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Precision Agriculture - Digital Technologies

GUEST COLUMN

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As crop information is increasingly tracked, digitised, and synced with other variables like soil composition and weather forecasts, thus, farm equipment and processes are becoming more agile. Commonly called precision agriculture, new technologies that harness the power of data are revolutionising that how agriculture is managed. A large group of farmers in different parts of the world are not shy about embracing new technologies. The wheel, tractors and chemical compounds in fertilizers, just a few have made a world of difference through the centuries. Yet a yawning tech gap in farming has emerged in recent decades, with real-life consequences. In our approaches to land management, resource use, labour, transportation and more, we're firmly stuck in an outdated industrial model – emphasising massive output at all costs, while ignoring externalities from environmental impact to financial repercussions and human tolls. The reality is that we have to quickly and efficiently bring farming from the industrial age into the digital one.

In recent years, technology in agriculture, also known as 'Ag-Tech' is rapidly changing the industry. In this new era, the farmer can use technology to gain control of the changing dynamics and leverage market insight without relying on traders. One of the ways governments, authorities and agriculture trading companies can help farmers is by providing access to different value-add services. To update our readers about role of digital technologies in precision agriculture, more information about the subject has been illustrated below:-

A. Digital Technologies Being Used in Precision Farming

Helping small farmers and positively impacting global issues too, smart agriculture, also known as precision agriculture, allows farmers to maximise yields using minimal resources such as water, fertilizer, and seeds. By deploying sensors and mapping fields, farmers can begin to understand their crops at a micro scale, conserve resources, and reduce impacts on the environment. Smart agriculture has roots going back to the 1980s when Global Positioning System (GPS) capability became accessible for civilian use.

Once farmers were able to accurately map their crop fields, they could monitor and apply fertilizer and weed treatments only to areas that required it. During the 1990s, early precision agriculture users adopted crop yield monitoring to generate fertilizer and pH correction recommendations. As more variables could be measured and entered into a crop model, more accurate recommendations for fertilizer application, watering, and even peak yield harvesting, could be made.

In this article, we will explore how these sensing technologies have been woven into modern large agribusiness and discuss how progression of the technology both to small farms at home as well as globally can increase our capacity to produce more to meet the needs of the increasing Indian population.

Agricultural Sensors

A number of sensing technologies are used in precision agriculture, providing data that helps farmers to monitor and optimise crops, as well as adapt to changing environmental factors.

These sensing technologies include:

- Location Sensors use signals from GPS satellites to determine latitude, longitude, and altitude to within feet. Three satellites minimum are required to triangulate a position. Precise positioning is the cornerstone of precision agriculture.

- Optical Sensors use light to measure soil properties. The sensors measure different frequencies of light reflectance in near-infrared, mid-infrared, and polarised light spectrums. Sensors can be placed on vehicles or aerial platforms such as drones or even satellites. Soil reflectance and plant colour data are just two variables from optical sensors that can be aggregated and processed. Optical sensors have been developed to determine clay, organic matter, and moisture content of the soil.

- Electrochemical Sensors provide key information required in precision agriculture: pH and soil nutrient levels. Sensor electrodes work by detecting specific ions in the soil. Currently, sensors mounted to specially designed "sleds" help gather, process, and map soil chemical data.

- Mechanical Sensors measure soil compaction or "mechanical resistance." The sensors use a probe that penetrates the soil and records resistive forces through use of load cells or strain gauges. A similar form of this technology is used on large tractors to predict pulling requirements for ground engaging equipment.

- Dielectric Soil Moisture Sensors assess moisture levels by measuring the dielectric constant (an electrical property that changes depending on the amount of moisture present) in the soil.

- Airflow Sensors measure soil air permeability. Measurements can be made at singular locations or dynamically while in motion. The desired output is the pressure required to push a predetermined amount of air into the ground at a prescribed depth. Various types of soil properties, including compaction, structure, soil type, and moisture level, produce unique identifying signatures.

