Smart Farming powered by Analytics

The future of agriculture in India

Contents

1. Indian Agricultural Sector

On the face of it, the Indian agricultural sector presents some staggering numbers. It provides livelihood to 58% of India's population with a Gross Value Addition of 265.51 billion USD (agriculture, forestry & fishing combined)[1]. At 283.37 tons, India had a record production of food grains in 2018-19[1].

While these numbers may seem impressive on an absolute basis, they fail to promise if we delve a little deeper. Although this sector employs (directly/indirectly) about 58% of the population, it contributes only about 15.87% to the country's GDP[2]. This brings us to a key parameter, that is, agricultural productivity. The most popular metric to measure agricultural productivity is Agricultural Value Added per Worker. A comparison of the top 20 economies on this metric reveals that India's agricultural productivity has great scope of improvement (Illustrated in Figure 1).

All the countries with the lowest agricultural value added per worker are mostly developing/ underdeveloped economies with high population densities viz. India, Indonesia, China, etc.

India fares the lowest amongst the top 20 economies (by GDP) in terms of agricultural value added per worker. Clearly, there are certain problems that need to be addressed. Now, let us look at the key problems faced by the Indian agricultural sector.

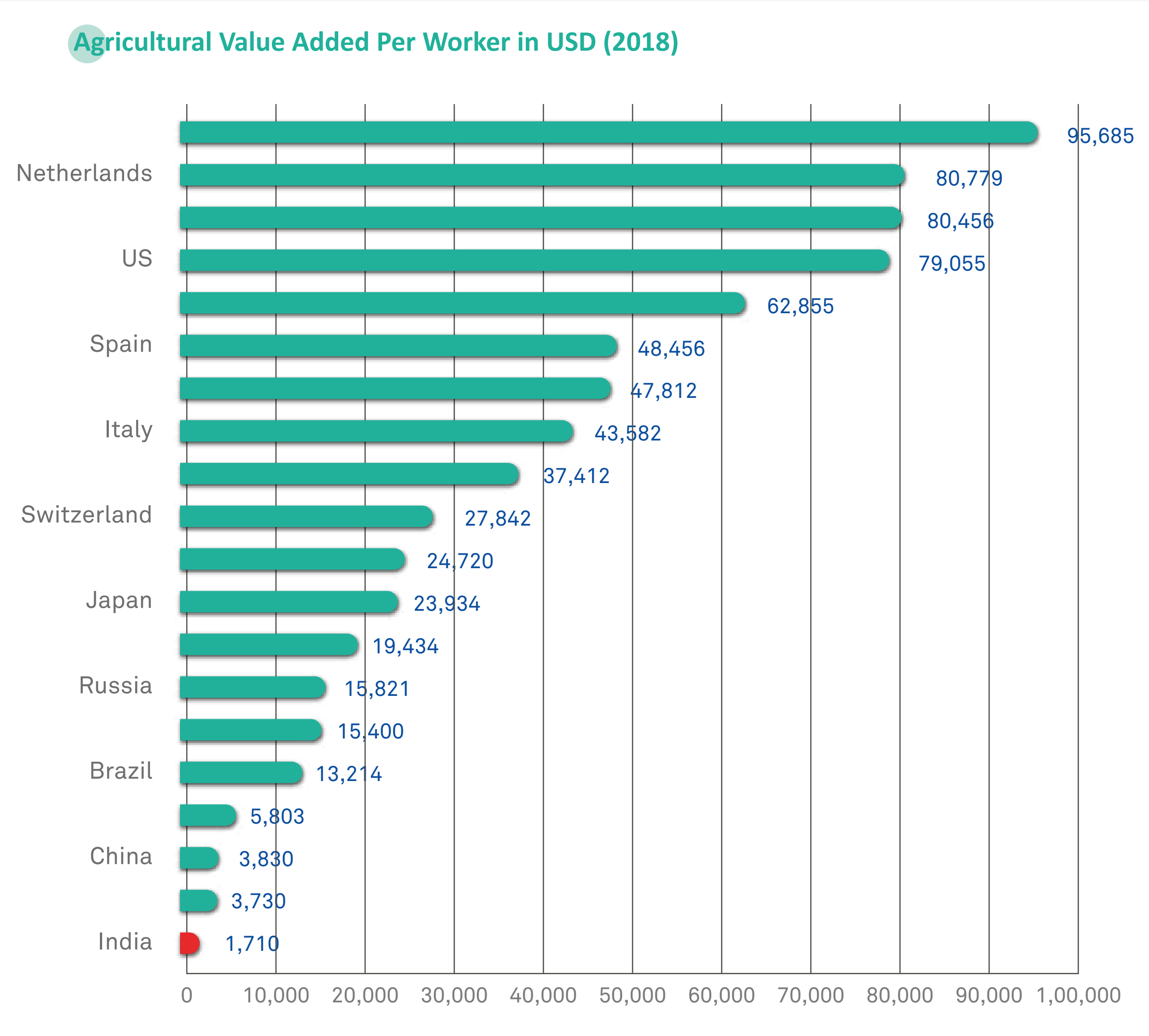


Figure 1: Agricultural Value Added Per Worker* (2018)

