

Farming-as-a-Service (FaaS) and Software-as-a-Service (SaaS) for Sustainable Agriculture 4.0 Ecosystem: A Supply Chain Management Perspective

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Abstract

Agriculture is considered as the pillar of India which can fulfill the basic need of every human beings. There is basic need of efficient re-inventions of existing agriculture farming practices, combined with tech-driven innovations. Promoting new technologies to strengthen India's agricultural research and productivity is one of the most important needs for agricultural growth. For disaster recover from the economic crisis, natural calamities, farmers in India are progressively adopting smart farming technologies like Farming-as-a-Service (FaaS), Food-as-a-Service (FaaS), Agriculture Drone-as-a-Service (DaaS), Equipment-as-a-Service (EaaS), Agriculture Robot-as-a-Service (RaaS) and Software-as-a-Service (SaaS) models for Sustainable Agriculture domain to address the emerging issues. There is poor access to existing agriculture software application to all stakeholders of agriculture and there is no any unique software app having all FaaS available in single platform. In this paper researcher focuses on the importance to develop end-to-end innovative farming-as-a-Services. As technology solution for all agriculture stakeholders like farmers, start-up, Farmepreneur, governments, Agri-entrepreneurs, equipment suppliers, agronomists and IT vendors etc.

Keywords: Farming-as-a-Service (FaaS), Food-as-a-Service (FaaS), Agriculture Drone-as-a-Service (DaaS), Equipment-as-a-Service (EaaS), Agriculture Robot-as-a-Service (RaaS), Software-as-a-Service (SaaS)

INTRODUCTION

India is primarily considered to be a nation where agriculture and its allied initiatives are considered as the chief source of livelihood for more than 80 percent population. The share of agriculture in gross domestic product (GDP) has reached almost 20 per cent in year 2021 owing to resilience of farming communities amid the current diversities. Agriculture sector has been the only entity that has clocked a positive growth in the recent times and the consistent supply of staples has enabled to provide food security for Indians as well as Global citizens. Agriculture being the prime means of livelihood, there is a basic need of re-inventing the farming best practices, combined with tech-driven innovations in this segment to ensure sustainability and eliminate poverty and hunger [1]. Promoting new technologies to strengthen India's agricultural research and productivity is one of the most important needs for a sustainable agricultural eco-system. To ensure efficiency, productivity, quality, volume and

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continuous supply of staples, farmers in India are progressively adopting smart farming technologies utilizing drones and robots. Subsequently with introduction of Farming-as-a-Service (FaaS), various models are being created to build sustainable eco-system to address the emerging issues in this sector [2]. The awareness, accessibility and availability of infrastructures, hard and soft resources to majority of Indian farmers is till date scarce and very poor and hence there is a dire need to introduce and propagate the thoughts, ideas, studies and researches with respect to implementation of Agriculture 4.0 the focus being information and technology enabled farming practices. In this chapter the authors focus on introducing relevant technology enabled services that will ensure economic sustainability, enhance food security through data driven decision making by various stakeholders like farmers, agri-business and agri-tech start-ups, farmpreneurs, government and non- government agencies, equipment suppliers, agronomists, IT suppliers and vendors. The analyzed information will be used as a vantage by farmers to select precision farming practices to aid productivity, to empower personnel to provide timely assistance, and industries to implement real-time monitoring using sensors and devices [3]. The chapter will help formulate concepts, methods, practices, benefits and introducing several case scenarios to effectively propagate the service mode of farming that will imbibe pay-as-you go model ensuring cost optimization and operational ease.

PRESENT STATUS OF AGRICULTURAL ECOSYSTEM IN INDIA

India has the second largest population in the world and is considered by a comprehensive diversity in climate. Previously agriculture is understood as life leading activity with huge number of hidden unemployment in rural households, consequently the contribution from agriculture segment also been ignored and it was considered as a low-tech industry which has no potentiality to tackle more contribution to the economy and development. So utmost agriculture peoples are forced to migrate to nearby cities in search of work. The farmers are really heart and soul of the economy are now struggling all over the India to sell their production at an affordable cost. They work day and night to cultivate good crops, but most often they sleep with empty stomach [4].

This highpoints the need for developing more innovative device in the rural economy that boosts employment opportunities in the agriculture segment, which can be called as Agripreneurship in Agriculture. Since the innovative technology not only develops an alternative source of employment but also helps radicalize farming techniques and brings innovation to improve food production. We well understood that farmers only meet the basic needs of our planet and the expectations of governments, consumers, and food processors, retailers and every individual of mankind [5].

