Intelligent and Natural Agriculture With Industry 4.0

Alper AYTEKİN[*,1], Ahmet AYAZ[1], Fatma TÜMİNÇİN[1]

[*1]Bartın University, Faculty of Economics and Administrative Sciences, Department of Management Information System,74100, BARTIN

Abstract

It is estimated that by 2050 the world population will increase by one third. Most of these people will continue to live in developing countries. This means that more people will live in cities. According to FAO, if current revenues and consumption increase continue, agricultural production is expected to need 60% additional production to meet the expected demands for food and feed. Therefore, the agriculture and food sector must transform itself to feed the ever-increasing global population. It should be noted that this process will be very difficult given that climate change will also require additional costs. It has become mandatory to use intelligent systems both to manage this process and to meet the needs. To do this, it need to take advantage of all the facilities offered by Industry 4.0. With technologies that make things easier by increasing the productivity of the producer, profit and quality in agriculture has become even smarter. In this study, a general analysis of the future of the agricultural sector is made, and the possible consequences of intelligent and natural agriculture with Industry 4.0 are discussed.

Keywords: Industry 4.0, Internet of Things, Robotic Agriculture Systems

Endüstri 4.0 ile Akıllı ve Doğal Tarım

Öz

2050 yılına kadar dünya nüfusunun üçte bir oranında artacağı tahmin edilmektedir. Bu insanların çoğu, gelişmekte olan ülkelerde yaşamaya devam edecekler. Bu da daha fazla insanın şehirlerde yaşayacağı anlamına gelmektedir. FAO'ya göre mevcut gelirler ve tüketim artışı bu şekilde devam ederse, tarımsal üretimin gıda ve yem için beklenen talepleri karşılamak adına %60 oranında ek üretime ihtiyaç duyulacağı öngörülmektedir. Bu nedenle tarım ve gıda sektörü, sürekli artan küresel nüfusu beslemek için kendisini geleceğe hazırlamak zorundadır. İklim değişikliklerinin de ek maliyetler gerektireceği düşünülecek olursa, bu sürecin oldukça zor olacağı bilinmelidir. Hem bu süreci yönetebilmek hem de ihtiyaçları karşılamak için akıllı sistemler kullanmak zorunlu hale gelmiştir. Bunun için Endüstri 4.0'ın sunduğu tüm imkanlardan faydalanmak gerekmektedir. Üreticinin verimliliğini artırarak işleri kolaylaştıran teknolojiler sayesinde, tarımda kar ve kalite daha da akıllı hale gelmektedir. Bu çalışmada, tarım sektörünün geleceği ile ilgili genel bir analiz yapılmış, ek olarak akıllı ve doğal tarımın Endüstri 4.0 ile olası sonuçları tartışılmıştır.

Anahtar Kelimeler: Endüstri 4.0, Nesnelerin İnterneti, Robotik Tarım Sistemleri

*Sorumlu Yazar (Corresponding Author):
Alper AYTEKİN (Dr.); Bartın University, Faculty of Economics and
Administrative Sciences, Department of Management Information System,
74100, Bartın-TURKEY. Tel: +90 (378) 223 5357, E-mail: aytekin@bartin.edu.tr,
ORCID: 0000-0002-2756-7870

1. Introduction

The developing technology has taken place in the agricultural sector which is important for the society as well as in every field of life and has continued to take it rapidly. Technology has become an indispensable tool in agriculture in order to increase the speed and productivity in agricultural production in the face of increasing demand. The use of the Internet in many areas and the fact that it became widespread with the expression internet of things (IoT) 'started to form the fourth industrial revolution and this revolution was named after the Industrial 4.0 revolution. With this revolution; catching the developing and advancing age and technology is important in the agricultural sector as it is in all other sectors and it is aimed to minimize the risks in agricultural production and to decrease the costs besides the increase in productivity (Akay, 2019). The fourth industrial revolution in the early 21st century is based on digital transformation. This revolution is characterized by concepts such as a more widespread and mobile internet, sensors that have become smaller and more powerful and cheaper on the one hand, artificial intelligence and machine learning. Digital technologies, which are based on computer hardware, software and networks, are not new, but they are becoming more sophisticated and integrated, unlike the third industrial revolution, and thus have the potential to transform societies and the global economy (Schwab, 2016). One of the methods that can be taken to overcome the hunger problem is to approach the problem through the agricultural sector in this period of rapid technological developments. Rapid technological development and innovation can be expected to meet the future food need in a sustainable manner. (Food and Agriculture Organization-FAO, 2017). Recent research by the (McKinsey Global Institute, 2017) shows that the agricultural sector has the lowest digital penetration rate compared to any industrial sector. Although the agricultural sector is far behind in adding efficiency and new services, it is necessary to accelerate the digital transformation in agriculture without wasting time.