1.1 Key problems faced by the Indian Agricultural Sector

A number of factors curtails India's agricultural output – while some of them are systemic or historical in nature, the others are environmental or technological (See Figure 2). The systemic factors have evolved over centuries of agricultural activity dating back to ancient times while the geographical features of agrarian land and weather patterns primarily dictate the environmental factors. The technological factors have emerged primarily due to lack of advancement of agricultural techniques, and affordability of machinery and equipment. Let us look at all these factors one by one:

Systemic factors

a. **Cropping pattern:** In many areas, continued application of obsolete cropping patterns inhibits agricultural productivity. Practices like mono-cropping not only lead to lesser output but also lead to soil degradation.

b. **Land ownership/ Fragmented land holdings:** The average size of land holding in India is less than 2 hectares. This makes it difficult to achieve economies of scale and introduce new technologies and machinery

c. **Land tenure:** Due to absentee landlordism (despite the abolished zamindari system), the tenure of land holdings for farmers is not secure. This makes it an adverse environment for the application of modern farming techniques, crop rotation, etc.

d. **Agricultural credit:** There is lack of systematic financing provisioning for farmers. Co-operatives and other financial institutions have not been able to eliminate village money lenders who lend money at exorbitant interest rates, thereby making finance unaffordable for farmers.

Environmental factors

a. **Erratic Monsoon:** One of the key factors influencing agricultural productivity in India is the unpredictable behavior of monsoons. This problem is aggravated due to the lack of irrigation facilities across India.

b. **Soil infertility:** Increasing pressure on agricultural land in India has led to overuse of fertilizers, increase in tillage, abandonment of traditional organic soil revival techniques and insufficient rotation of crops. This has resulted in soil degradation and loss of fertility.

c. **Water sources:** Water sources are not effectively linked to fulfill demand for irrigation to all farming areas.

d. **Topography:** The diverse topography of India's land makes it essential to identify the right crops for the various soil variants and climatic conditions.

Technological Factors

a. **Lack of farm equipment:** Farm mechanization in India is low despite growth over the decades. A good measure to gauge mechanization is power availability per hectare, which is low in India.

b. **Lack of new farming techniques:** Due to lack of awareness regarding new farming techniques and over-adherence to old traditional ways of agriculture, farmers in India have not been successful in widely adopting new farming techniques.

c. **Lack of water supply:** There is lack of efficient ways of water supply for irrigation. Groundwater supplies more than half of India's demand for irrigation mostly by flooding through open channels. This, however, is an inefficient means of water supply as it leads to depletion of the water table. 39% of wells in India are already showing decrease in ground water levels .

d. **Lack of storage facilities:** Even if production factors are enhanced, lack of storage facilities inhibits production. Estimates suggest that about 1.35 billion USD worth of food grains are wasted in India every year due to lack of storage facilities .

Other factors

a. **Lack of agriculture marketing:** A number of factors lead to the unorganized nature of the agricultural industry, for example, the small scale of operations managed by small households, over-dependence on monsoon and other natural water sources, etc. This makes proper marketing of Indian agricultural products difficult.

b. **Agriculture pricing:** Unlike other industries, here, the farmer is more often a price taker rather than being the price maker. This is because of the ownership contracts, people involved in logistics as well as other intermediaries. Illiteracy among farmers is also a key factor that makes it difficult for farmers to get a fair value for their produce.