The facts is that Indian agri. Industry contributes to 13.7% to GDP. Provides foods to 1.30 Billion peoples and Seventh largest agricultural food exporter worldwide. Currently more than 52% of India's population is involved in agriculture [6].

There are many reasons for Farmer's financial distress. Some of them are as under-

1. Repeated crop failures
2. Lack of access to insurance credit system
3. Poor government support
4. Poor food security
5. Poor technology available for agriculture sector
6. Lack of availability of irrigation water
7. Unfavorable climatic conditions
8. Lack of transparency in supply chain
9. Inadequate and poorly distributed rainfall
10. Frequent crop failures

Due above issues there are increasing pressures from climate change, soil erosion and biodiversity loss, pest & disease and from Food preferences are shifting, and customers are concerned about how it

is produced. While modern agriculture offers a wide range of technological solutions, the results vary since each farm is different, with different landscapes, soils, accessible technology, and potential productivity [7].

To respond to global drivers of change such as population increase, shifting eating patterns, and climate change. To strike a balance between human needs and environmental implications, decisionmakers must be aware of potential tradeoffs between these aims. On the other hand, in India, traditional farming practises are based on sustainability, as well as innovative, hardworking, and entrepreneurial farmers. We as Indian require a shift in our approach and thinking towards agriculture transformational change and consider greatest challenges of the 21st century as:

1. Innovation & Technology in agriculture
2. Employment Generation
3. Sustaining food
4. Nutrition security
5. Adaptation and mitigation of climate change
6. Sustainable use of critical resources such as water, energy and land.

All these challenges underscore the need for a new vision for agriculture as we move forward in the 21st century.

The paradigm shift must begin with policymakers shifting from a production-centric to a sustainability-focused perspective. Unlike the green revolution, the agro-ecological technological package cannot be homogeneous. Each farm is distinct. Farmers should be taught some basic agro-ecological ideas and procedures, and then be free to explore, create, and adopt what works best for them in their specific circumstances [8].

CHALLENGES AND OPPORTUNITY FOR AGRICULTURE INNOVATION

Innovation necessitates knowledge from a variety of sources, including users of that knowledge; it entails these various sources of knowledge interacting with one another in order to share and combine ideas; these interactions and processes are typically context-specific; and each context has its own set of routines and traditions that reflect historical origins shaped by culture, politics, policies, and power. Strengthening agricultural innovation systems is so more about general ideas and concerns than specific operational and policy advice. It's more about ensuring that settings that foster diverse approaches to innovation exist, and that competitors collaborate to constantly alter institutional and regulatory framework conditions for innovation [9].

Food production must adapt to increasing population expansion, resource depletion, soil degradation, limited land utilisation, and a growing paucity of water. Digital farming will be difficult to adopt until network performance and bandwidth speeds are greatly increased. Because many agro-sensors/gateways rely on cloud services for data transmission and storage, cloud computing must improve. Farmers have limited access to reliable and timely market information, there is no supply and demand forecasting, supply chains are poorly structured and inefficient, there are insufficient cold storage facilities and a lack of proper food processing units, and there is a lot of intermediation between farmers and consumers. Global economic variables such as fluctuating commodity prices and trade issues, as well as the reality that a crop can be damaged by weather, insects, or disease, complicate a farmer's commercial decisions [10].

Following Table 1 shows some biggest problems faced by farmers in India and opportunities for Technology innovations in agriculture sector.

Diverse agro-climatic conditions, high domestic demand and a large domestic market, fertile soils, ability to adopt S & T for agriculture, access to global markets, enterprising farming community, well-

developed research and extension capabilities, and scope for agriculture are some of the development opportunities available.

Farmers encounter a number of obstacles when it comes to implementing IoT in agriculture. Infrastructure Deficit - Farmers will be unable to benefit from IoT technology even if they accept it due to a lack of connection infrastructure. Farms are located in rural areas with limited internet access [11].

Table 1. Challenges and Opportunities faced by Indian Farmers.

S.N.	Challenges	Opportunities
1	Inspire young people to stay in rural areas	Harnessing Rainwater
2	Agricultural Marketing	Best practices-right products, at the right rates, and at the right time
3	Small and fragmented land-holdings	Adopting Technology and innovation
4	Irrigation	Get IP for farming prior art
5	Soil erosion	Adoption of mechanism Big Data is only for Big Farming (Smart Data)
6	Inadequate storage facilities	ROI for suitable investment
7	changing tastes and expectations	Organic fertilizer development

This suggests a simple but significant shift in perspective. If we are engaged in development and agree that development is about change, let us focus on the conditions required to demand and apply new knowledge to bring about that change rather than on the provision of new knowledge and technology from research. There are a lot of them now. It is impossible to mention all of them here.

