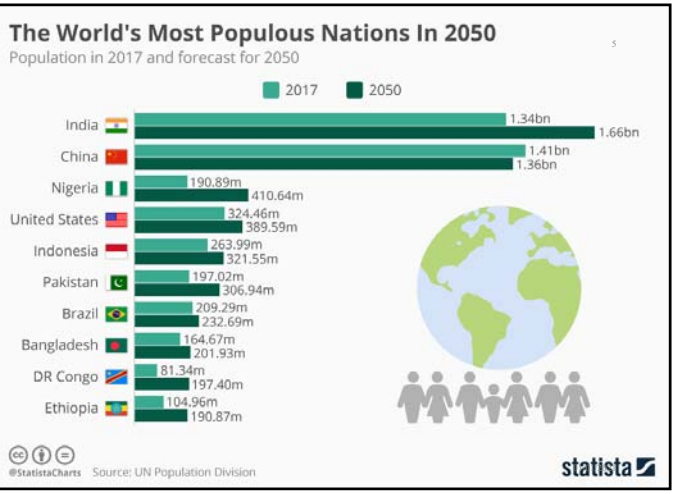

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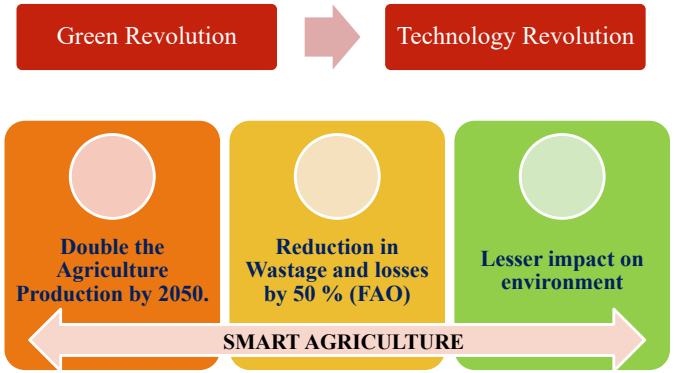

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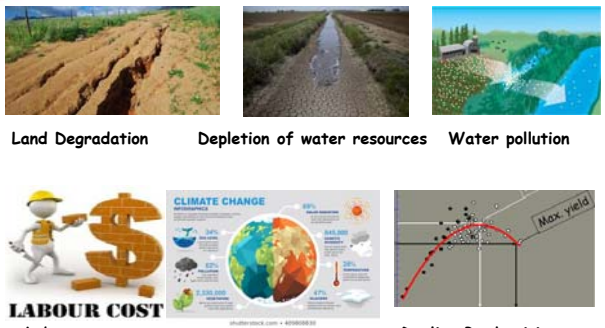
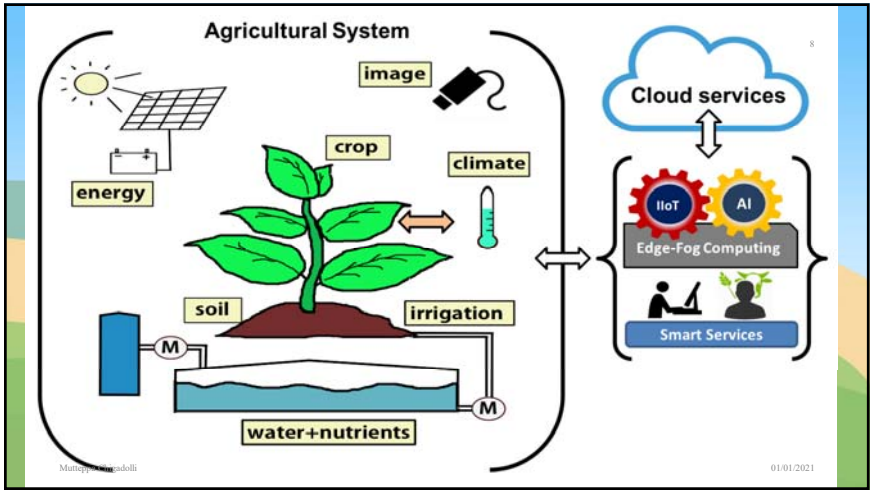


