

Smart Agriculture in Iran: Background, Necessities, Challenges and Solutions for Establishment

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Abstract—Smart agriculture refers to use of new technologies in agriculture and helps farmers and experts to better manage their production unit and have higher yield and productivity. Technology is the main tool in smart agriculture. In this article, which has been prepared in a documentary and analytical method, while briefly reviewing the definitions of smart agriculture and its benefits, the challenges of its entry and development in Iran's agricultural sector have been discussed in detail, and solutions to solve these challenges have been suggested as well. Agriculture is an important part of Iran's economy and plays a role in employment and gross national product. Although the use of digital technologies is being used sporadically in some agricultural fields throughout the country, due to the insufficient development of related infrastructure, the low share of the budget of this sector in financial planning and the small scale of operation, smart agriculture in Iran is in its pre-maturity stages. The introduction of artificial intelligence into Iran's agricultural sector seems necessary in the four areas of designing a model of intelligent cultivation, improving productivity through activity intelligence, improving communication between the links of the value chain, and developing data-based agriculture. Due to the fact that the third and fourth areas have received less attention in Iran, therefore, in this article, the role of smart agriculture in improving the relationship between the circles of the agricultural value chain has been analyzed in the form of data-driven agricultural development.

Keywords—Artificial Intelligence, data-driven agriculture, new technologies, value chain.

I. INTRODUCTION

ONE of the common words in developed societies is the "fourth industrial revolution" or "industry 4", which refers to rapid technological changes for the mutual and more effective connection of different circles of a business chain (industry, agriculture, services, etc.) with each other. This term, which was first used by the founder and executive manager of the World Economic Forum, Klaus Schwab, actually represents a kind of political, social and economic change, which is based on the completion of the digital developments of the late 19th and early 20th centuries, and is caused to improve people's and societies' understanding of the world around them [10]. The fourth industrial revolution is not only related to industry, but it has created a revolution in other sectors, including agriculture, through introduction and development of various sensors, robots and software, and has led to improvement of mutual communication of processes, improvement of quantity and quality of products, better preservation of environment and, finally, more capital entering to this sector.

One of Iran's strategic policies is to become an artificial

intelligence country in the region by 2032. Although the country has good environmental potential in the field of agricultural production and the role of the agricultural sector in the country's food security, the introduction of this technology into the country's agricultural sector has not been taken seriously, compared to the military and industrial sectors [14].

Based on available information, until the end of 2021, only one active company has been operating in the field of digital agriculture in the country, while experts believe that artificial intelligence and digital agriculture have the potential to improve the country's agricultural production about 25% by 2030 [15]. According to the mentioned topics, in this article, while briefly reviewing the advantages and challenges of using artificial intelligence in the country's agriculture and the need to pay attention to it, some successful examples of this novel technology in some neighboring countries have been mentioned in the frame of a comparative study.

II. DEFINITION OF ARTIFICIAL INTELLIGENCE AND SMART AGRICULTURE

Artificial intelligence is one of the sciences used in the fourth industrial revolution, which is usually defined as "the study of how computers can be made to do things that humans currently do more correctly or better" [7]. Some of the most important capabilities of artificial intelligence are as follows [17]:

- Responding to undefined or highly uncertain situations;
- Appropriate analysis regarding ambiguous messages;
- More detailed analysis of differences and similarities;
- More detailed analysis of information and presentation of more logical results;
- Being able to establish two-way communication.

In developed countries, artificial intelligence in agriculture is considered equivalent to the term "Smart Agriculture." Smart agriculture is an emerging concept in which the management of agricultural units (agronomy, gardening, animal husbandry, and fisheries) is done through using efficient and effective technological services such as Artificial Intelligence (AI), Internet of Things (IOT), drones and robots, Cloud Computing, experience and knowledge, as well as the presence of all stakeholders (public and private sectors) [12]. The purposes of smart agricultural are to improve the quantity and quality of products, timely and optimal consumption of production factors (water, inputs, labor, mechanization, etc.), reduction of risks caused by variable environmental phenomena (such as climate), reduction of production costs, improvement of the beneficiary

income or economic enterprise, and, finally, protecting the environment. The use of smart agriculture, by providing the possibility of more informed decision making for farmers and other stakeholders, will cause a sustainable improvement of productivity. It should be noted that the use of artificial intelligence in the agricultural industry will not necessarily eliminate labors or the physical presence of humans; often by facilitating the interactions among the cycles of a value chain, producers can produce their products more easily and with better quality, and consumers also get the productions more easily and cost-effectively.