AGRICULTURE 4.0

Agriculture 4.0 refers to the industry's next key trends, such as a greater focus on precision agriculture, the internet of things (IoT), and the use of big data to generate higher economic efficiencies in the face of expanding populations and climate change.

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In conjunction with Oliver Wyman, the World Government Summit produced Agriculture 4.0 - The Future of Farming Technology in 2018. Demographics, natural resource scarcity, climate change, and food waste are the four major changes that will put pressure on agriculture in the near future, according to the report. The term "Agriculture 4.0" has gained traction in the media [12].

To meet above challenges and grab opportunity as shown in Table 2 we will necessitate a concerted effort on the part of governments, investors, and agricultural technology innovators. Water, fertilisers, and pesticides will no longer be applied consistently over entire fields in Agriculture 4.0. Farmers will instead utilise the bare minimum of quantity and focus on very specific places. Because of technological improvements such as sensors, devices, machinery, and information technology, farms and agricultural activities will have to be run significantly differently. Robots, temperature and moisture sensors, aerial photographs, and GPS technology will all be used in the future of agriculture. Farms will be more profitable, efficient, safe, and environmentally friendly as a result of these modern equipment, precision agriculture, and robotic systems. Farmers may have a better understanding of current output techniques and determine which improvements will provide the most value by utilising smart data. Agriculture 4.0 is much more than a trend. The word has become a catch-all for the next stage.

AGRICULTURE USE CASES

Now we are moving towards pervasive where a very wide variety of appliances will be connected to the web. Internet of Things (IoT) is becoming one of the most widely integrated eras. An

agricultural environmental system monitoring services that facilitate controlling services. He increasing challenges in the agriculture sector are making it impossible to maintain sustainability. However, according to experts, using block chain in agriculture can shift this scenario for good. Let's understand why block chain is essential for this industry?. Agriculture is undergoing a renaissance. Farmers can manage crops and livestock more consistently and efficiently thanks to the Internet of Things and artificial intelligence. Farmers are being empowered by autonomous agricultural equipment, livestock monitoring systems, and precision farming solutions to feed an increasingly hungry and environmentally fragile globe. To help enhance yields and better allocate resources, the farming and agricultural industries rely on new ideas and technology breakthroughs. Tractors and harvesters were among the mechanical inventions of the late 19th and early 20th centuries. The Internet of Things (IoT) is becoming a driving factor behind improved agricultural productivity at lower costs, which opens the door wide for engineers wishing to bring a smart farming system or IoT agricultural sensor to market.

Table 2. Future Challenges for Indian Agriculture.

Technology Type	Category of Service	Device/System	Use Case	Algorithm used
Internet of Things (IoT)	- FaaS - ADaaS - EaaS - RaaS - MaaS	- Drone - Robot - Autonomous tractor - Sensors - pH probe - Capacitance hygrometer	- greenhouse monitoring - Drip Irrigation leakage monitoring - Canal Water Supply - Plant & Soil Management	- path-generating algorithms - Kernel-based clustering algorithm - heuristic simulated annealing algorithm
Blockchain	- FaaS - ADaaS - EaaS - RaaS - MaaS	- Farm Management Software (FMS) - Immutable ledger system	- Farm Inventory Management - Agricultural Supply Chain - Microloans - Agricultural Subsidies - Payment from Consumer to Farmers	- Proof Of Work (PoW) - Proof Of Stake (PoS) - Proof of Elapsed Time (PoET)
Artificial Intelligence(AI)	- FaaS - ADaaS - EaaS - RaaS - MaaS	- AI Sensors - AI Chabot's	- detecting diseases in plants - pests, and poor plant nutrition on farms - weather forecasting - improve crop yields - reduce food production costs	- Computer vision Algorithm - Deep learning algorithm - KNN algorithm
Data Science	- FaaS - ADaaS - EaaS - RaaS - MaaS	- MyCrop - real-time system - RFID chip	- Optimize their production cycles - Yield Predictions - Digital Soil and Crop Mapping - Fertilizers Recommendation	- Random forest algorithm - BigML - Partitioning clustering algorithms

Farming-as-a-Service (FaaS)