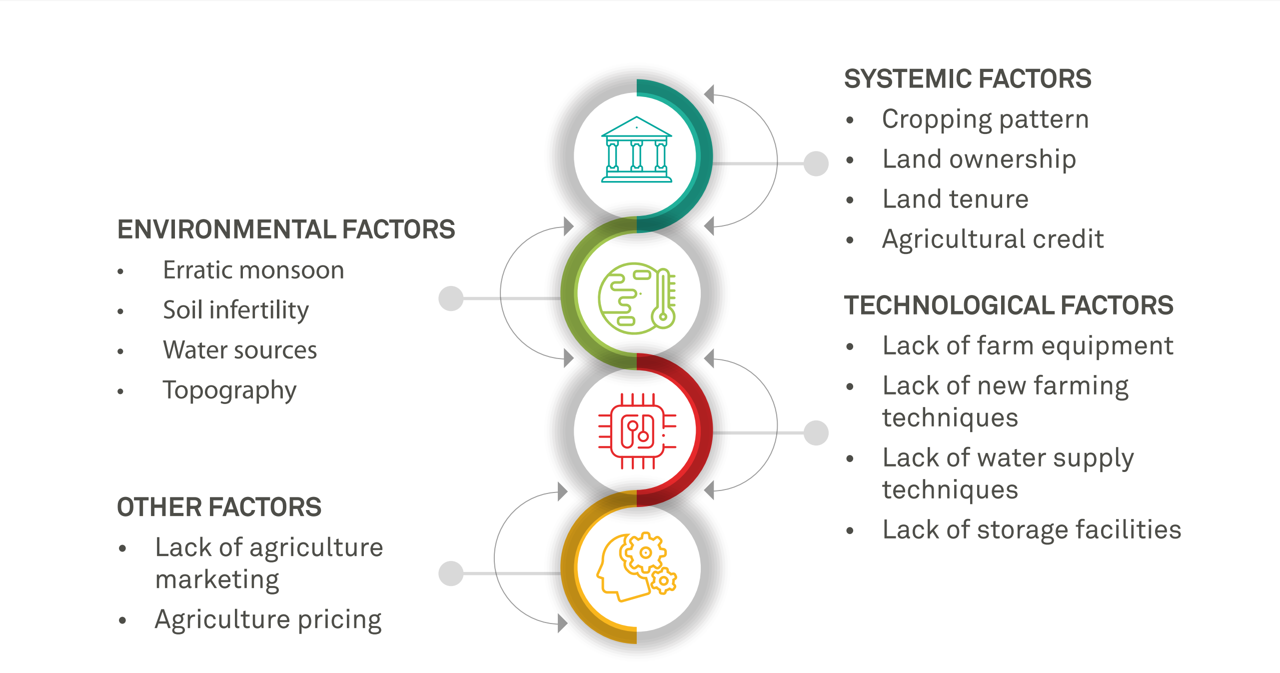


Figure 2: Factors curtailing India's agriculture

Typically, in the Indian context, a single rural household with all its members are dependent on farming as their single source of livelihood. In such a scenario, it becomes even more necessary to tackle the above-mentioned problems with a comprehensive strategy. While addressing most of these factors need policy interventions, but tackling some of them can be easier through the adoption of Analytics & Smart Farming.

In the subsequent sections, we will explore Smart Farming, and how it can alleviate some of the problems discussed above, with the power of Analytics in conjunction with IoT & Cloud.

2. Smart Farming

Smart Farming refers to the application of modern Information and Communication Technologies (ICT) in agriculture. It promises to revolutionize the world of agriculture through the application of solutions such as Internet of Things (IoT), actuators and sensors, geo-positioning systems, drones or unmanned aerial vehicles (UAVs), precision equipment, robotics, etc. backed and powered by technologies such as Big Data, Analytics and Cloud.

Smart Farming has a real potential to deliver more efficient and sustainable agricultural production, through data-driven insights and decisions, and better resource management.

From the farmer's point of view, Smart Farming will provide the farmer the means for better decision making and more efficient operations and management. Smart farming is associated to three fields of technology, which are inter-related:

- **Management Information Systems:** Systems for collecting, processing, storing, and sharing data in a suitable form to carry out a farm's operations and functions.
- **Precision Agriculture:** Management of the vagaries of weather, soil and other environmental conditions as well as demand scenarios to improve economic returns following the use of inputs and reduce environmental impact. It employs Decision Support Systems (DSS) for farm management in order to optimize returns while preserving resources. - enabled by technologies like global positioning system (GPS), global navigation satellite system (GNSS), images captured by drones or unmanned aerial vehicles and hyperspectral images captured by satellites. This helps in the creation of maps depicting how several parameters spatially vary. (e.g. farm yield, organic matter content, soil moisture and nitrogen levels, terrain, etc.).
- **Agricultural Automation and Robotics:** Another aspect of smart farming that deals with application of robotics, automatic control and artificial intelligence (AI) at various levels of agricultural production, including farm bots and farm drones.

As is evident from its very definition, Smart Farming is closely interlinked with IoT, cloud & analytics. IoT is one of the pillars of smart farming. Primarily, it's utility lies in generating data from various sources pertaining to environmental conditions, seed quality and quantity etc. However, amongst all its use cases, four of them are most prominent (Shown in Figure 3):

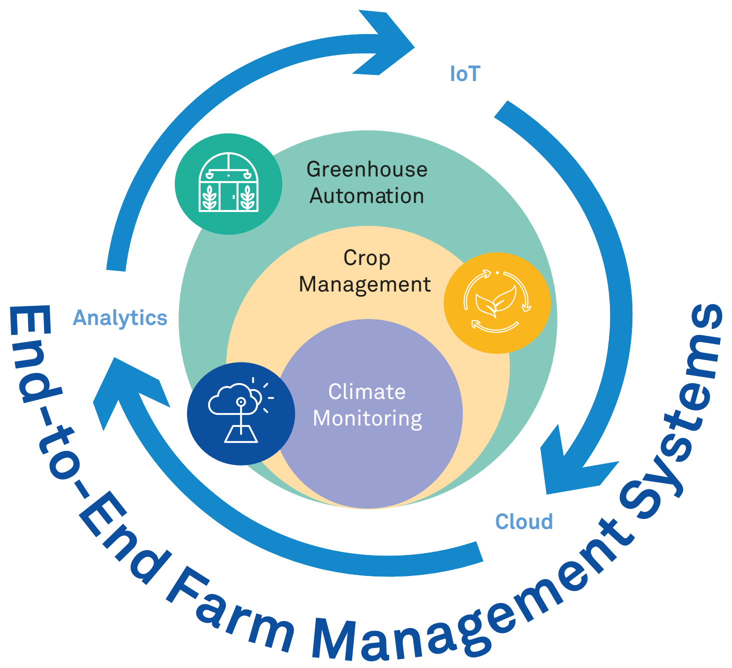


Figure 3: IoT & Smart Farming

- **Climate Monitoring:** Weather stations are formed with the combination of several smart farming sensors. They are placed across the field to gather data from the environment and send the same to the cloud. The parameters measured are used to understand climate conditions, select appropriate crops, and then respond appropriately for improvement. Examples of such IoT devices are allMETEO, Smart Elements, and Pycno.