III. BENEFITS OF USING ARTIFICIAL INTELLIGENCE IN AGRICULTURE

In today's global village, closed agricultural systems (without connections to other sub-sectors or other economic sectors) are fraught with inefficiencies. Contrarily, systems equipped with digital technologies, due to the high power of receiving, storing and analyzing data, have greatly increased the speed and reduced the cost of providing solutions, and by performing more transparent and accurate analyzes, enable decision makers to make more informed choices and policies in accordance with the realities of the agricultural sector. Actually, by establishing new concepts and innovation in the design and commercialization of products, these technologies have led to increase productivity in all circles of the value chain, increase farmers' income, increase productivity, reduce waste, improve supply and generally improve business performance [1]. In Fig. 1, the existing and novel technologies related to an agricultural ecosystem are shown.

Some of the most important advantages of using artificial intelligence in agriculture are:

- Improving the supply chain (from the farm to the market) and the stability of the income of the beneficiaries;
- Developing the digital communication of small farmers with each other in order to manage the supply of products to the market based on the basket (amount and type) of demand;
- Improving the health of products due to the possibility of monitoring the products supplied by each producer in each circle of the value chain
- Improving the productivity of production factors (water, fertilizers, and chemical pesticides);
- Significantly reducing the waste of products during the production chain through real-time monitoring of storage and logistical infrastructure;
- Intelligent management of risks related to natural phenomena.

IV. NECESSITY OF PAYING ATTENTION TO ARTIFICIAL INTELLIGENCE IN THE COUNTRY'S AGRICULTURAL SECTOR

Agriculture is a sector with economic priority in Iran, which more than 35% of all families are directly or indirectly dependent upon for livelihood. This sector has also accounted for approximately 9-15% of the economy's GDP, but since Iran is known as an oil producing country, the agricultural sector is

usually neglected and has always faced many challenges. Some of the most important challenges of the country's agricultural sector are [9]:

- Small-scale agriculture: According to the statistics provided by the Iranian Statistics Center (2022), about 86% of the country's farmers are operating in lands with an area of less than two hectares, which has caused the instability and fragility of this sector [18];
- Implementing less sustainable agricultural practices that have led to increasing soil degradation, putting pressure on water resources, and biotic and abiotic stresses on plants;
- Lack of water resources, drought and decrease in rainfall in recent years and lack of proper management of limited water resources;
- Lack of attention to different circles of the value chain throughout the agricultural process, such as:
 - Existence of a gap in the circles between the market and the farm and the resulting challenges regarding product pricing or its fluctuations;
 - Absence of production circles and high tendency to sell raw products;
 - Absence of appropriate circles for transportation, storage, waste recycling, etc.;
 - Lack of financial attractions for extension and dissemination of new technologies;
 - Low degrees of mechanization due to small scale of activities and lack of economic efficiency to invest capital into this sector;
 - Lack of attention to smart (digital) agriculture at farm levels.

In order to overcome the country's agricultural sector challenges, experts have proposed various solutions from water resource management to soil management and smart agriculture along with political and institutional support [8]. In this article, the smart agriculture solution has been analyzed. According to the research conducted by Huawei in 2022, the volume of the "world's smart agriculture" market has increased from 13.7 billion dollars in 2015 to about 35 billion dollars in 2021, which shows a 2.5 times increase in the volume of transactions of this market during about 6 years [19].

Also, according to the announcement of the European Union in 2021, there have been about 4,500 manufacturers with an annual turnover of 26 billion euros activating in the agricultural sector of this Union, where approximately 75% of their sales were related to digital technologies [20]. In another part of this report, it has been emphasized that the development of artificial intelligence and smart agriculture is targeted as the most important approach in improving the agricultural sector of this union until the end of 2030 [14]. In 2020, the Food and Agriculture Organization of the United Nations (FAO) announced in a warning that in the next 40 years, 90% of food security will be dependent on research and smartening of the agricultural sector [2].

