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10 Social and Economic Impacts

10.1 SOCIETAL AND ECONOMIC IMPACT OF AI, ML, AND IoT IN INTELLIGENT PRECISION FARMING

The world population is projected to attain an 8.6 billion mark in 2030 [1], with India and China being the most populated countries. To feed the growing populace, stress and over-exploitation of arable lands have maximized. Due to the urbanization and growth of Industry 4.0, more agricultural land is rendered barren and occupied for manufacturing and production units. Unscientific methods, substandard chemicals, and fertilizers, natural calamities, global warming, and untimely locust attacks are only a few challenges that farmers and food production in the socio-economic class experience. With the introduction of Agriculture 4.0 or smart precision farming, a ray of hope shines to avert the above effects. The contribution of the agricultural industry to the world economy will increase. The potential of AI/ML/IoT and the benefits mankind can reap from these have already been explained in detail in the previous chapters. The societal and economic impacts of these precision tools and techniques can be summarized as:

- The usage of ICT such as AI/ML/IoT/smartphones in agribusiness has helped in the betterment of daily farming operations as well as in long-term strategic decisions.
- These approaches will assist in the reduction of harsh effects on the environment as inputs will be applied in the right amount, in the right quantity, at the right time, and at the right place.
- Higher net value in terms of yield and profit will be promoted.
- Multiple crop fields that are located apart can be managed under one roof.
- There exist integrated management of livestock and farming for better management and decision-making.
- Spatial and temporal assessment and management within the field has now become convenient.
- Management of robots, drones, and other machinery has become easy and remotely controllable.
- Keeping watch on desertification, leaching, rains, trespassing, and poaching is easy and affordable.
- Accurate forecasting and prediction models benefit the farmers in scheduling activities depending on the mood of nature and climate vagaries.
- Market and mandi price checks have helped in fetching the right amount for the yields.

- Organic farming has flourished by imbibing these environment-friendly technologies [2].
- Labor costs, timely weather forecasts, site-specific and variable-rate application, and crop loss reduction are the most motivating contributions of these sustainable tools towards the entire society.
- Conservation of natural resources, like land and water, has been possible at a larger scale.
- With a progressive decision support system, Agriculture 5.0 has combined advanced software-based information technology and farm management with physical observations and planning in the field to formulate detailed geographically specific action plans.
- With geo-positioning systems, agricultural machinery is enabled to execute plans.
- Record-keeping and keeping track of events for past years is accessible via the internet or offline.
- Analytics and modeling of acres of land using web, cloud-based decisions, and crop monitoring systems are now possible.

10.2 EXISTENCE OF FORUMS FOR INNOVATION AND COMMERCIALIZATION OF INTELLIGENT PRECISION FARMING TECHNOLOGY (IPFT)

Intelligent Precision Farming Technology (IPFT) are not readily adopted by the farmers due to many reasons, including [3], [4]:

- Smaller farm size or sparsely located marginal farmers
- Low income and fear of investing in these tools
- Restricted extension of such tools and techniques to rural areas to motivate users and relate the various benefits
- Preparedness of entrepreneurs, startups, and other reputable companies to work for the flourish, cost reduction, universal access, and progress of such tools and technology
- Confined subsidies and costly loans for investments in adopting these latest ICTs [5].

Salient reasons for the crisis in agricultural production and painful farmer suicides all over the world, particularly in India, include economically and physically investing more in crops and while attaining lesser outputs, cropping patterns, monsoon vagaries, lack of irrigation in summer, droughts, fewer market values, inadequate storage facilities, low-grade seeds, and low-quality biocides and fertilizers [6]. All of these issues need to be addressed at global platforms. With increasing dependency on farm productions, India still thrives on introducing technological advancements in the farming sector in dealing with gaps, production increment, supply chain, logistics and warehousing, and meeting the demands of the population [6] as shown in Figure 10.1. Many prominent forums