Agriculture is the most important sector of the Indian economy that provides employment to majority of the population of the country's workforce. India is the second-largest producer of fruits and vegetables in the world. Still, it suffers from a heaping number of disasters such as climate change, unpredictable monsoon or lack of it, droughts, floods, migration of farmers towards the cities in search of better-paying jobs, and more. People involved in agriculture are the last to be taken care of, even when they are the one who feeds the whole country. Farming-as-a-Service (FaaS) offers innovative services like information sharing, analytics and precision farming tools via a subscription or pay-per-use model and design IT based data-driven decision techniques more affordable for a

majority of small farmers to boost productivity and efficiency of farmers. The data is collected directly through drones, satellites, farmers, market agents and government agencies. The gathered information is further processed and analyzed to find what works well on the sector. The analyzed information is leveraged by farmers to adopt precision farming practices to boost productivity, government to empower field officers to provide timely support, and corporates to optimize input application and real-time monitoring of crop output. Many start-ups in India have adopted FaaS solutions. Following are the some use cases of F-a-a-S.

Use Cases

1. Smart Sensors
2. planting seeds
3. Self-Driving Tractors
4. Linkage of farmers to the marketplace
5. weed control
6. cloud seeding

Food-as-a-Service (FaaS)

Agriculture is the backbone of the Indian economy, but the industry currently needs more support than any other technology domain. India is a country of over a 1.30 billion people in population, out of which, over 70% of the population lives in the rural areas. Agriculture is a major industry and an influencer of the Indian economy. F-a-a-S would promote much-needed process and product improvements in Indian agriculture, such as multipurpose agricultural equipment, real-time data capture and analysis tools, farmland and farm produce aggregation, and farmer financial technology. The growing population demands quality foods on time and on budget. Underlying these rapid changes are macro forces that influence the way the India produces, distributes, buys, sells, and consumes food. The shift from rural to urban life will increase demands for future food-stocks and shorter, more efficient supply chains. In addition, wealth inequality continues to widen, creating disparities in access to healthy food amongst socioeconomic and income groups. Consumers will continue to seek ways to improve their diets to manage health and wellness, to counteract escalating obesity and non-communicable diseases. Following are the some use cases of F-a-a-S:

Use Cases

1. DoorDash (iOS / Android)
2. Seamless (iOS / Android)
3. Postmates (iOS / Android)
4. GrubHub (iOS / Android)
5. Uber Eats (iOS / Android)
6. Instacart (iOS / Android)

Drone-as-a-Service (DaaS)

Agriculture is vibrant for the development of the nation we, human beings benefit from agriculture many way or the other, which has made agriculture a key area of innovation and technology usage. Farmers will always need information to refer to, most especially when growing crops that are not common in their land. The average farmer has access to unsophisticated sources of information such as TV, radio, newspapers, government agricultural agencies, farm supply, and traders. There is, therefore, a need for a system that allows farmers access to relevant information.

As drones become an integral part of smart farming, they help farmers deal with a wide range of challenges and secure a great number of benefits. Most of these benefits stem from eliminating any guesswork and reducing uncertainty. The success of farming normally depends on an embarrassment of factors farmers have no control over weather and soil conditions, temperature, precipitation, etc. The key to efficiency lies in their ability to adjust, which is impacted by a large extent by the

availability of accurate nearly real-time info. This is the area where the use of drone technology can truthfully become a game changer. By gaining access to a critical data, farmers can increase crop production, save time, reduce expenses and act with accuracy and precision. Machine learning is also among the trending technologies; hence, there exist several technologies and systems that run on a machine learning framework. Several machine learning systems in agriculture have been tested and created. Several machine learning algorithms' effectiveness in agriculture and other application domains has also been conducted and this is because machine learning is a very effective tool for efficient use of resources, prediction, and management, which are needed in agriculture. Following are the some use cases of D-a-a-S:

Use Cases

1. Search and rescue
2. Weather forecast
3. Aerial photography
4. Shipping and delivery
5. Geographic mapping
6. Crop surveillance

Machine-as-a-Service (MaaS)

Pay-per-use for machines and equipment has become a successful business model in various agriculture industries, including farming, fishery, poultry, dairy equipment's and machinery. And others. EaaS front-runners in industrial manufacturing have already applied this model for emerging revenue streams to differentiate themselves in the marketplace and/or meet agriculture customer expectations. Equipment-as-a-service (E-a-a-S) is rapidly moving from a specialized notion established by the providers of agriculture and other specialized devices to general adoption. They are the ease of connecting all sorts of equipment and devices in the internet of things (IoT), E-a-a-S is also becoming more feasible and affordable for farmers and agronomist. Today, E-a-a-S is controlled to make rapid inroads into complex crop. An E-a-a-S model can benefit machine and equipment providers by providing industry-leading equipment uptime and a transparent price structure. It can be an appealing business concept for a long-term sustainable revenue stream if done correctly. Agriculture equipment manufacturing companies. Following are the some use cases of E-a-a-S:

Use Cases

1. Water Management
2. Disease Detection
3. Crop management
4. Species management
5. Livestock Monitoring
6. Soil management

Robot-as-a-Service (RaaS)

In modern years, the robots have found their own place in agriculture. In recent years, the use of robots in agriculture has increased dramatically, solving some of the field's obstacles and complications. To compile a comprehensive and up-to-date state-of-the-art on the use of robots in agriculture. Robots as a service (RaaS) suppliers bring robots to the agriculture sector to manage repetitive, tedious, and risky tasks. Traditionally, robots are used to undertake repetitive and tedious jobs that are typically performed by low-paid humans. Because deploying robots can be costly, businesses may struggle to see a return on their investment. The RaaS approach, which is becoming more frequent in agricultural robots, is becoming increasingly popular in the field of robotics. Apples are picked by robots, strawberries are picked by robots, lettuce is harvested by robots, and weeds are removed by robots. Drones collect airborne photos that farmers may use to check crop health fast. And thousands of miles distant from conventional agriculture zones, robotic greenhouses are popping up, growing veggies.

Following are the some use cases of R-a-a-S:

Use Cases

1. Greenhouse farming
2. Surface temperature
3. Air temperature
4. Seed planting (cloud seeding)
5. Precision Framing
6. Weed and pest control

DISCUSSION'S

Innovative technologies are already disrupting the traditional norms of farming, with previously unaffordable mechanism and devices now accessible and regularly deployed on farms across the India. IoT based drones provide a third eye in the sky, investigation for pests in the field requiring further attention. The modern advances in sensor technology means robots, drones, Chabot are now able to use supplementary wavelengths in the variety to assess crops, pests, insect, weeds and sick crops from the air.

Blockchain like technology is also on the rise, creating an innovative mode of interaction in the supply chain. This technology eradicating the need for an intermediary. It doesn't end there. Blockchain can decrease inefficiency and significantly improve food safety and security. Traceability is also improved, with regulators quickly able to check the source of foods and detect the scope of any contamination issues and marketplace. These and other technological AI, Data Science, IIoT, Quantum Computing, RFID etc. Innovations are acting as a significant disruptor, driving change and greater efficiency for thousands of areas from agriculture like fishery, poultry farm, dairy farming etc. The awareness, accessibility and availability of infrastructures, hard and soft resources to majority of Indian farmers is till date scarce and very poor and hence there is a dire need to introduce and propagate the thoughts, ideas, studies and researches with respect to implementation of Agriculture 4.0 the focus being information and technology enabled farming practices.

Smart agriculture software with artificial intelligence (AI), IoT, Data Science, Blockchain, Quantum Computing offers farmers a path to the extensive automation of manual agri work.

Agriculture agriculture apps should go next up to roots of crops. As a technology innovators look ahead to 2021 and beyond, we discover with a few ag-tech companies to gain insight into the trends shaping mobile app development for agriculture transformation.

We need to address the key structural challenges, such as the lack of infrastructure, technology and financing, is crucial and success adoption of digital technology since these services will be available through mobile, apps and web. This can help in the creation of large scale database of farmers, collection of data from farmers' fields over a period of time and enables the stakeholders to make data driven and precise decisions to boost productivity and efficiency. IT companies also plays an important role in redefining the agri sector through innovative solutions such as AI, Data Science, IIoT, Quantum Computing, RFID and-FaaS, DaaS, EaaS, RaaS, MaaS and make it more efficient through improved access to technology, capital and entrepreneurial skills.

CONCLUSION

The new wave of innovative technology goes to agriculture sector and it looks a lot like the tech disruptions which we are expecting everywhere tools like social networks to cutting-edge tech like self-driving tractor, farming is going digital, and stakeholders will have a lot of innovative solutions to choose from in the coming years. This means they will also need to decide what the array of innovative technology means for increasing productivity, scaling business and driving sustainability and survival of human beings from starvation. To summarize, - FaaS, DaaS, EaaS, RaaS, MaaS FaaS these services hopes to drive much-needed process and product innovations in Indian agriculture.

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