Further investigations have shown that countries with somewhat similar conditions to Iran, such as India, Turkey, Georgia, and Azerbaijan, have been able to make relatively quick and valuable changes in their agricultural sector by

adopting and introducing new digital technologies such as Internet of Things, artificial intelligence, metadata, and block chain [2], [5], [11]. The presence of these technologies has

increased the share of agriculture in the gross national product of these countries.



Fig. 1 Comparison of existing and novel technologies in agricultural ecosystems [2]

Among these countries, Turkey is one of the largest hubs and agricultural partners of the European Union, which has equipped its farmers with advanced technologies for production of agricultural products to a great extent, and their use of these technologies is increasing day by day. In line with the use of artificial intelligence in agriculture, Turkey established a digital platform on April 29, 2020 with the aim of establishing direct communication between farmers and consumers. In this program, and in the first step, it was decided to supply 10% of vegetables to official markets through digital platforms. The ultimate goal of providing this platform is not only to manage the supply and demand of products to different domestic markets, but also to influence the cultivation pattern through the analysis of regional and interregional supply and demand baskets. According to the announcement of the Ministry of Agriculture and Forestry of Turkey, with the launch of the digital agriculture market, the beneficiaries will be able to plan to increase their income and improve their products' quality due to the moment-to-moment monitoring of the supply and demand of agricultural products in various qualities and different markets [5]. In addition, consumers can choose the most suitable product for themselves with access to a wide range of markets, products, qualities and prices. The digital and online tracking of the entire value chain, from seed to product, has been announced as the second goal of this program. It will cause small scale farmers to receive similar services in competitive conditions, and also sell their products to the market at the same price if the quality is equal. The third and final step of this program is the creation of zero waste along the production chain of agricultural products [5].

In another example, India, which has always faced the challenge of feeding a growing population, has recognized one of the most important ways to reduce the effects of this challenge is to eliminate the disruptions along the links of its

food production and supply chain. For this reason, in 2010, they designed a program entitled "Creating a more agile and efficient agricultural sector", which is based on the development of digital technologies in this sector. By the end of 2021, nearly 1,000 technology companies (startups) in the field of agriculture have been established in India under the name "Agri-Tech", which provides a wide range of solutions based on digital technologies in various fields of agriculture, such as financial calculations, insurance, supply of inputs, access to product quality testing laboratories, marketing, and product monitoring from field to market [2]. According to the size and population of the country, the number of companies established in this field seems low, the main reason for which is the lack of sufficient infrastructure. The Indian government has started a lot of investments to address this deficiency, so that, according to studies announced by the World Bank, India will become a regional superpower in the field of smart agriculture in the years leading up to 2030 [2]. The Indian government's approach in implementing the mentioned program is based on the following three principles [2]:

- Creating infrastructures required for the development of smart agriculture;
- Correcting data collection and proper analysis and management;
- Participation and convergence of all stakeholders to introduce the fourth industrial revolution and the benefits of establishing smart agriculture for small and large-scale beneficiaries;

Another country that has entered in the field of smart agriculture and has achieved acceptable success is the Republic of Azerbaijan, which focuses most on improving supply and distribution chains, storage, reducing losses and increasing the competitiveness of products through the development of digital technologies. In this regard, this country has taken the approach

of creating agricultural parks. Until 2021, 17 agricultural parks with an area of 104 thousand hectares had been successfully operating in this country, and according to the plans, their number will increase to 51 by the end of 2030 and the total land area will increase to 200 thousand hectares. It is predicted that the production capacity of these parks will reach one billion Manats per year at the end of 2030. The main approach in these parks is to create a complete value chain with fully connected circles through digital technologies. Currently, these parks include a combination of small and large-scale farmers' lands, who use equipment such as machines equipped with GPS and ground scanning, robots, drones, sensors, and the Internet of Things to improve field productivity. Another measure taken in the direction of smart agriculture in this country is the use of risk analysis software for short-term and long-term changes in climatic phenomena (hail, frost, floods, storms, etc.). Innovations in agriculture are not limited to technical aspects only. The Republic of Azerbaijan is trying to supply local agricultural products to global markets. "Made in Azerbaijan" program with the support of the presidency, export and promotion of agricultural products under a single brand is also on the agenda. In this regard, the government has allocated a budget for marketing and advertising inside and outside the country using digital platforms [11].