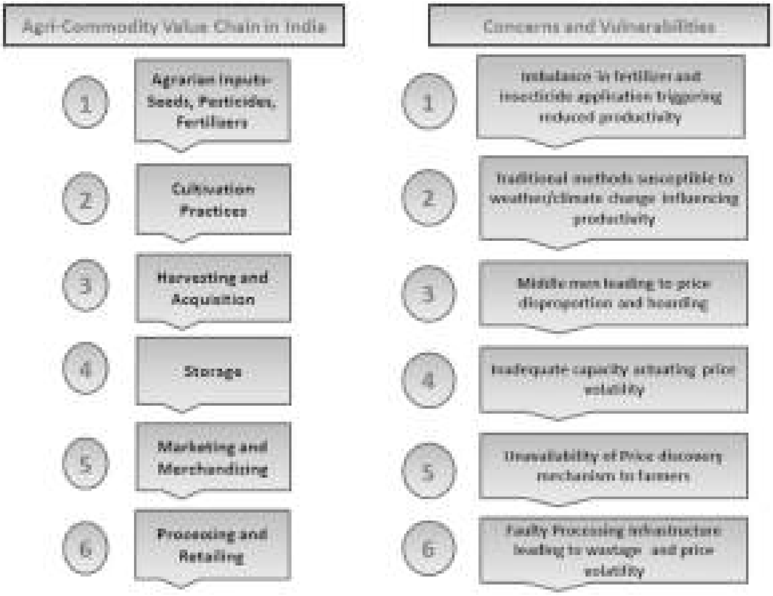

FIGURE 10.1 Agri-Commodity Value Chain India [22].

and policies cooperated to support the agricultural industry all over the world, India included. The United Nations Food and Agriculture Organization has collaborated with most of the African, Gulf countries, and other ranked agricultural business organizations to discuss and share innovative methods, tools, and successful experiences in using emerging technologies or replacing traditional farming with Agriculture 5.0. Innovators, investments plans, profitable ways of market engagement, import-export information, and partnerships are deliberated to foster the growth of the latest tools at the disposal of practitioners, entrepreneurs, and decision-makers with the help of the Global Forum on Agricultural Research(GFAR) [7] and the Consultative Group on International Agricultural Research (CGIAR). Young men and women are nurtured and motivated to practice the use of disruptive technologies and transformed them into employed entrepreneurs [8]. European countries [9] and the US enjoy the most modernized type of farming.

To cope with suffering crop loss in order to show support to farmers and to provide a catalyst for the grower community, the Indian Council of Agricultural Research (ICAR) has pioneered a chain of programs with more impetus from the Government of India. Many Abhiyan, district-level Krishi Kendra's [10], consortiums for e-resources [11], web and mobile app[12]-based advisory systems, weather forecasts [13], disease prediction, knowledge management portals, and repositories of experimental and geospatial for various crops [14], [15], their import-export data, production data at state levels and research publications, and reports have been maintained to aid researchers and innovators in finding solutions. Introduction of bridge courses on precision farming, AI/IoT or the data science domain for non-computer sciences background students [16], and Agriculture 5.0 tools and techniques by NAHEP, the National Academy of Agricultural Sciences (NAAS), and the Indian National Agricultural Research System (NARS) [17] are preparing young engineers to be inclined towards this new age of farming and are empowering people to use this to double farmer income. Seminars, Kisan Melas, workshops, and meet-ups play a vital role in spreading the word. ICAR has entered into more than 57 MoUs with world-renowned agricultural institutes and is part of numerous multinational co-operations like BRICS, IBSA, SAARC, and more. [18]. World tech giants like IBM, Intel, and Microsoft are now partnering with farmers and using the AI/ML-based strategies to maximize production. The International Crop Research Institute for Semi-Arid Tropics (ICRISAT) is working with Microsoft to develop an AIs owing app to send sowing advisories to farmers by informing them of the optimal date to sow [19]. NASSCOM, in collaboration with the Government of Karnataka, UP, Gujrat, and Haryana, is helping the incubation of start-ups in the area of AI and IoT and is providing modern solutions even for small land-owners [20]. The National Institution for Transforming India (NITI) Aayog, upon realizing the potential of AI, started an initiative called “AI FOR ALL” in 2018 in order to extract and reap the benefits of agriculture [21], [22]. The government of India has signed an MOU with IBM to use AI to secure the farming capabilities of Indian farmers. The pilot study will be conducted in states like Madhya Pradesh, Gujarat, and Maharashtra. In an attempt to push and secure innovative technologies in agriculture, the government of India has also launched another initiative – AGRI-UDAAN.

Maha Agri Tech Project uses satellite images and the data analysis done by Maharashtra Remote Sensing Application Center (MRSAC) and the National Remote Sensing Center (NRSC) to assess the area of land and the conditions of selected crops in certain talukas.

10.2.1 Cost-Benefit Analysis of IPFT

Cost-benefit analysis (CBA) is a systematic way of estimating the strong and weak features of a suitable alternate option, which has the capacity to provide benefits at a low cost. CBA is useful in comparing the value of the cost of a decision or policy against an investment task.