- **Greenhouse Automation:** In addition to gathering data, greenhouse automation systems can automatically adjust conditions according to set parameters. Examples are Farmapp, Growlink, GreenIQ, etc.

- **Crop Management:** There are IoT devices placed in the field to collect data specific to crops, such as temperature, moisture content, leaf water potential, etc. They help to gauge overall crop health and detect any anomalies to prevent diseases. Examples are Arable and Semios.

- **E2E Farm Management Systems:** Generally, such systems include several IoT devices and sensors, installed on the premises and additionally, a powerful dashboard with in-built analytics and accounting/reporting features. Thus, they enable remote farm monitoring capabilities and streamlining of business operations. Examples are FarmLogs and Cropio.

Some other applications of IoT in agriculture include vehicle tracking, storage management and logistics, among others.

As far as cloud in Smart Farming is concerned, it primarily serves purposes like managing data storage, data visualization, data processing applications, data center allotment for analysis and front-end interface for farmers to view the field condition. If we look at a high-level architecture of a simple smart farming system (See Figure 4), it is best to envision a three-layered architecture, with the bottom layer being the front-end layer for sensors and other IoT devices to collect data from the field and crops. In-between there must be a gateway layer composed of microcontrollers connected to the other two layers through internet (WiFi) and responsible for being the communication link between the front-end and the back end layer.

However, the use of cloud in conjunction with IoT devices that are spread across the field, is fraught with certain challenges from three standpoints: data security during transfer of data back and forth between the IoT devices and the cloud, processing speed while doing so, and lastly but most importantly, the cost of cloud computing and bandwidth.

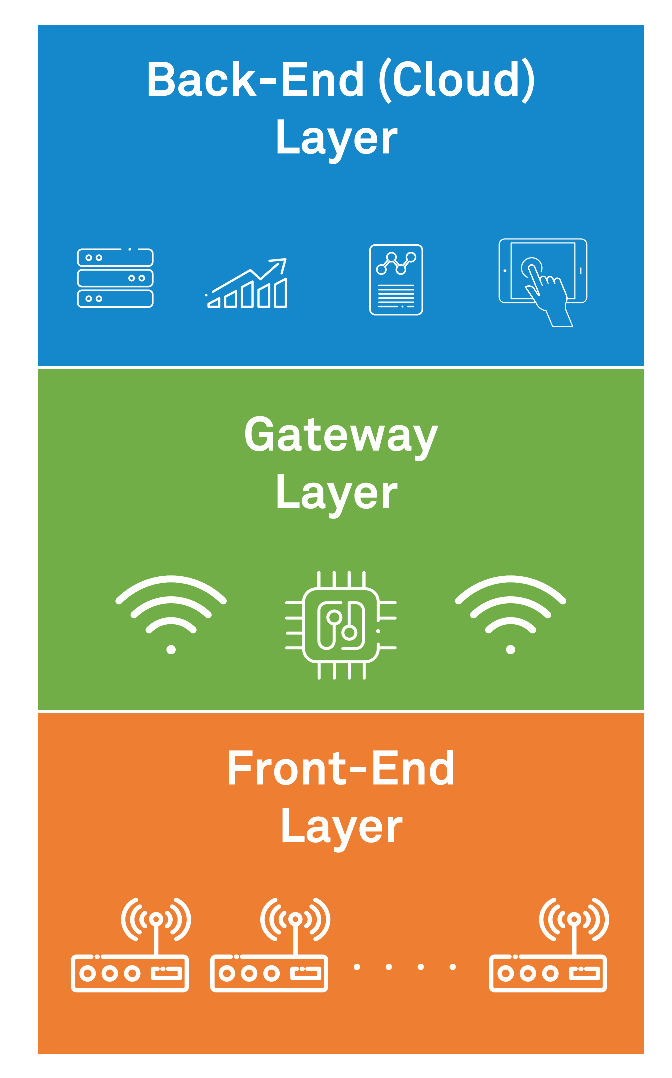


Figure 4: High-level architecture of a Smart Farm

Edge Analytics and Computing is a promising alternative to cloud as it tackles all of the three above-mentioned challenges by eliminating the need for all the data to be transferred to the cloud and back. This reduces cloud-computing costs, additionally, edge analytics and computing enhances network efficiency, which leads to increase in processing speed.

2.1. Role of Analytics in Smart Farming

Analytics has a wide span of use cases and application areas across the agricultural value chain. However, for the sake of simplicity, we will confine our discussion only to crop production and agricultural financing and insurance.

Analytics solutions leverage Big data, IoT, Cloud Computing and GPS technologies to generate relevant data, which in turn is used to derive actionable insights. This helps farmers and financial corporations make better data-driven decisions.

To unlock the power of analytics, basic information from Management Information Systems should be requisitioned. This will ultimately help in driving precision agriculture and better decision making to realize benefits. The framework given in Figure 5 describes Analytics-enabled Smart Farming and its benefits.