Despite the environmental potentials (variety of weather conditions and the possibility of growing different crops), a relatively large area of land, access to regional markets (including the Persian Gulf and Central Asia) and abundant educated manpower, the speed of entry and acceptance of new Digital technologies in Iran's agricultural sector has been very slow and complicated. Unfortunately, the lack of appropriate information infrastructures that provide correct statistics and information to farmers, traders and even consumers, as well as lack of an integrated policy system, are the most fundamental obstacles to the slow development of digital technologies in the country's agricultural industry [6]. The most important challenges of entering and using digital technologies in Iran's agriculture are:

- Lack of balanced and equal distribution of infrastructure related to digital technologies at different levels of supply chain circles (from farm to market);
- The small scale of agricultural and horticultural activities in the country;
- Different levels of knowledge and awareness of users in different circles of the supply chain in using digital technologies;
- Different levels of financial capabilities in different circles of the supply chain in order to supply and update digital technologies;
- The need for multi-purpose planning and policies in accordance with the technical, economic and social characteristics of different groups of beneficiaries in each of the circles of the supply chain (from farm to market);
- Problems related to legal issues and regulations of using digital technologies in Iran. For example, the use of drones requires going through long administrative procedures and obtaining permits from multiple entities. Also, the legal

mechanisms for the use of robotics, block chain, artificial intelligence, Internet of Things and social media technologies have not been properly regulated and approved.

- The lack of managerial (not technical) human resources that are able to create a common language between agricultural industry experts and technology experts. In other words, the training of human resources for the purpose of leadership and culture building in the field of digital agriculture has priority over the training of technical specialists.
- Lack of definition of study projects regarding digitalization of agriculture in rural development plans.

V. MAIN APPROACHES IN APPLYING ARTIFICIAL INTELLIGENCE IN IRAN'S AGRICULTURAL SECTOR

Considering the nature and traditional structure of the country's agriculture, the mentioned challenges, as well as the requirements of smart agriculture from the aspects of science, tools, and new technologies, it seems that the introduction of artificial intelligence into the Iran's agriculture requires a holistic approach with the aim of accelerating its adoption and utilization of these technologies by all stakeholders. Each of these groups has its own unique role. For example;

- The government can provide infrastructure and innovative policies with appropriate financing mechanisms;
- Startups can provide innovative solutions in the form of prevailing technologies.
- Companies, firms, and specialized associations can open new markets to the group of members by sharing data and creating common intellectual properties (brands).
- By providing the required capital, investors can become the foundation for the activation of entrepreneurs along the production chain.
- Farmers (small and large scale) can increase the effectiveness of smart agriculture by establishing intra-group and inter-group communication and using cost-effective smart technologies with different levels of complexity (according to knowledge and financial capabilities).

VI. BACKGROUND OF SMART AGRICULTURE IN IRAN

Despite the developed countries have entered the fourth generation of the industrial revolution with rapid advances in digital technologies, Iran is still in the transition phase from second to third generation agriculture. Although the use of digital technologies is being used sporadically in some agricultural areas in the country, but due to infrastructure problems, smart agriculture is still in its pre-maturity stages.