Agricultural Weather Stations

Agricultural Weather Stations are self-contained units that are placed at various locations throughout growing fields. These stations have a combination of sensors appropriate for the local crops and climate. Information such as air temperature, soil temperature at a various depths, rainfall, leaf wetness, chlorophyll, wind speed, dew point temperature, wind direction, relative humidity, solar radiation, and atmospheric pressure are measured and recorded at predetermined intervals. This data is compiled and sent wirelessly to a central data logger at programmed intervals. Their portability and decreasing prices make weather stations attractive for farms of all sizes.

B. Internet of Things (IOT) and Sensors in the Field

The Internet of Things (IoT) is disrupting the agriculture industry – in a good way. In fact, there is extreme potential for using the IoT within the agriculture sector. Sensors placed strategically around fields along with image recognition technologies are allowing farmers to view their crops from anywhere in the world. These sensors send farmers up to date information in real-time, so changes can be made accordingly to their crops.

- **IoT and Sensors in Equipment:**

Much like the technology within the field, sensors are being placed on agricultural equipment to track the health of the machine and more. Some are built for yield mapping and harvest documentation, right from the cab of the implement while others are monitoring when tractors need to be serviced. All together, these sensors are reducing the amount of downtime machines experience.

- **RFID Sensors and Tracking:**

After crops are harvested, Radio Frequency Identification (RFID) sensors can be used to track production from the field to the store. The end user, or the consumer, will be able to follow a detailed trail about the food they consume from the farm it came to the location where it was purchased. This technology could increase trustworthiness for manufacturers and their responsibility to provide fresh produce and goods.

C. Smart Phone Tools

In the northern region of Ghana, an initiative delivers tailored climate information services to farmers which assist their decision making vis-à-vis climate variability. Primary users include individual farmers and traders, farmers' associations, agribusinesses, and public sector organizations such as national agricultural ministries. An online platform handles buy and sell offers, agricultural input and crop prices, extension messages, locations where seeds and fertilizers are available, among others. Users access content on the internet and on their mobile phones, choosing from a range of applications to create a personalized interface. For example, farmers can sign up to receive alerts on their mobile phones when new market prices are posted or send a request for the most recent prices.

The smart phone alone has several tools that can be adapted to farming applications. For instance, crop and soil observations can be logged in the form of snapped pictures, pinpoint locations, soil colors, water, plant leaves, and light properties. The Table below lists some in-phone tools that are useful for gathering data

Use of smart phone tools in farming:

Smart phone Tool Smart Farming Applications

Camera Provides pictures of leaf health, lighting brightness, chlorophyll measurement, and ripeness level. Also used for measuring Leaf Area

Index (LAI) and measuring soil organic and carbon makeup.

GPS Provides location for crop mapping, disease/pest location alerts, solar radiation predictions, and fertilizing.

Microphone Helps with predictive maintenance of machinery.

Accelerometer Helps determine Leaf Angle Index. Also used as an equipment

rollover alarm.

Gyroscope Detects equipment rollover.

D. Drones

An agricultural drone is an unmanned aerial vehicle applied to farming in order to help increase crop production and monitor crop growth. Sensors and digital imaging capabilities can give farmers a richer picture of their fields. How are drones currently being used in agriculture?

- They increase yields, save time, increase return on investment, are easy to use, crop health imaging, water efficiency and other environmental benefits.

- Look to the sky. Agricultural drones let farmers see their fields from the sky. This 'bird eye view' can reveal many issues such as irrigation problem, soil variation, and pest; fungal infestations. Multispectral images show a near-infrared view as well as a visual spectrum view. The combination shows the farmer the differences between healthy and unhealthy plants, a difference not always clearly visible to the naked eye. Thus, these views can assist in assessing crop growth and production.

- In agriculture, an important use for drones is thermal imaging. Multi-spectral sensors are mounted on a drone, which give farmers a valuable picture of how their crops—specifically crop canopies—perform under different growing methods. Imaging data from a drone is a good indicator of crop vigour and canopy stress.