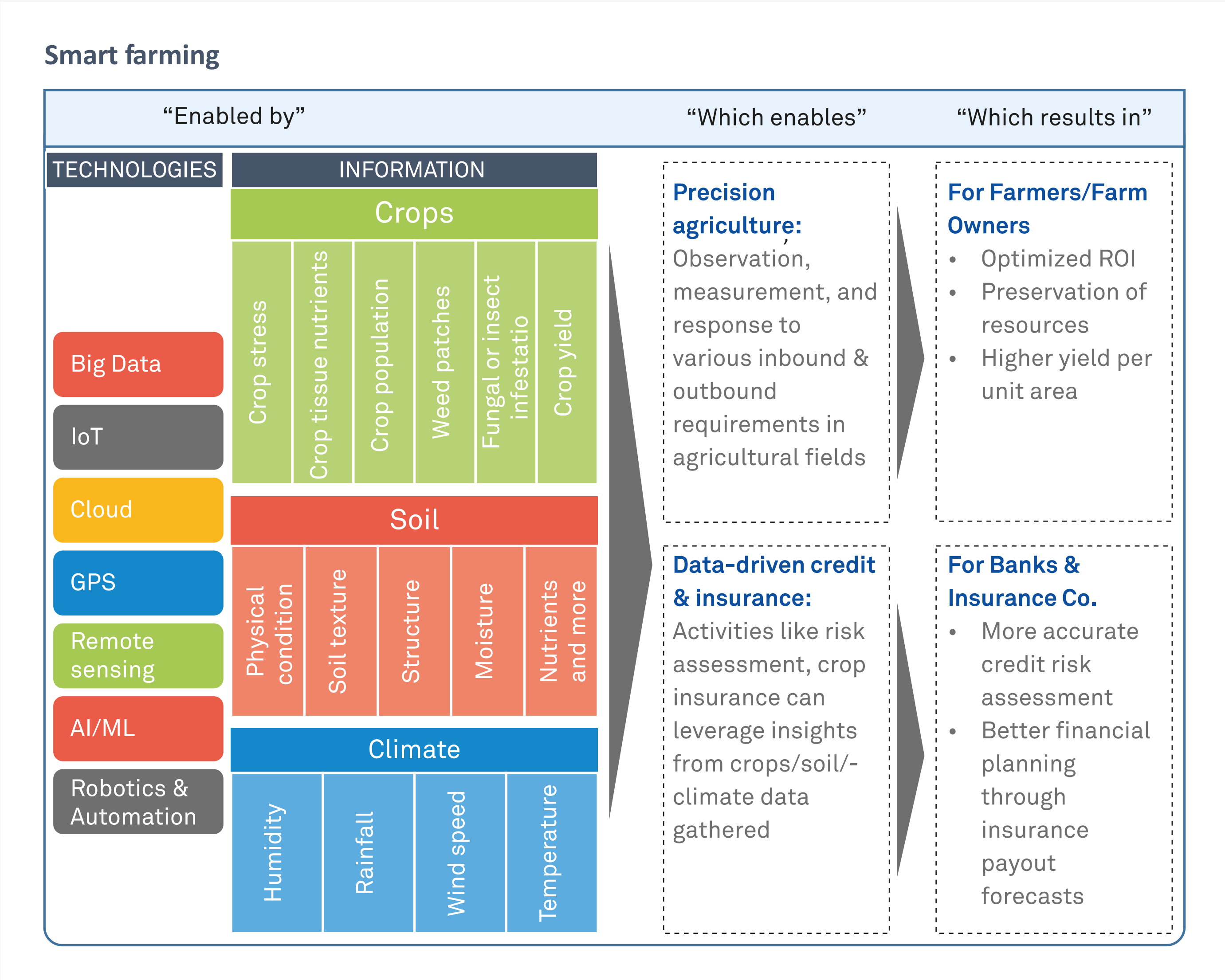


Figure 5: Role of Analytics in Smart Farming

But to fully realize Smart Farming objectives, a plethora of skills within analytics – across the data lifecycle will be necessary viz. data capture, storage, transfer, transformation and analytics, and data driven marketing (See Figure 6).benefits.