According to surveys carried out in 2021, the country's digital economy consists of eight main branches, and the position of agriculture, despite its high importance in the country's food security and environmental potentials, with only 8.6% of its turnover, ranks the seventh. The main challenges of not developing smart agriculture in Iran have been mentioned in detail in the previous paragraphs [21]. The research

conducted in this regard has shown that among the mentioned factors, the lack of development of related infrastructures, the low share of the budget of this sector in the financial planning and the small scale of exploitation have had the most negative contribution to this lack of development. For example, the general review of the country's budget bills during the years 2015-2021 indicates that despite the relative increase in the budget for telecommunications and digital communications, the share for agriculture in the total budget has only grown by 1.2%. This issue has caused Iran to rank 92nd among the 139 countries surveyed in 2020 and get a score of 3.7 out of 7 in terms of the Network Readiness Index (NRI), which is one of the criteria affecting the development of digital agriculture [14]. Researchers believe that this ranking does not show the lack of physical development of digital infrastructure in Iran, but it implies that the dominant view of digital infrastructure in the country is a general view, not a view as a tool for creating, developing, improving and sustaining new businesses in the agricultural sector [16]. Of course, as mentioned at the beginning of this paragraph, smart agriculture has been introduced in some agricultural fields in the country in a scattered manner, but each of them faces challenges for different reasons, the most important of which are mentioned below:

A. Smartization of Systems

These systems are mainly used in the greenhouse sector of the country. According to the statistics provided by the Ministry of Jihad Agricultural, the area of greenhouses in the country has been increased from about 6000 hectares in 1996 to about 15000 hectares in 2022 [23]. This growth has increased the attention of experts, specialists, and investors to this sub-sector and the incorporation of some new digital technologies into it. Most of the technologies incorporated into the field of greenhouses were related to automation (climate, nutrition, irrigation, carbon dioxide injection, and lighting) and in the form of hardware and software equipment (control algorithm) [22].

In the field of hardware, production systems are usually based on Programmable Logic Controllers (PLC), and manufacturers rarely design electronic boards based on the specific needs of each greenhouse. The main reason is that most of the country's greenhouses are small-scale, and their owners, due to economic and infrastructure reasons, wouldn't like to use automation systems or dedicated digital equipment, and instead prefer to use general controllers available in the market. For example, due to the delay in the development of mobile phone infrastructure, the possibility of using short message systems has recently been provided for most regions of the country in the form of digital technologies. Also, the electronic boards and systems used in the country are not very stable and due to the metal structure of the greenhouses, the height, and density of the bushes, or the climate and weather conditions governing the internal environment of the greenhouse (humidity or high temperature), lose their effectiveness gradually and even issue wrong commands in some cases [3].

B. Robots

Generally, robots are not used in Iran's agricultural sector. However, the use of this equipment has recently started in the form of research projects in the country's greenhouses (mainly for the purpose of spraying). The most important reason for the lack of development of this technology in the agricultural sector of the country is the lack of proper maneuverability in domestically designed samples.

C. Drones

Despite various advertisements, the use of drones in Iran's agriculture is mainly related to spraying. However, imaging of lands and analysis of the results is also expanding. One of the most important reasons for not using drones in Iran's agriculture is their high initial price as well as their high maintenance costs (especially the depreciation of lithium polymer batteries).

D. Internet of Things

The major application of this technology in the agricultural sector of the country is in the field of irrigation and compared to other technologies, it has had better progress. Various methods are being assessed by the researchers; in the most improved method, the sensors of soil moisture, temperature, relative humidity, sunshine hour, radiation intensity, and wind speed are installed in the field and the amount of plant evapotranspiration are calculated by receiving data from sensors in weather stations. The Irrigation requirement of each crop is calculated based on the climatic and soil conditions of the farm, and the farmer can irrigate his/her farm or garden automatically or manually. The most important challenge of this method is the lack of access to online data from weather stations and the inability to forecast the future conditions of the farm based on previous information. In addition, the equipment used in this method are relatively expensive and without the financial support of the government or investors, it will not be welcomed by the country's small-scale agricultural community. Another challenge of this method is the lack of stable coverage of Internet services throughout the day and night, which makes it difficult for the user to control the farm online at the moment [13].

VII. NECESSARY FIELDS OF THE COUNTRY'S AGRICULTURE FOR THE INTRODUCTION OF ARTIFICIAL INTELLIGENCE

Considering the potentials and challenges in the agricultural sector and the need to provide food security for the country's growing population, the introduction of artificial intelligence into the country's agricultural sector is necessary in the following four main areas:

- Designing smart crop pattern;
- Improving productivity through smartization of the activities;
- Improving communication among circles of value chains;
- Development of data-driven agriculture.