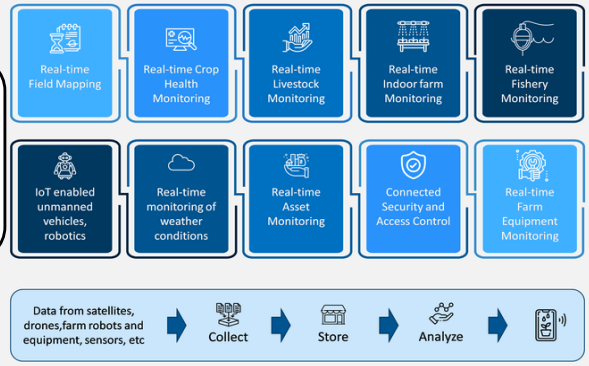


OBJECTIVES:

1. To understand the concept of Smart Agriculture
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

1. CONCEPT OF SMART AGRICULTURE

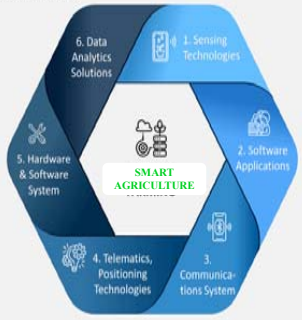
SMART AGRICULTURE = Precision Agriculture + Smart Farming + Digital Farming



1. CONCEPT OF SMART AGRICULTURE

Smart Agriculture involve the integration of advanced technologies into existing farming practices in order to increase production efficiency and the quality of agricultural products.

Smart agriculture deals with applying inputs (what is needed) when and where it is needed, has become the third wave of the modern agriculture revolution.



SMART AGRICULTURE PRACTICES

- 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 etc which helps in increasing agricultural production, productivity with optimimum resource utilization and lesser impact on environment.

TRANSFORMATIVE DISCOVERIES FOR SMART AGRICULTURE

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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. More than **8.3 million "things" got connected every day.**

TOP 10 TECHNOLOGIES IN SMART AGRICULTURE

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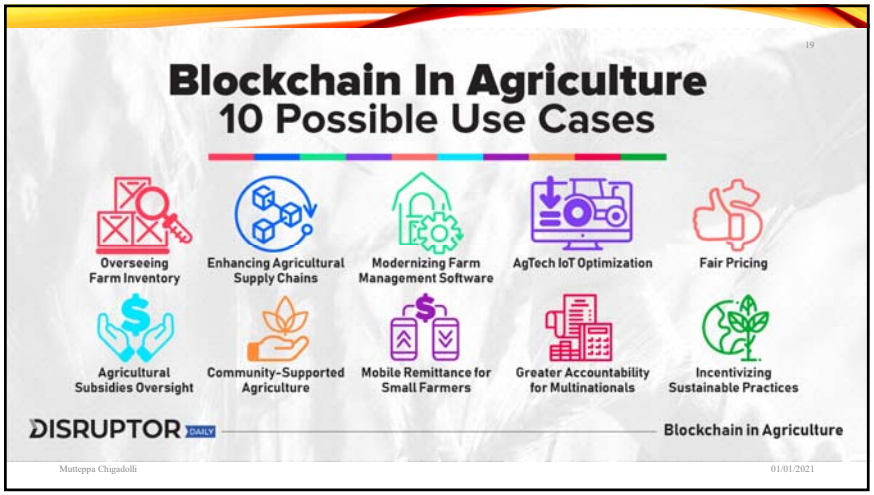
- Satellite Monitoring
- Soil / Plants... Sensors
- Mobile Devices
- Smart Zone Seeding
- Autonomous Robotics
- Weather Modeling
- Smart Micro Irrigation
- Fertilizer Modeling
- Internet of things
- Inter-Compatibility & Standardization

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.**

Muttepa Chigadolli



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3. BLOCKCHAIN:

- **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.

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4. ROBOTICS:

- A machine resembling a human being and able to replicate certain human movements and functions automatically.
- 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.

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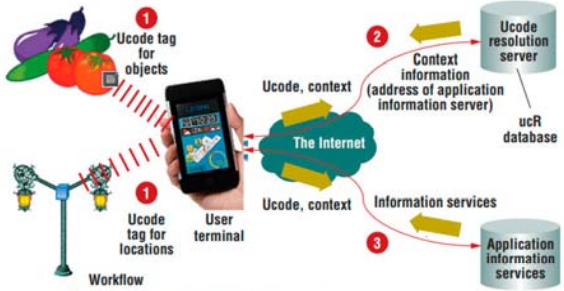
5. AUTONOMOUS SWARMS:

- Autonomous swarms = Swarm robotics+ Blockchain.
- 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.
- With autonomous swarms, pesticide and fertilizer can be applied more sparingly and planting and harvesting can be done with individual attention to each plant.