- Additionally, the drone can survey the crops for the farmer periodically to their liking. Weekly, daily, or even hourly, pictures can show the changes in the crops over time, thus showing possible "trouble spots". Having identified these trouble spots, the farmer can attempt to improve crop management and production.

There are several types of drones say, Crop Spraying Drones, NVDI Drones, Seeding Drones, and Surveillance Drones for agriculture purpose. These drones are fully automated and can help in improving productivity.

E. Machine Learning and Analytics

Perhaps one of the most innovative pieces of the digital transformation is the ability to use machine learning and advanced analytics to mine data for trends. This can start way before the planting of the seed, with plant breeders. Machine learning can predict which traits and genes will be best for crop production, giving farmers all over the world the best breed for their location and climate.

F. You Tube for The Farm:

In Karnataka, India, providing localized knowledge through a farmer-centric peer-to-peer approach is helping enhance uptake of improved farm management technologies. Short videos created by farmers in the local language on topics relevant to neighbouring farmers are proving to be an effective dissemination strategy.

Following steps are followed in the process:-

- A content gathering team decides the videos to be produced in consultation with the farmers.

- Field staff identifies progressive farmers who have adopted the management practices to be disseminated.

- Farmer shares his/her experience about the technology on delivering climate information through mobiles

- An online platform handles buy and sell offers, agricultural input and crop prices, extension messages, locations where seeds and fertilizers are available, among others.

- Users access content on the internet and on their mobile phones, choosing from a range of applications to create a personalised interface.

- Videos are screened at small village gatherings (20-30 farmers) using battery operated portable projectors. After the screening farmer facilitator collects feedback from farmers. The feedback system also captures the adaptation rate of technologies screened earlier.

- A recent survey showed 97% of farmers willing to pay for access to climate information.

- Primary users include individual farmers and traders, farmers' associations, agribusinesses, and public sector organizations such as national agricultural ministries.

G. Robotics and Precision Farming

Much like using robots and artificial intelligence in other industries, robotics within agriculture would improve productivity and would result in higher and faster yields. Such robots like the spraying and weeding robots recently acquired by John Deere can reduce agrochemical use by an incredible 90%.

- **Applications**

Agricultural robots automate slow, repetitive and dull tasks for farmers, allowing them to focus more on improving overall production yields. Some of the most common robots in agriculture are used for harvesting and picking

- **Robot Types**

Agriculture is quickly becoming an exciting high-tech industry, drawing new professionals, new companies and new investors. The technology is developing rapidly, not only advancing the production capabilities of farmers but also advancing robotics and automation technology as we know it.

The need, at heart of this phenomenon is to increase production/ yields significantly. The UN estimates the world population will rise from 7.3 billion today to 9.7 billion in 2050. The world will need a lot more food clothes, and farmers will face serious pressure to keep up with demand.

Agricultural robots are increasing production yields for farmers in various ways. From drones to autonomous tractors to robotic arms, the technology is being deployed in creative and innovative applications.

- **Agricultural Robot Applications**

Some of the most common robots in agriculture are used for harvesting and picking of cotton, weed control, autonomous mowing, pruning, seeding, spraying, thinning, pheno-typing, sorting, packing and utility platforms.

Harvesting and picking is one of the most popular robotic applications in agriculture due to the accuracy and speed that robots can achieve to improve the size of yields and reduce waste from crops being left in the field. These applications can be difficult to automate, however. Harvesting and picking robots are becoming very popular among farmers, but there are dozens of other innovative ways the agricultural industry is deploying robotic automation to improve their production yields.

The demand for food and clothing is outpacing available farmland and it's up to farmers to close this gap. Agricultural robots are helping them do just that. Agriculture has quickly become a high-tech business. If you want to learn more about emerging robotics industries, join companies like Amazon, Microsoft and GM at the annual A3 Business Forum to network with leaders in the automation industry

H. How Artificial Intelligence (AI) is Used in Agriculture?

AI-driven technologies are emerging to help improve efficiency and to address challenges facing the industry including, crop yield, soil health and herbicide- resistance. Agricultural robots are poised to become a highly valued application of AI in this sector.