Regarding the first and second fields, a relatively large number of general and specialized articles, comments and analyzes are presented, and with a little searching, the required general and specialized information can be studied. Therefore,

their republishing in this article has been omitted. This is despite the fact that the third and fourth fields are highly regarded in the international community and increasing successes are being reported, but they have been given less attention in Iran. Due to the special position of these two areas in improving the country's agricultural situation, some materials in this regard have been analytically presented.

A. Improving Communication among Circles of the Country's Agricultural Value Chain

In Iran, agriculture, horticulture, fisheries and aquaculture, animal husbandry and greenhouses are the main sub-sectors of the agricultural sector, which studies have shown that all of them usually face serious challenges throughout their value chain as follows [8]:

- *Post-harvest losses in storage and transportation:* A significant part of the product is wasted due to long transportation time, temperature fluctuations and pollution.
- *Inadequate supply of quality products according to buyers' expectations:* At the time of delivery, buyers are often faced with products that do not meet the necessary quality standards and do not meet their expectations. Currently, due to the unplanned presence of middlemen in the value chain, various products are generally offered without quality separation and in non-scientific and standard ways.
- *Weak ability to trace the origin:* Normally, as the products move along the chain, the information about the origin of their production and transportation is lost. This is critical since sometimes buyers may need to resupply the product directly from the producer, or verify the origin of the supplied products, or even track the producers in case of food safety risks.
- *Market transparency:* In Iran, the main circles of production, distribution and consumption (producers, intermediaries and buyers) have difficulty in communicating with each other in form of a transparent chain. For this reason, most buyers resort to non-standard supply centers in order to meet their demand at lower costs, which in many cases do not have a sufficient balance between the price paid and the product received, and most buyers express dissatisfaction. On the other hand, in order to reach the market or remain in it, farmers have to offer their products at a low price and of course in an uncertain quality, or choose a high price for their products by offering high quality and special products. This type of performance by buyers and farmers ultimately makes value creation along the value chain highly vulnerable and increases the risks of chain inefficiency.

One of the solutions to reduce the aforementioned challenges is to move towards smart (digital) agriculture and use platforms that facilitate communicating and adapting among the main circles of an agricultural value chain (producers, suppliers, requesters, traders, whole and partial intermediaries, and the final consumer). These platforms can be made available online at local, regional or even trans-regional scales as follows:

- *Local or regional platforms:* In fact, these platforms connect manufacturers, suppliers, intermediaries, and

buyers (in a way, retailers with local consumers). These platforms require appropriate investment in the financial and infrastructure aspects to develop the scale and reach as many members of local or regional circles as possible. If this does not happen, these platforms will mainly promote electronic retail sales. However, on the same scale, they may significantly increase the economic and financial attractiveness of the agricultural sector. Examples of these platforms are currently running in different rural areas of India, Turkey and Azerbaijan.

- *Trans-regional platforms:* In fact, it is a type of hyper-platform whose main purpose is to facilitate direct communication between farmers and consumers, which, due to the elimination of intermediaries as much as possible, leads to the promotion and improvement of farmers' income. The successful example of these platforms is related to India, where their widespread application began about 10 years ago, and according to the estimate of the Indian National Government, it is predicted that in a 20-year period (leading to 2030), approximately 57-70 billion dollars as added value to the agricultural sector of this country would be achieved [2]. It is also predicted that during this period, about 61-75 million farmers who constitute 35-43% of the agricultural workforce in India will benefit from these platforms. These platforms are strictly under the supervision and support of the national government of India. The most important role of the government in these platforms is monitoring to ensure fair pricing of products for farmers and consumers. Although examples of these platforms are being created and expanding in Iran in the form of chain hypermarkets, most experts believe that these platforms are still not mature enough in terms of effective communication between the producer and the final consumer, and the government's supervision is not performed well. It is necessary to improve their functional maturity with the support of the government and the entry of more funds, along with the awareness of producers and consumers about the benefits of such platforms [2].