The most economic advantage of IPFT is the availability of site-specific applications: catering to high in-field variability, early information of pests, disease attacks, and soil nutrients, and cutting down of labor force [23]. Thus, the use of extra inputs and, therefore, higher yields will help farmers in achieving acceptable economic benefits, and the marginal profit should be higher than marginal cost investments. To provide financial benefits, minute and precise information about the field are collected using satellites and sensors mounted on drones or UAVs. Once analyzed, the data once serves as an aid to farmers in understanding the crop and taking care of it, as required. These technologies require a fair investment of money that only farmers with many hectares of land can afford (as done in Europe and the USA), but some similar free or government-sponsored solutions are also available for small landholders.

Figure 10.2 demonstrates the benefits of applying the following PA technologies at three different implementation levels:

Level 1: Autosteering with Real-Time Kinematics (RTK)

Level 2: Autosteering with RTK and Section Control of Sprayer

Level 3: Autosteering with RTK and Cection Control of Sprayer and Fertilizer Spreader

The benefits are higher irrespective of cost spent in the case of large hectares of arable land. Small farmers can gain access to these advanced machines and technologies by custom hiring of these machines. However, financing of long-term loans for this must be scaled up. Market reforms are quite crucial because they play a critical role in helping a farmer to directly attain the true value, without having to split finances with market intruders or dealers. Availability of agro-processing units will help the farmer to gain more value for their crops while avoiding any damage caused in storage and transportation. Foreign direct investments in both technology purchase and crop production will definitely attain more benefits.

10.2.2 LIKELINESS OF FARMERS TOWARDS THE TECHNOLOGY ICAR–NAARM POLICY

The terms “smart farming” and “Agriculture 5.0” are in the early stages of development. These two terms can be referred to as umbrella terms under which the implementation of advanced communication, monitoring, real-time, imaging technologies in diverse tasks of agriculture. With cost reduction in electronic gadgets like laptops, desktops, smartphones, and sophisticated, built-in, tiny instruments, this is, therefore, made affordable for every farmer. Farmers, including young, educated men and women in Europe, the United States, and other OECD countries are exploiting their usage at a rather impressive rate [25]. Attempts made by research to survey the likeliness of farmers towards IPFT were studied. In a survey [23], 16% of Danish farmers adopted the use of real-time tractors and harvesters, and almost 45% of the land was cultivated using these systems. There was a reported 3% usage of UAVs, and satellite images were used for fertilizer, seeding, and pesticide application. Similar trends were observed among the farmers of Australia, North America, the US (who used satellite and air photos), the UK (variable-rate application technologies), and Sweden [26]. It was also discovered that people below the age of 40 years were mostly enthusiastic about the incorporation of IPFT. In a market report from the European Union, it was predicted that the use of driverless and GPS-enabled tractors will flourish by up to 35% in 2020, while the prices of these devices will fall by 30% [27].

In India, a questionnaire survey conducted by the ICAR-NAARM (National Academy of Agricultural Research Management) in 2018 [28] studied the

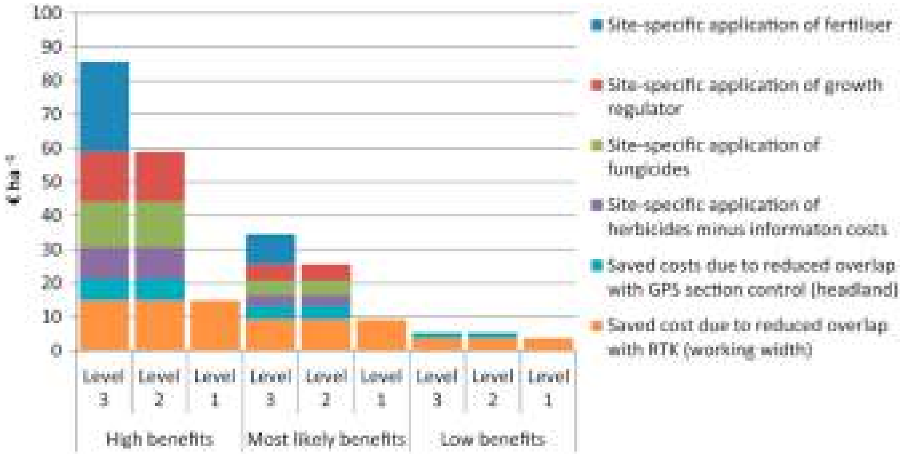

FIGURE 10.2 Estimated Benefits from Implementing Smart and Precision Application [24].

inception and popularity of the revolution of IPFT among the farmers, researchers, and young entrants. It was identified that about 34% of the respondents were aware of AI and IoT, but only 28% of them were knowledgeable about their applications in agriculture. The growth in innovative ideas and app and software development using AI and IoT started to develop.