Artificial Intelligence in the Agricultural Industry – Insights Up Front

Based on our research, the most popular applications of AI in agriculture appear to fall into three major categories:

- Agricultural Robots – Companies are developing and programming autonomous robots to handle essential agricultural tasks such as harvesting crops at a higher volume and faster pace than human laborers.

- Crop and Soil Monitoring – Companies are leveraging computer vision and deep-learning algorithms to process data captured by drones and/or software-based technology to monitor crop and soil health.

- Predictive Analytics – Machine learning models are being developed to track and predict various environmental impacts on crop yield such as weather changes.

I. Revolutionising Agriculture Through Information and Communication Technologies (ICTS):-

Over the last few decades, massive technological development and opportunities have transformed people's lives. However, these opportunities have not benefited the agriculture sector in a significant way. Farmers and various other actors along the agriculture value chain need significant amounts of information. Information and Communication Technologies (ICTs) will play a key role in knowledge exchange, targeted recommendations, market integration and access to finance to make agriculture a profitable enterprise and attractive for the youth. Digital Agriculture is "ICT and data ecosystems to support the development and delivery of timely, targeted information and services to make farming profitable and sustainable while delivering safe nutritious and affordable food for all.

Globally, a large number of technologies are available for the improvement of agriculture/ cotton. Use of such technologies, their efficiency and suitability under Indian condition is a big question mark. A separate article has been published on Precision Farming and Indian Cotton Farmers giving an overview of the situation.

(The views expressed in this column are of the author and not that of Cotton Association of India)

UPCOUNTRY SPOT RATES

(Rs./Qtl)