B. Development of Data-Driven Agriculture Using Artificial Intelligence

By definition, data-driven agriculture is a type of strategy based on new digital technologies in which decisions follow the facts and real data in the circles of a chain instead of instinct, experience, and inner feelings. Basically, in this strategy, the information of decision-making is provided through data and processes and verified by experience or direct knowledge [4]. It should be noted that the use and influence of data in decision-making, before it is a technical and technological topic, is a business approach that will lead to better and less risky decisions due to the clear communication among different circles of a chain. In this strategy, data are used based on a set of digital communication principles, including the possibility of using standard data, respect for information exchange protocols, macro policies of countries, and respect for the privacy of all stakeholders.

Although Iran's economy is moving towards digitalization at a relatively fast pace, the agricultural sector has not yet reached the maturity stage and is in the lower ranks of this market due to the challenges mentioned in the previous sections. The existence of numerous retail markets, decentralized transport companies with different service qualities and costs, and lack of a workforce with knowledge in the field of digital economy confirm the above claim. It should be noted that the challenge of Iran's smart agriculture, beyond the slow speed of its digitization, is the severe lack of correct and processable data. If, even with short, medium and long-term arrangements and

plans, the speed of incorporation of digital equipment (hardware and software) into the agricultural sector improves, but the market participants cannot use metadata, it is still not possible to create more value in this sector. In digital environments, stakeholders in the circles of a value chain (companies, beneficiaries, intermediaries, buyers, consumers, etc.), record many data and transactions weekly or monthly. But, if they cannot share their data with each other - assuming privacy owners and owners of transactions, the possibility of maximum exploitation of the created digital market will not be provided.