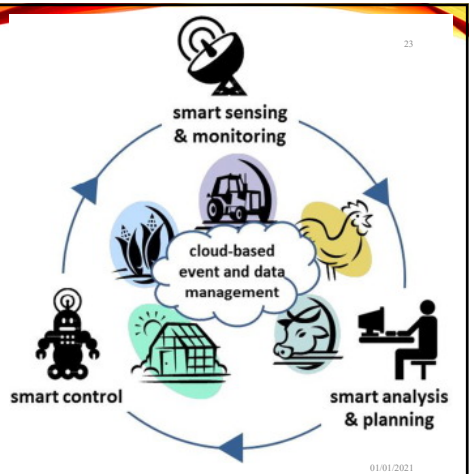
6. Artificial Intelligence of Things (AIoT):

- 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 **analyze data and make decisions and act on that data without involvement by humans**



7. BIG DATA:

- **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**.
- Big data provides farmers granular data on rainfall patterns, water cycles, fertilizer requirements, and more. This enables them to make smart decisions, such as what crops to plant for better profitability and when to harvest. The right decisions ultimately improve farm yields.



2. To deliberate smart agricultural practices for higher farm resource use efficiency

1. Precision in Seed Sowing and Planting

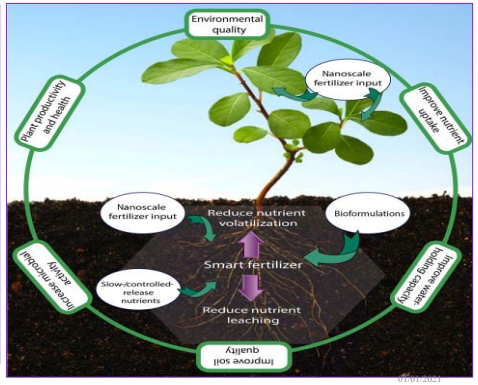
- Seed sowing at right place and right amount is very tedious in fields.
- Effective seeding requires control over two variables: **planting seeds at the correct depth**, and **spacing** plant at the appropriate distance apart to allow for optimal growth.
- Precision seeding equipments are designed to maximise these variables every time.

Pneumatic precise rice seeder and fertilizer applicator

2. PRECISION IN NUTRIENT MANAGEMENT

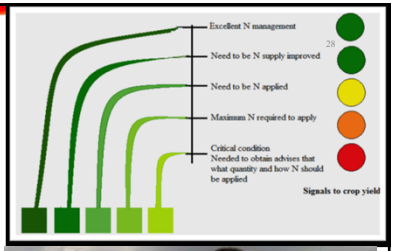
A. Smart Fertilizers: Smart fertilizers are new type of fertilizers which are formulated based on micro-organisms and nano-materials.

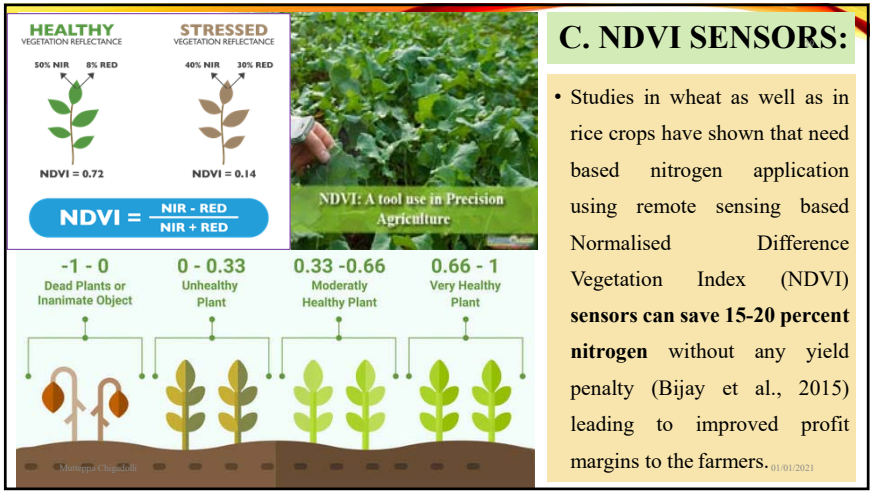
- Nanotechnology based smart fertilizers development with an emphasis on controlled- release will synchronize nutrient availability with the plant demands thereby reducing nutrient losses.
- Reduced - phosphate by 50 to 25 % and increased yields by 10 percent.
- Smart micronutrients the reduction in dose was up to 90 percent.
- Farmers' income can be raised by 15-20 percent.