Standard Descriptions with Basic Grade & Staple in Millimetres based on Upper Half Mean Length [By law 66 (A) (a) (4)]								Spot Rate (Upcountry) 2018-19 Crop November 2019					
Sr. No.	Growth	Grade Standard	Grade	Staple	Micronaire	Gravimetric Trash	Strength /GPT	18th	19th	20th	21st	22nd	23rd
1	P/H/R	ICS-101	Fine	Below 22mm	5.0 – 7.0	4%	15	- -	- -	- -	- -	- -	- -
2	P/H/R (SG)	ICS-201	Fine	Below 22mm	5.0 – 7.0	4.5%	15	- -	- -	- -	- -	- -	- -
3	GUJ	ICS-102	Fine	22mm	4.0 – 6.0	13%	20	8970 (31900)	8970 (31900)	8970 (31900)	8970 (31900)	8970 (31900)	8970 (31900)
4	KAR	ICS-103	Fine	23mm	4.0 – 5.5	4.5%	21	10292 (36600)	10292 (36600)	10292 (36600)	10292 (36600)	10292 (36600)	10292 (36600)
5	M/M (P)	ICS-104	Fine	24mm	4.0 – 5.5	4%	23	10714 (38100)	10714 (38100)	10714 (38100)	10714 (38100)	10714 (38100)	10714 (38100)
6	P/H/R(U)(SG)	ICS-202	Fine	27mm	3.5 – 4.9	4.5%	26	- -	- -	- -	- -	- -	- -
7	M/M(P)/ SA/TL	ICS-105	Fine	26mm	3.0 – 3.4	4%	25	10264 (36500)	10264 (36500)	10264 (36500)	10264 (36500)	10264 (36500)	10264 (36500)
8	P/H/R(U)	ICS-105	Fine	27mm	3.5 – 4.9	4%	26	- -	- -	- -	- -	- -	- -
9	M/M(P)/ SA/TL/G	ICS-105	Fine	27mm	3.0 – 3.4	4%	25	10376 (36900)	10376 (36900)	10376 (36900)	10376 (36900)	10376 (36900)	10376 (36900)
10	M/M(P)/ SA/TL	ICS-105	Fine	27mm	3.5 – 4.9	3.5%	26	10545 (37500)	10545 (37500)	10545 (37500)	10545 (37500)	10545 (37500)	10545 (37500)
11	P/H/R(U)	ICS-105	Fine	28mm	3.5 – 4.9	4%	27	- -	- -	- -	- -	- -	- -
12	M/M(P)	ICS-105	Fine	28mm	3.5 – 4.9	3.5%	27	- -	- -	- -	- -	- -	- -
13	SA/TL	ICS-105	Fine	28mm	3.8 – 4.2	3.5%	27	- -	- -	- -	- -	- -	- -
14	GUJ	ICS-105	Fine	28mm	3.8 – 4.2	3%	27	- -	- -	- -	- -	- -	- -
15	R(L)	ICS-105	Fine	29mm	3.7 – 4.9	3.5%	28	- -	- -	- -	- -	- -	- -
16	M/M(P)	ICS-105	Fine	29mm	3.8 – 4.2	3.5%	28	- -	- -	- -	- -	- -	- -
17	SA/TL/K	ICS-105	Fine	29mm	3.8 – 4.2	3%	28	- -	- -	- -	- -	- -	- -
18	GUJ	ICS-105	Fine	29mm	3.8 – 4.2	3%	28	- -	- -	- -	- -	- -	- -
19	M/M(P)	ICS-105	Fine	30mm	3.8 – 4.2	3.5%	29	- -	- -	- -	- -	- -	- -
20	SA/TL/K/O	ICS-105	Fine	30mm	3.8 – 4.2	3%	29	- -	- -	- -	- -	- -	- -
21	M/M(P)	ICS-105	Fine	31mm	3.8 – 4.2	3%	30	- -	- -	- -	- -	- -	- -
22	SA/TL/K / TN/O	ICS-105	Fine	31mm	3.8 – 4.2	3%	30	- -	- -	- -	- -	- -	- -
23	SA/TL/K/ TN/O	ICS-106	Fine	32mm	3.5 – 4.9	3%	31	- -	- -	- -	- -	- -	- -
24	M/M(P)	ICS-107	Fine	34mm	3.0 - 3.8	4%	33	- -	- -	- -	- -	- -	- -
25	K/TN	ICS-107	Fine	34mm	3.0 - 3.8	3.5%	33	- -	- -	- -	- -	- -	- -

(Note: Figures in bracket indicate prices in Rs./Candy)