10.2.2.1 Farmers Perception and Concern

Although the adoption of IPFT is growing at a rapid rate, there are still some concerns that aggravate the farmers about the use and purchase of such technologies. These issues are expounded below:

- Cost is the most critical parameter that determines the attitudes of farmers. Financial commitment towards technologies of less cost and with bundled features of visible benefits are considered a good choice. Moreover, farmers appreciate systems that are free of costs.
- Lack of awareness and trust in the efficacy of automated technology is still keeping them at bay.
- Machinery is of huge size.
- There exists a fear of purchasing farm machinery or other instruments with no scope of upgrade, thus rendering them obsolete. Thus, these turn into a burden and a cause of demotivation.
- The use of sophisticated operating mechanisms and the lack of knowledge, especially computer-based knowledge, is one of the main hurdles and concerns.
- Technical issues suffer a lack of support.
- There is no evidence for financial viability and profitability from the use of IPFT.

10.3 CONCLUSION

Even with the introduction of IPFT and Agriculture 5.0 being trending and influential, there are still a lot of difficulties going on. Demands to grow more but with fewer burdens on growers will only be achieved if the right efforts are made to make these updated farming practices available to all. A targeted production mark with no bad impacts on the environment and economy shall be achieved. In this regard, more motivating policies and schemes need to be projected for the supply chain as well as quality production.

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11 Environmental Impact and Regulations

11.1 POTENTIAL IMPACT ON THE ENVIRONMENT WITH DIFFERENT IPFT

Reduced labor force, efficient productivity, and profitability are the main advantages of using IPFT. Both socioeconomic and environmental benefits could be achieved directly or indirectly by adopting precision farming technologies. Environmental impacts occur in the form of pollution and over-exploitation of natural resources [1]. The damage to the environment is impossible to revert; therefore, using IPFT is of much concern and makes safeguarding the environment possible. Variable-rate application and site-specific farming have saved nature from extra dosage and over-toxicity. Most countries have banned the use of uniform air sprays by airplanes. Site-specific applicators are estimated to achieve a 10–15% cost reduction in annual chemical sprays on a farm.

Timely decision and advisory support for disease and pest management have managed the overuse or frequent use of chemicals, thus becoming both economical and nature-friendly. Moreover, the safe disposal of damaged or obsolete instrumentation must be done with care. Manufacturers should design instruments, such as mechanized equipment like drones, UAV, sensors, to use solar or other forms of renewable energy as their sources for operation [2], [3]. All of these contributions are the cornerstone for sustainable agriculture, as this preserves soil and crops, supports farmers, and helps with the continuous supply of food inside ecological, economic, and social bonds.

11.2 POLICY MAKING AND GOVERNANCE

The importance of policy-building and extending the policy horizons will result in endless benefits for the farmer communities. This helps to produce and assess information and to spearhead the development of the legal model in a manner that is fair, impartial, and accountable. Free data sharing with the stakeholders will become more transparent [4]. Various governance and policy measures that are required all over the world in general, and particularly quite important in India, include the following [5], [6]:

- To improve the economic viability of farming by ensuring that farmers earn a “minimum net income,” and to ensure that agricultural progress is measured by the advance made in improving that income

- To make mainstream the human and gender dimension in all farm policies and programs and to give explicit attention to sustainable rural livelihoods
- To complete unfinished agenda in land reforms and to initiate comprehensive assets and agrarian reforms
- To develop and introduce a social security system and support services for farmers
- To protect and improve the land, water, biodiversity, and climate resources – by creating an economic stake in conservation – that are essential for sustained advancements in the productivity, profitability, and stability of major farming systems.
- To foster community-centered food, water, and energy security systems in rural India and to ensure nutrition security at the level of every child, woman, and man
- To introduce measures which can help attract and retain youth in farming by making it both intellectually stimulating and economically rewarding by conferring the power and economy of scale to small and marginal farmers both in the production and post-harvest phases of farming
- To strengthen the biosecurity of crops, farm animals, fish, and forest trees for assuring both work and income security of farmer families as well as the health and trade security of the nation
- To enhance the well-being of the indigenous and local population as well as their knowledge, often supplemented by welfare activities by both the government and NGOs