B. Leaf Color chart:

- ❖ Leaf color is a fairly good indicator of the nitrogen status of plant.
- ❖ The leaf colour chart developed by International Rice Research Institute, Phillipines.
- ❖ The monitoring helps in the determination of **right time of nitrogen application**.
- ❖ The studies indicate that nitrogen can be saved from **10-15 percent** using the leaf colour chart. (Singh et al., 2015)





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 et al., 2015) leading to improved profit margins to the farmers.

D. NUTRIENT EXPERT (NE):

- NE is the recently developed precision nutrient management technology guided by **decision-support system** software for improving crop yields.
- International Plant Nutrition Institute **(IPNI) in collaboration with CIMMYT has developed a Nutrient Expert (NE),**
- It is 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.

Decision support tools help advisers develop fertilizer recommendations for a specific field or growing environment

- IPNI has developed simple software based on the principles of SSNM to help advisers develop fertilizer recommendations for a specific field or growing environment

Source: http://seap.ipni.net/articles/SEAP0059-EN

http://seap.ipni.net/articles/SEAP0059-EN

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 thresolds and guide fertilizer-N timing on irrigated rice.

Web/ Mobile based services

Connect farmers with relevant agricultural science and services

Suite of compelling services and financial products

Insurance
Input providers
Microfinance
Service providers
Marketing

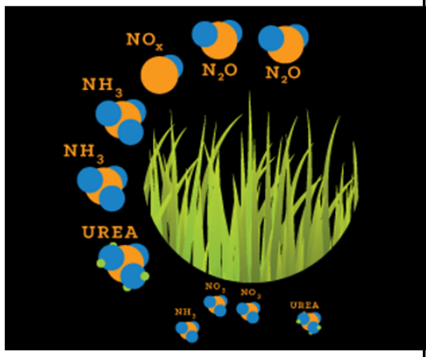
Interactive Apps --- providing management guidelines

1. Invest wisely at start of season - Crop Manager
2. Protect investment during season - Crop Doctor

→ Requires a solid business approach

E. UREA DEEP PLACEMENT (UDP):

- UDP technique, developed by the IRRI & IFDC.
- 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).



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 unfavorable 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.

3. EFFICIENT WATER MANAGEMENT PRACTICES

- Pressurized 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.

4. WEED AND PEST MANAGEMENT PRACTICES

1. **New Generation Herbicides**: Recently some post emergence new generafion 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.**
   Ex: Tembotrione in maize, Pyrazosulfuron ethyl in rice; Clodinafop + Metsulfuron methyl in wheat are found very effective to control both broad leaved and grassy weeds.

2. **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. **Ex:** Maize, Soyabean and Cotton have been engineered for glyphosate.

C. ARTIFICIAL INTELLIGENCE AND AUTOMATION IN WEED MANAGEMENT:

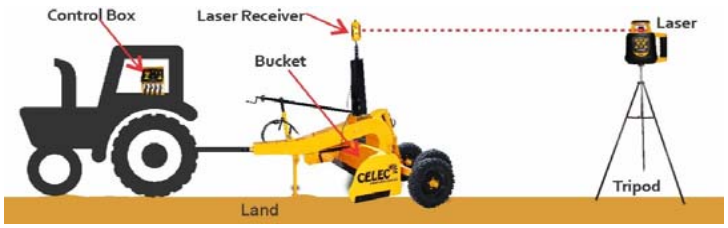
ii) Raised-bed Planting: Raised-bed planting refers to growing of crops **in row geometry** and on raised beds with furrow irrigation arrangements using a multi-crop raised bed planter. Helps in saving irrigation water by 30-40 percent.

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.