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Sr. No.	Growth	Grade Standard	Grade	Staple	Micronaire	Gravimetric Trash	Strength /GPT	18th	19th	20th	21st	22nd	23rd
1	P/H/R	ICS-101	Fine	Below 22mm	5.0 – 7.0	4%	15	10686 (38000)	10686 (38000)	10686 (38000)	10686 (38000)	10686 (38000)	10686 (38000)
2	P/H/R (SG)	ICS-201	Fine	Below 22mm	5.0 – 7.0	4.5%	15	10826 (38500)	10826 (38500)	10826 (38500)	10826 (38500)	10826 (38500)	10826 (38500)
3	GUJ	ICS-102	Fine	22mm	4.0 – 6.0	13%	20	- -	- -	- -	- -	- -	- -
4	KAR	ICS-103	Fine	23mm	4.0 – 5.5	4.5%	21	- -	- -	- -	- -	- -	- -
5	M/M (P)	ICS-104	Fine	24mm	4.0 – 5.5	4%	23	- -	- -	- -	- -	- -	- -
6	P/H/R(U)(SG)	ICS-202	Fine	27mm	3.5 – 4.9	4.5%	26	10292 (36600)	10320 (36700)	10320 (36700)	10348 (36800)	10348 (36800)	10348 (36800)
7	M/M(P)/ SA/TL	ICS-105	Fine	26mm	3.0 – 3.4	4%	25	- -	- -	- -	- -	- -	- -
8	P/H/R(U)	ICS-105	Fine	27mm	3.5 – 4.9	4%	26	10432 (37100)	10461 (37200)	10461 (37200)	10489 (37300)	10489 (37300)	10489 (37300)
9	M/M(P)/ SA/TL/G	ICS-105	Fine	27mm	3.0 – 3.4	4%	25	- -	- -	- -	- -	- -	- -
10	M/M(P)/ SA/TL	ICS-105	Fine	27mm	3.5 – 4.9	3.5%	26	- -	- -	- -	- -	- -	- -
11	P/H/R(U)	ICS-105	Fine	28mm	3.5 – 4.9	4%	27	10489 (37300)	10517 (37400)	10489 (37300)	10517 (37400)	10517 (37400)	10517 (37400)
12	M/M(P)	ICS-105	Fine	28mm	3.5 – 4.9	3.5%	27	11107 (39500)	11079 (39400)	11079 (39400)	11079 (39400)	11079 (39400)	11079 (39400)
13	SA/TL	ICS-105	Fine	28mm	3.8 – 4.2	3.5%	27	11107 (39500)	11079 (39400)	11079 (39400)	11079 (39400)	11079 (39400)	11079 (39400)
14	GUJ	ICS-105	Fine	28mm	3.8 – 4.2	3%	27	11079 (39400)	11051 (39300)	11051 (39300)	11051 (39300)	11051 (39300)	11051 (39300)
15	R(L)	ICS-105	Fine	29mm	3.7 – 4.9	3.5%	28	10995 (39100)	10995 (39100)	10995 (39100)	10995 (39100)	10995 (39100)	10995 (39100)
16	M/M(P)	ICS-105	Fine	29mm	3.8 – 4.2	3.5%	28	11445 (40700)	11417 (40600)	11417 (40600)	11417 (40600)	11417 (40600)	11417 (40600)
17	SA/TL/K	ICS-105	Fine	29mm	3.8 – 4.2	3%	28	11389 (40500)	11360 (40400)	11360 (40400)	11360 (40400)	11360 (40400)	11360 (40400)
18	GUJ	ICS-105	Fine	29mm	3.8 – 4.2	3%	28	11332 (40300)	11304 (40200)	11304 (40200)	11304 (40200)	11304 (40200)	11304 (40200)
19	M/M(P)	ICS-105	Fine	30mm	3.8 – 4.2	3.5%	29	11557 (41100)	11529 (41000)	11529 (41000)	11529 (41000)	11529 (41000)	11529 (41000)
20	SA/TL/K/O	ICS-105	Fine	30mm	3.8 – 4.2	3%	29	11501 (40900)	11473 (40800)	11473 (40800)	11473 (40800)	11473 (40800)	11473 (40800)
21	M/M(P)	ICS-105	Fine	31mm	3.8 – 4.2	3%	30	11726 (41700)	11698 (41600)	11698 (41600)	11698 (41600)	11698 (41600)	11698 (41600)
22	SA/TL/K / TN/O	ICS-105	Fine	31mm	3.8 – 4.2	3%	30	11670 (41500)	11642 (41400)	11642 (41400)	11642 (41400)	11642 (41400)	11642 (41400)
23	SA/TL/K/ TN/O	ICS-106	Fine	32mm	3.5 – 4.9	3%	31	12063 (42900)	12035 (42800)	12035 (42800)	12035 (42800)	12035 (42800)	12035 (42800)
24	M/M(P)	ICS-107	Fine	34mm	3.0 - 3.8	4%	33	14904 (53000)	14875 (52900)	14875 (52900)	14875 (52900)	14875 (52900)	14875 (52900)
25	K/TN	ICS-107	Fine	34mm	3.0 - 3.8	3.5%	33	15129 (53800)	15129 (53800)	15129 (53800)	15129 (53800)	15129 (53800)	15129 (53800)

(Note: Figures in bracket indicate prices in Rs./Candy)