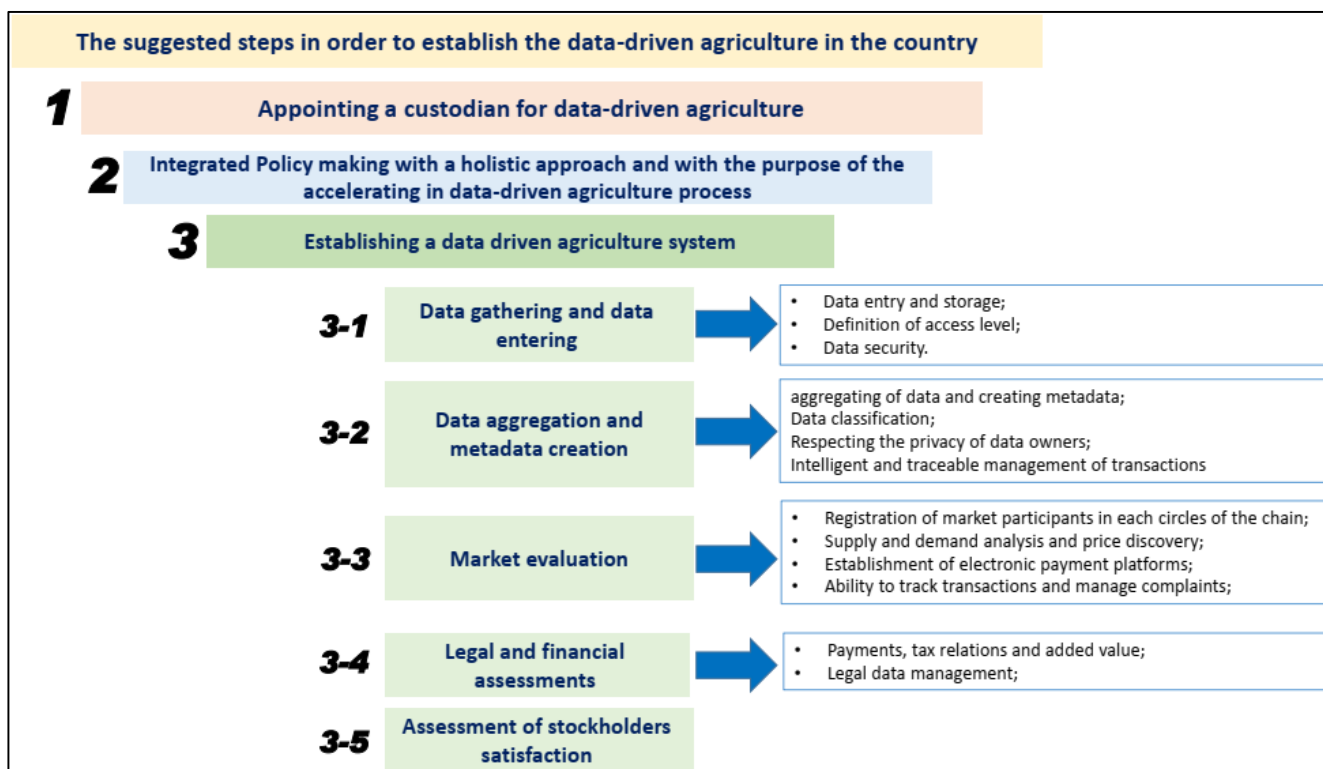


Fig. 2 Initial suggested steps to establish data-driven agriculture in Iran

Currently, various countries, including India, have started making huge investments in data-driven agriculture. According to a research conducted by McKinsey and the National Association of Software and Service Companies of India (NASSCOM), there is an opportunity of 65 billion dollars in the agricultural sector in this country, which can be realized if entering into data-driven agriculture is achieved. Based on this, 7 main fields for data collection were identified as follows, and NGOs, government organizations, and users of different sub-sectors were used to collect data [2]:

- Weather conditions (rainfall, humidity, hours of sunshine, intensity of radiation, temperature, wind, etc. in different areas);
- Soil condition (texture and fertility, nutrients, physical and chemical properties);
- Land use (irrigated and rain fed) and types of crops produced;

- Yield and production contents by crops in different regions;
- Product specifications including appearance defects, type of use (fresh or industrial), durability, production time, etc.;
- Product storage network including storage locations and capacities, tariffs, transportation costs, etc.;
- Agricultural market network:
 - Daily purchase prices by crops, market, and supplier (farmer, middleman, etc.);
 - Volume of import and export based on time and place.

At a glance, such information is also available in various sub-sectors of Iranian agriculture, but in practice, due to serious weakness in data management, it will be very difficult to access a set of them as reliable data. The main reason for this weakness is lack of a single trustee and integrated national system in various fields of agriculture, which itself originates from the lack of data-driven approaches in the management fields related to agriculture in the country. Considering the useful experiences

of the countries in the region regarding the establishment of data-driven agriculture and also inspired by the samples implemented in India, it seems that the following steps can be suggested for the establishment of data-driven agriculture in the form of the following diagram. It is obvious that the presented steps are only suggested according to the author's point of view and the consensus of other specialized experts and strategists can be modified or supplemented.

VIII. CONCLUSION

"Fourth industrial revolution" is a term that is not only related to the field of industry, but also in other sectors including agriculture, due to the introduction and development of various technologies, has led to the improvement of the mutual communication of the processes, the quantitative and qualitative improvement of the products, the better protection of the environment and the promotion of stable income for the beneficiaries of this sector. Based on the general policies of the Islamic Republic of Iran, planning should be done in such a way that by 2032, the country will become an artificial intelligence power in the region in various fields, including agriculture. Artificial intelligence in agriculture is equivalent to the term "smart agriculture" in which the management of agricultural units is carried out using efficient technological services. Since about 9-15% of the country's Gross Domestic Product (GDP) is provided by the agricultural sector, taking advantage of new technologies such as artificial intelligence can help greatly in improving the quality and quantity of products as well as the stability of the economic indices of this sector [24]. Artificial intelligence can be incorporated in the four areas of "Designing a Smart Cultivation Pattern", "Increasing Productivity through Intelligence", "Improving Communication among the circles of Value Chains" and "Developing Data-Driven Agriculture" in the country's agricultural sector. Regarding the first and second areas, positive steps have been taken in the country, but regarding the third and fourth areas, the country's agricultural sector needs more detailed investigations, a stronger presence of elites, investors, and technological companies. In this article and in order to improve communication among the circles of the country's agricultural value chain, to use local, regional and trans-regional smart platforms, and in order to develop data-driven agriculture, establishment of a national integrated system and also creation of an agricultural data market have been recommended in a three-step process.

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