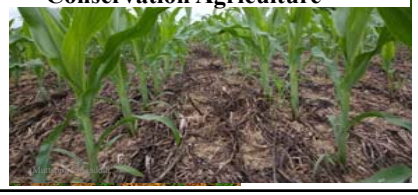
5. RESOURCE CONSERVING PRACTICES

i) Laser land levelling: 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.



6. PRACTICES FOR HIGHER PRODUCTIVITY AND PROFITABILITY

Conservation Agriculture



MULTILAYER FARMING

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- **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.
- **Example: Colocasia, Potato And Leafy Vegetable like coriander**

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

HYDROPONICS

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- **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**.
- Hydrophonics: 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 & pH METER

•**3 in 1 Soil Tester:** Measure 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 FOR SMART AGRICULTURE

LIST OF DIFFERENT SMART AGRICULTURE PRACTICES

SI. 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	Soil moisture & pH meter	Multilayer farming
4.	GIS	Expert Systems	Leaf color chart	Organic farming
5	GPS	DSS	Pneumatic planter	Mulching
6.	Smart fertilzers	M-kisaan portal	Kisan raja-Motor controller	Vertical farming
7.	Sensors	Websites	Deep thunder	IFS
8.	AIOT, Big data	Plant doctor		Raised bed planting
9.	Robots, Drones, Swarms			

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	

DATA DRIVEN TOOLS FOR SMART AGRICULTURE

TOOLS	FEATURES
Global positioning system	• 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 (clay and organic matter content) and soil conditions (relief and drainage) • 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.

TOOLS	FEATURES
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 • 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.

- MOU between GoK and Microsoft to empower **smallholder farmers** with AI-based solutions to help them increase income and **price forecasting** practices.
- **Kerala** with **Cisco** to develop the **Agri-Digital Infrastructure Platform** and provide access to e-**learning and advisory services** to farming and fishing communities in Kannur district.


Vodafone India Foundation, Nokia deploy smart agriculture solution

Our Bureau | Mumbai | Updated on December 08, 2020 | Published on December 08, 2020

The pilot project will benefit more than 50,000 farmers across 100 locations in Madhya Pradesh and Maharashtra

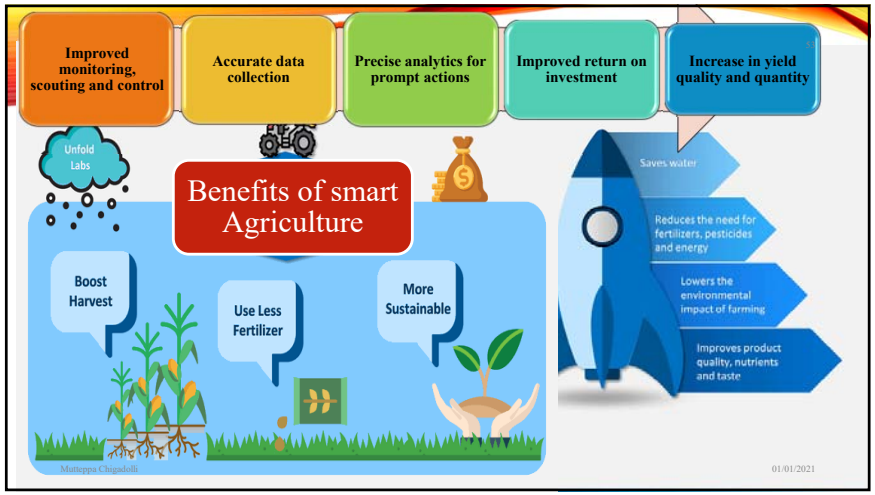
Vodafone India Foundation, Vodafone Idea Ltd's (VIL) corporate social responsibility (CSR) arm, has entered into a partnership with Finnish telecom equipment maker Nokia to deploy a smart agriculture