11.2.1 Current Policy Trends and Regulation in India

The policy recommendations for the use of IPFT in India are listed below [6]–[8]:

- Encouraging investment in projects/infrastructure to support and deliver AI-based services and promoting partnerships with the private industry
- Developing integrated flagship programs such as “Niche Area Excellence” in known consortia of ICAR establishments
- In the case of ICAR, playing a bigger supportive role for implementing AI and the widespread use of AI applications for farmers by strengthening linkages with private industries. This kind of handholding and support is required for private businesses in terms of capacity building and domain consultancy.
- Supporting policies for developing competent skills in these areas; training young and middle-level scientists in AI and IoT in identified institutions abroad
- In the case of ICAR-NAARM, acting as a nodal point for providing capacity building programs in AI/IoT to the NARES which can be extended to industry and agricultural startups as well.

- Sharing of APIs enabling real-time access to data from AICRPs/KRISHI and other sources, thus creating a central data warehouse
- Creating incentives for students to pursue courses of study that will allow them to create the next generation of AI
- Separating laws made for drone flying in monitoring crops in India by the Digital Sky Platform (Director of Directorate General of Civil Aviation, India).

11.2.2 Research and Development Needed in India

- Blockchain technology for tracking and tracing of agricultural commodities from farmers to consumers
- IoT and robotic systems for applications like cold storage and supply chain logistics for monitoring and product quality assurance, fertigation, irrigation, ultrasonic sensor-based spraying system that may be developed as field prototypes as well as for commercial production
- IoT-based wireless sensor network (WSN) for pest and disease forewarning and irrigation scheduling by monitoring various parameters like temperature, relative humidity, etc.
- Models for applicability developed at the farm level for efficient drainage effluent system, root zone salinity, crop evapotranspiration, hydrology, and irrigation scheduling in greenhouses
- Term banks (terminologies/vocabularies/dictionaries) created for the agricultural domain and sub-domains in Indian languages; working for the development of a phonetic dictionary of agricultural domain terms for adaptation of speech-based systems
- Digital grading of food grains, fruits, vegetables, spices, etc. The devices will be useful if produced at low cost and easy to implement with minimum infrastructural requirement covering a wide geographical area.
- Algorithms/processes/models which have the direct application of modern tools of AI and machine learning in agriculture
- Custom hiring applications of farm equipment through a mobile app (like Uber for taxi services) to enable small farmers to make proper use of equipment on a sharing basis rather than purchasing
- Exploration of various problem domains of integrated water management system such as the estimation of actual evapotranspiration and root zone soil moisture from satellite image derived hydrological parameters, delineation of waterlogged/salt-affected cropped land, and economic losses, improving water productivity in a saline-irrigated environment [7], [8].
- Listing of all scattered knowledge resources and establishing a framework for accumulating these resources in an incremental fashion
- Need-based sensors, a kind of material that remains sensitive for many years, that must be efficient and cost-effective
- Safe disposal of field sensors
- Handy neuro-chips for farmers, similar to a kind of Fit bit

An estimate by Markets and Markets Research valued AI in agriculture to be US $432 million in 2016, and it is expected to grow at the rate of 22.5% CAGR and valued at US$2.6 billion by 2025. According to CB Insights, agricultural tech startups have raised over US$800 million in the last five years.

11.3 CONCLUSION AND FUTURE PERSPECTIVE

Globally, digital and AI technologies are helping solve pressing issues across the agriculture value chain. The relative role of each technology in creating impact is dependent on the nature of the work along with the issues at hand. From analyzing millions of satellite images to finding healthy strains of the plant microbiome, these startups have raised over US$500 million to bring AI and robotics to agriculture. India has approximately 30 million farmers who own smartphones, which is expected to triple by 2020, and 315 million rural Indians will be using the internet by 2020. An Accenture study says – digital farming and related farm services can impact 70 million Indian farmers in 2020, adding US$9 billion to farmer income. These are not futuristic scenarios; rather, they are in play today, as enabled by a vast digital ecosystem that includes traditional original equipment manufacturers (OEM), software and services companies, cloud providers, open-source platforms, startups, research and development institutions and others. Future growth is interdependent on the close partnerships and co-operation among these players.

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