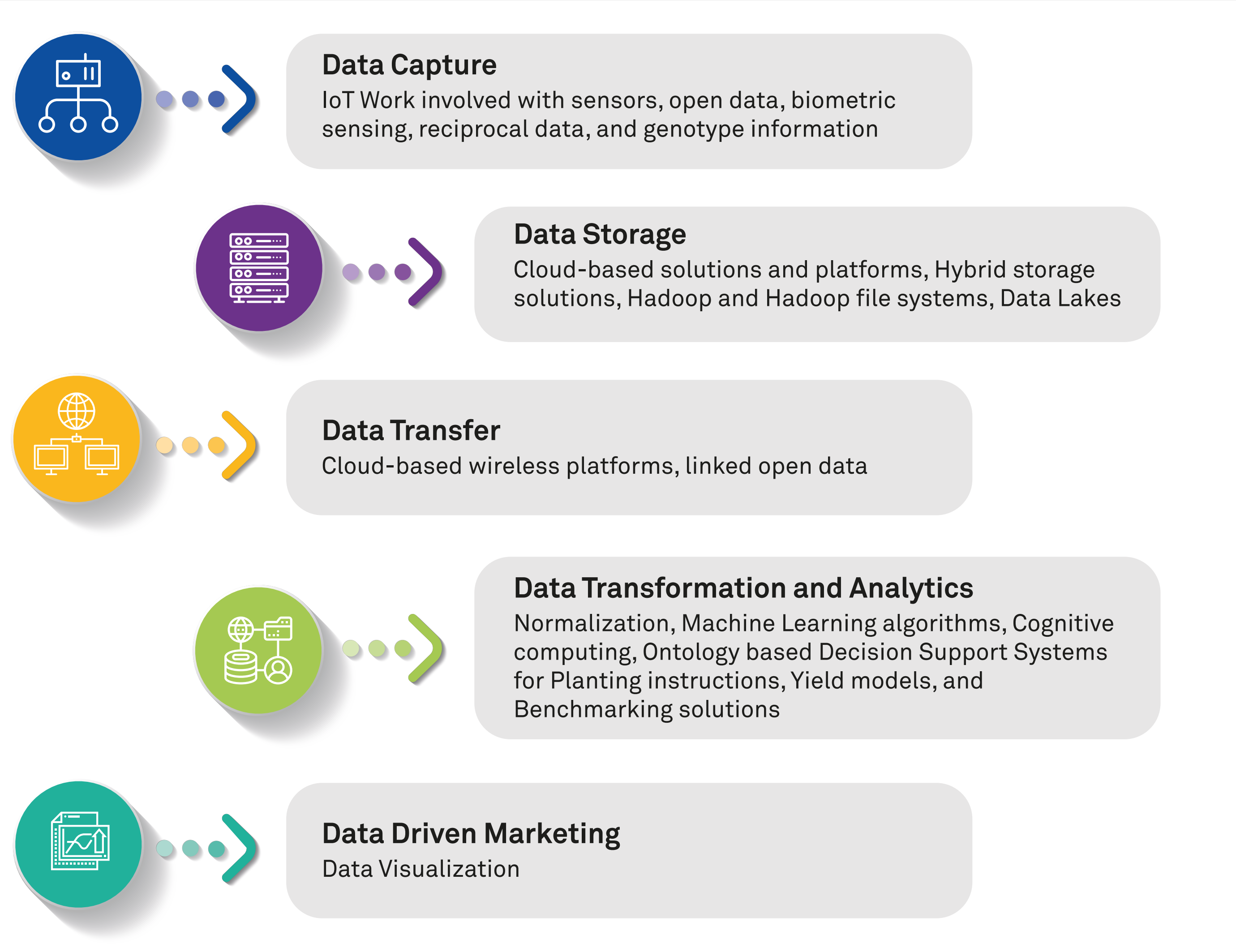


Figure 6: Analytics skills relevant for Smart Farming

2.2 Use cases of Analytics in Smart Farming

Analytics in smart farming has a number of use cases in conjunction with IoT– some of which are:

- Remotely monitor farm equipment and their performance
- Analytics to monitor farm processes and improve efficiency
- Predictive Analytics for accurate weather forecast
- Predictive Analytics for crop yield forecast
- Analytics for determining farmers' credit score or possible crop insurance payout based on crop yield predictions

2.3 Analytics in every step of the farming cycle

- Crop selection: Sensors on the field can provide granular data on soil and weather conditions, water content, fertilizer/manure requirement and pest infestations. Using this data, farmers can make the right crop selection
- Land preparation: Preparing the land through tractors and ploughing equipment can be made easier through GPS-enabled tractors and trucks. This will help in optimizing the usage of heavy equipment.
- Seed selection: This can be done more effectively taking into account the data from sensors about the soil health, weather, water content, pest data and also fertilizer/manure content and requirement. Predictive analytics can also help select the best seeds for the given environmental and economic factors.
- Seed sowing: The time and process for seed-sowing is determined by the type of seed, weather, and soil and water conditions. Data regarding all of the above factors collected through sensors and smart devices can help in performing seed sowing more economically and optimally.
- Irrigation: It is also a function of crop type, soil type, water content, and previous and present weather conditions as well as forecast. Such data can aid in optimizing the irrigation process as needed.
- Crop growth: Analytics can help in running diagnostics to monitor crop growth as and when required. Corrective measures can be taken if deviations are detected through the analysis.
- Fertilization/ Manuring: Nutrient content of the soil as well as the requirement should be known for proper fertilization/manuring. Data analytics helps in making relevant inputs available to the farmers for decision making regarding the choice and frequency of usage of fertilizers/manure.
- Harvesting: This process involves machines and heavy equipment. The operations of these machines can be optimized through data analytics.

3. Putting it altogether – 'Smart Farm Operating Model'

A highly effective Smart Farm Operating Model is illustrated in Figure 7. The day-to-day monitoring and control of crop and environmental parameters affecting the crop, plus the regular data-driven crop planning is classified into the core Smart Farm operations, while other ancillary activities associated with the farm such as marketing, inbound/outbound logistics, and crop finance and insurance are bucketed into 'other Smart Farm operations'. Together, these two buckets constitute what we perceive as a Smart Farm ecosystem.

Typically, there would be sensors and IoT devices placed across the field to collect environmental and crop health parameters which would be relayed to the data cloud via a gateway. The data cloud, is primarily responsible for data storage, processing and analytics. Reporting dashboards allow farmers/decision makers view the data and key insights. At an immediate level, this can help them use a User Interface or an app to trigger on-field smart devices like actuators/motors or temperature controllers. At a macro level, analytics helps them use the production data, the environmental data along with demand data to plan for the future.