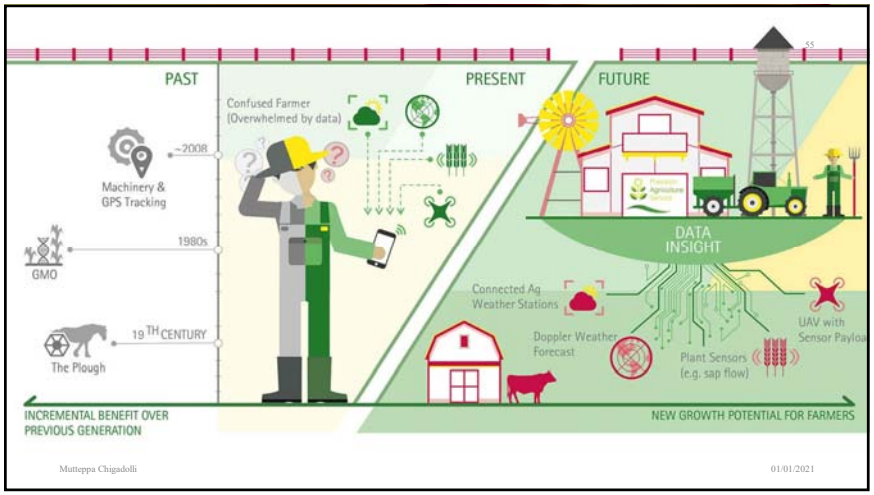
INITIATIVES OF SMART AGRICULTURE IN INDIA

- **NITI Aayog --National Strategy for Artificial Intelligence in India**, -economic growth and social inclusion.
- MOU with IBM to use **AI to secure the farming capabilities of Indian farmers-** To provide **weather forecast and soil moisture information** to farmers to take pre-informed decisions regarding better management of water, soil and crop.
- To promote innovative technologies in agriculture sector, the **AGRI-UDAAN** is launched to mentor 40 agricultural start-ups and enable them to connect with potential investors.
- **Maha Agri Tech Project in Maharashtra-** to address various risks related to cultivation such as poor rains, pest attacks, etc., and to accurately predict crop yielding.

PREDICTIVE ANALYTICS APP

- In India, 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.


Improved monitoring, scouting and control
Accurate data collection
Precise analytics for prompt actions
Improved return on investment
Increase in yield quality and quantity
Unfold Labs
Benefits of smart Agriculture
Boost Harvest
Use Less Fertilizer
More Sustainable
Saves water
Reduces the need for fertilizers, pesticides and energy
Lowers the environmental impact of farming
Improves product quality, nutrients and taste
Mutteppa Chigadolli
01/01/2021


PAST
PRESENT
FUTURE
Confused Farmer (Overwhelmed by data)
~2008
Machinery & GPS Tracking
1980s
GMO
19TH CENTURY
The Plough
DATA INSIGHT
Connected Ag Weather Stations
Doppler Weather Forecast
Plant Sensors (e.g. sap flow)
UAV with Sensor Payloa
INCREMENTAL BENEFIT OVER PREVIOUS GENERATION
NEW GROWTH POTENTIAL FOR FARMERS
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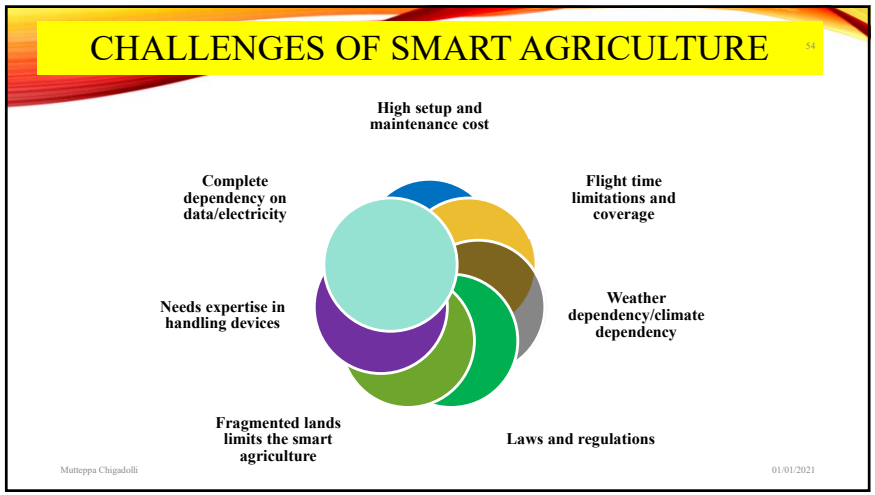
CHALLENGES OF SMART AGRICULTURE
High setup and maintenance cost
Complete dependency on data/electricity
Flight time limitations and coverage
Needs expertise in handling devices
Weather dependency/climate dependency
Fragmented lands limits the smart agriculture
Laws and regulations
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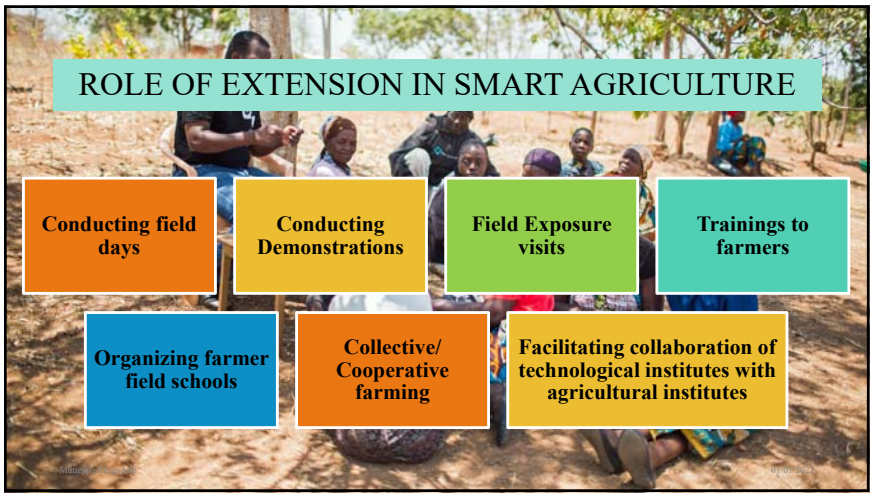

ROLE OF EXTENSION IN SMART AGRICULTURE
Conducting field days
Conducting Demonstrations
Field Exposure visits
Trainings to farmers
Organizing farmer field schools
Collective/ Cooperative farming
Facilitating collaboration of technological institutes with agricultural institutes

1. IMPACT EVALUATION STUDY OF NATIONAL MISSION ON MICRO IRRIGATION (NMMI)

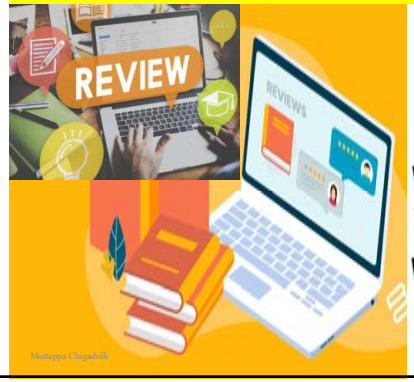
Govt. of India, (Global Agri System)

2014

13 States and 64 districts

(MH, GUJ, KTK, TN, AP, UP, BIHAR, RAJ, ODISHA, CHATTISGARH, SIKKIM, UTTARAKHAND AND HARYANA)

3. TO REVIEW THE STUDIES RELATED TO SMART AGRICULTURE



Impacts of NMMI

- Irrigation cost reduced by 20% to 50% with average of 32.3%.
- Electricity consumption reduced by about 31%.
- 28 percent reduction in total fertiliser consumption in the surveyed states.
- Average productivity of fruits and vegetables increased by about 42.3 % and 52.8%.
- Overall income enhancement of farmers was in the range of 20% to 68% with an average of 48.5%.

CASE STUDY 1. AGRIBOT: SAVING WATER AND SPRAYING PESTICIDES

Nimish Kapoor

2020

In locust outbreak areas India

- 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.
- 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.

- In conventional method 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.**
- If pesticide spraying is made mandatory by drone, about 1.5 lakh crore litres of water can be saved.
- 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.
- It takes about **3-5 minutes** for a drone to spray on **one acre of land**.
- The Agribot drone can cover **50 acres** a day with additional batteries.

CASE STUDY 3: ARTIFICIAL INTELLIGENCE BASED PILOT PROJECT IN KURNOOL

- In 2016, **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 (Nagpal, 2017).

CASE STUDY 3: MOBILE MOTOR CONTROLLER DEVICE- KISAN RAJA

- Vijay Bhaskar Reddy
- Developed an **IoT based autonomous irrigation solution**, **Mobile Motor Controller Device- Kisan Raja**
- 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.
- Kisan Raja **reduced water consumption by 30 percent** while improving land management decisions.

MOBILE MOTOR CONTROLLER DEVICE