Given the wealth of data that the on-field sensors provide, when demand related data is added to it, it can help reveal more insights, which are relevant for the marketing function. This data is also relevant for inbound logistics (supply, procurement as well as storage of seeds, fertilizers, manure, etc.) as well as outbound logistics (distribution to the market). Basically, it helps enable decisions on when to store and when to sell. Last but not the least, the plethora of production, climate, crop health and demand data and insights can help financial institutions and insurance companies gauge risks better to come up with better propositions for farmers.

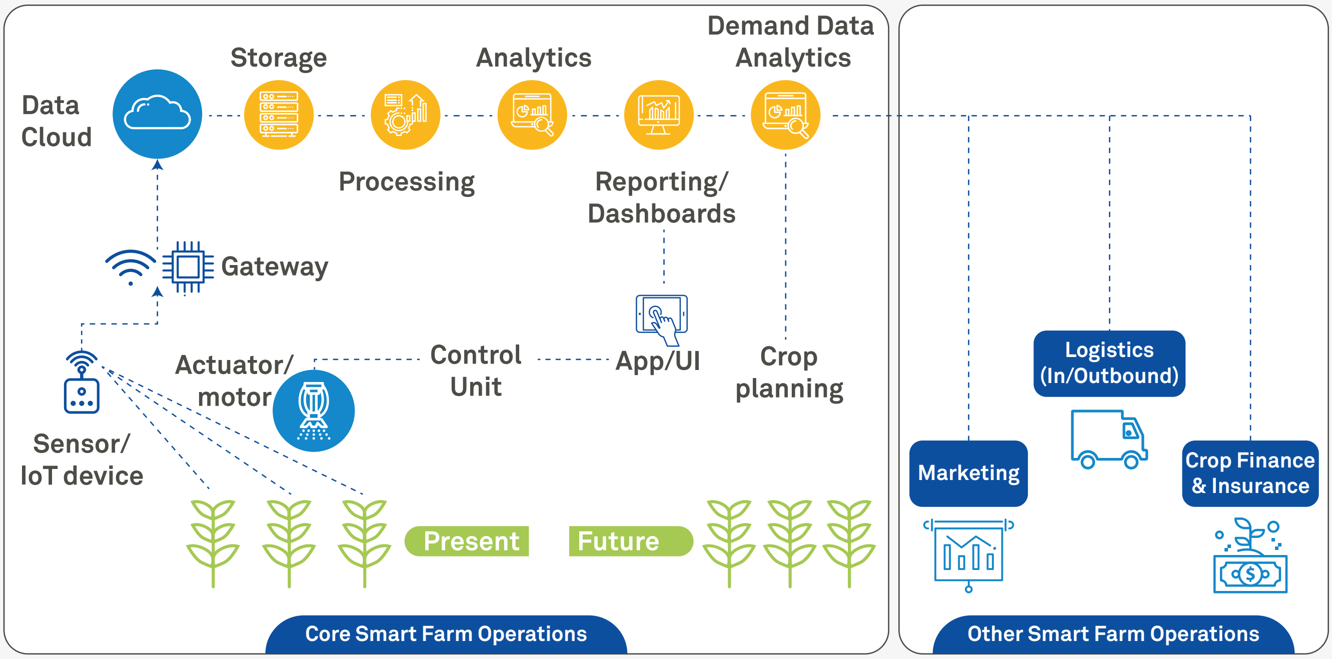


Figure 7: Smart Farm Operating Model

4. Global implementations of Smart Farming solutions

There have been several initiatives across the globe in the implementation of Smart Farming powered by Analytics. Some of the solutions and their implementation details are listed in Table 1 .

Implementation (Company & Region)	Key Value Proposition	Description
Nokia WING – Worldwide 	Low cost IoT provisioning & maintenance on a subscription model	WING, an innovative managed service, enables operators to support their enterprise customers with global IoT connectivity across borders and technologies. It has add-on features like 'Smart Agriculture as-a-Service', which provides affordable subscription-based access to regional climate & pest data for farmers to mitigate risks. This solution was used in Algeria to help a peach farmer increase his yields.
DTAC (Telenor)- Thailand 	Precision Farming IoT solution	DTAC & its partners (govt agencies) have launched a 1-year pilot project that introduces this IoT based solution to monitor, analyze and predict the factors affecting cultivation. It will allow farmers to have access to a more precise farming system that should help increase crop yields, control quality of agricultural products and reduce production costs. The trial includes farms within 300 km radius of Bangkok.

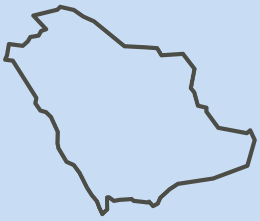
Implementation (Company & Region)	Key Value Proposition	Description
Saudi Greenhouse Management & Agri Marketing Co. – Saudi Arabia 	Greenhouse farm products, greenhouse farming advisory, support services	The company applies Smart Farming techniques in greenhouse farming to grow vegetables and other non-native food in deserts of Saudi Arabia. In addition, it also provides advisory and support services to other organizations with similar endeavors. They also undertake turnkey greenhouse project development.
Atilze – Indonesia 	Smart agriculture sensors; System of Rice Intensification	In Central Java, Atilze aims to increase rice yields by 30% - 50% and up to 50% water savings by deploying smart agriculture sensors and through the System of Rice Intensification (SRI). It works by determining the optimal water amount through precise measurement of soil moisture and thereby alternating between dry and wet soil condition. Sensors also track secondary parameters like soil pH, EC, air temperature and humidity.
Libelium - Colombia 	Crop Monitoring System backed by a wireless sensors network	In Colombia, local organization Red Tecnoparque Colombia has deployed a wireless sensors network to monitor crops. Libelium's Waspmote Plug & Sense! Sensor Platform has been selected to develop a precision agriculture project with remote sensors. These sensors allow producers to monitor key parameters including humidity, temperature, soil moisture, trunk & fruit diameter, precipitation & solar radiation. This solution also helps them with harvesting projection, optimizing water usage, preventing diseases, reducing fertilizers consumption and classifying soils.

Table 1: Global Smart Farming solutions and implementation details

5. Key challenges in Smart Farming adoption

5.1 Commercial viability

- • Small land holdings: Unable to realize economies of scale in purchase of seeds, manure, fertilizers, even in bank loans (considering transaction cost, banks view it as uneconomical to provide small loans).
- Farmers' income: Low income means no access to capital for implementing the use of IoT & other modern equipment that is needed for smart farming.

5.2 Other Challenges

- Unskilled workers: Adequate training and education is required to firstly understand the potential benefits of adopting smart farming and subsequently implement and use Smart Farm devices, and also understand insights and act on them
- Availability of basic amenities like roads, electricity and water is a concern in certain remote areas

6. Addressing key challenges

The solution lies in pooling small land holdings and other resources of farmers together to form cooperative farm societies, which are well-networked in order to bring in economies of scale. This will make it easier and economical for banks to lend and reduce risks. Smart devices can be purchased in bulk by these cooperatives at cheaper rates. Alternatively, third party vendors can provide smart devices to these cooperatives "As-A-Service". It would be preferable for vendors to lobby with governments to support farmers initially in installing and maintaining Smart Farm equipment until the benefits kick in. Moreover, adequate training is to be provided by these vendors. This can also be done in partnership with government agencies or NGOs for maximum reach. Also, it would be advisable to have interfaces with vernacular languages for ease of use. Moreover, it would be a prudent approach to start-off with identifying regions with higher farmer incomes (Like Punjab & Haryana) for ease of adoption and pilots (See Figure 8 for the solution approaches).

Awareness

- **Key Hurdle:**
- Low awareness of products and solutions
- **Solution:**
- Product & Solution providers can tie up with NGOs and SHG (Self-Help Groups) to create awareness
- Government agencies & media can also spread awareness through radio, TV, etc.

Adoption

- **Key Hurdle:**
- Small land holdings, low purchasing power of farmers & benefit realization
- **Solution:**
- Pool land holdings to purchase resources as cooperatives
- Alternatively, expensive capital products can be provided as-a-service to make them affordable.
- Product/Solution providers can lobby with the govt. to support farmer purchase in the initial stages
- Demonstrate case studies from pilots done in other parts of the country (preferably starting from the more affluent agricultural regions)

Action

- **Key Hurdle:**
- Farmers lacking digital skills to leverage benefits of smart farming
- **Solution:**
- Product & Solution providers can tie up with NGOs and SHGs for training
- Simplifying UI for ease of use/ incorporating vernacular languages in apps & other UI

Figure 8: How to address key hurdles in Smart Farming adoption

7. Conclusion

Looking at the various aspects of Smart Farming, we can infer that while Smart Farming powered by analytics can be a boon to agricultural productivity in India, there are however, areas that need attention.

A key area to be worked upon is the strategy to ensure economic feasibility and ease of adoption. Taking cues from implementations across the world, a prudent approach would be to start small – with pilots in small farming districts. Even though every market is unique, there are learnings from every implementation that can be taken forward. Once, a robust framework is developed, the solution can then be scaled across regions.

When it comes to affordability, which prima facie, seems like a big challenge, it must be noted that the global implementations mentioned in this paper are spread across both developed and developing economies. So, with the right framework and roadmap in place, it is likely that Smart Farming will enable Indian farmers to produce more and better with less, and thereby earn more and enhance their standard of living.

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Other References

https://www.smart-akis.com/index.php/network/what-is-smart-farming/#

https://www.analyticsvidhya.com/blog/2018/05/data-analytics-in-the-indian-agriculture-industry/

https://www.dataversity.net/predictive-analytics-use-cases/iegindia.org/ardl/Farmer_Incomes_Thiagu_Ranganathan.pdf

https://www.precisionag.com/digital-farming/digital-farming-keep-it-simple-analytics/

http://www.preservearticles.com/economics/causes-for-low-productivity-of-indian-agriculture/6784

https://www.zigya.com/study/book?class=12&board=cbse&subject=Geography&book=India+People+And+Economy&chapter=LAND+RESOURCES+AND+AGRICULTURE&q_type=&q_topic=Problems+of+Indian+Agriculture+&q_category=&question_id=GEEN12121362

https://easternpeak.com/blog/iot-in-agriculture-5-technology-use-cases-for-smart-farming-and-4-challenges-to-consider/

https://www.ijitee.org/wp-content/uploads/papers/v8i6s/F60160486S19.pdf

https://easternpeak.com/blog/3-edge-computing-use-cases-for-smart-farming/

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