2. Smart Agriculture

Agriculture is one of the most important issues for each community and on the world. Technology will be continuing to be an integral part of this important sector. With the introduction of the Internet of things, one of the components of Industry 4.0, into the agricultural sector, all agricultural machinery, from tractors to product tools, are equipped with sensors, so that agricultural machinery communicates with each other throughout the entire production process. With agricultural tools and fields equipped with digital sensors, to farmers, to what areas and what kind of fertilizers should be put, weather conditions, the minerals and plants needed, soil condition, estimated time of harvest by showing the detailed and real-time demonstration is aimed to maximize. Workload and cost are reduced with machines that work together and synchronously. Agricultural production, which is already productive thanks to technology in Europe, will become even more productive with the agricultural revolution, which is one of the results of Industry 4.0 and which some large companies call Agriculture 4.0, and by spreading this understanding to the world, smart people will quickly and cheaply produce the highest quality products (Kahraman, 2019). Farmers began to use some advanced agricultural techniques and technologies to improve the efficiency of their day-to-day jobs. For example, sensors placed in agricultural areas allow farmers to obtain detailed information about the acidity and temperature of the soil along with the topography and resources in the region. They can also access climate forecasts to predict weather conditions for the coming days and weeks. Farmers can use their smartphones to remotely monitor their plants and animals, and also predict their future by compiling statistics on feeding and producing their animals (Meola, 2016). With the internet of things, it is aimed to increase productivity in the agricultural sector. In this way, natural resources are used as much as necessary, thus reducing costs. Similarly, the use of intelligent systems in farms enables the analysis of the factors necessary for production and presents them simultaneously to the manufacturer. Thus, by using natural resources efficiently, the quality of the products is ensured. In addition, it allows machines to be in contact with each other and allows for quick decision-making mechanisms. The reason for the decrease in the labor force on the farm is that the producer has the opportunity to manage and monitor all work from a tablet or phone. Thus, fun, high quality and natural production opportunities are created. Technological innovation is not a new concept for agriculture. With industrial revolutions, chemical fertilizers, tractors and even satellite images have been used in agriculture. The next level of agriculture will take place with the internet of objects. High-tech agriculture is growing rapidly thanks to drones and sensors in intelligent farming, which has become widespread among farmers. There is a wide range of technologies to ensure the use of robots in agriculture. The existing technologies developed for other areas can be adapted for agricultural areas. Especially, technologies such as autonomous vehicles, artificial intelligence and machine vision need to be developed for agriculture. Today, farms have very different infrastructure, so early robots can operate in a limited amount in farms. In the future, it is likely that multi-purpose robots capable of performing many different tasks, adapted for a specific task similar to the existing vehicles used in farms. Most of the existing robotic platforms have become a common challenge since they are not resistant to natural elements such as rain, fog, mud, low and high temperatures. For example, the equipment of the manipulators is insufficient to deal with moisture in greenhouses (Duckett et al., 2018). Agricultural robots enable farmers to focus on increasing overall production efficiency by automating slow,

repetitive and tedious jobs. Some of the most widely used robots in agriculture are: harvesting and harvesting; autonomous mowing, pruning, seeding, spraying and thinning; weed control; Phenotyping; sorting and packing; can be expressed as auxiliary platforms. Indoor and outdoor harvesting and picking is one of the most popular robotic applications in agriculture because of the accuracy and speed that robots can achieve to increase yield and reduce waste from crop crops in the field. However, the automation of these applications can be difficult due to harsh conditions, including vision systems, the presence of dust, variable light intensity, temperature fluctuations, and wind-induced movement (Robotics Online, 2017).

Figure 1. In the future robotic agriculture systems (Duckett et al., 2018)

Smart agriculture and precision farming are taking off, but they could just be the precursors to even greater use of technology in the farming world opening doors to the development of farming drones. In another application for the internet of things, the temperature values of the cultivated soil can be monitored instantaneously, and more efficient decision can be made about the cultivation, irrigation and harvesting of the agricultural product. As shown in the figure 2, there are 4 different levels of temperature sensor on a ground pile. These sensors send the temperature values of the current level to the sensor box so that the data in the sensor box can be uploaded to the cloud and the data can be accessed instantly via the smartphone (Meola, 2016).

Figure 2. Control of soil condition via smart phone and sensors.

Intelligent and precise agriculture will be a pioneer in the use of technology in the world of agriculture. BI Intelligence, Business Insider's premium research service, predicts that in 2015, IoT devices in the agricultural world will increase to 30 million, while it will reach 75 million in 2020, a 20% annual growth rate (Meola, 2016).

3. Analysis of Food and Agriculture Industry

3.1. Current State

SWOT Analysis, in short, means evaluating the internal and external aspects of a particular situation or event. The internal situation is firstly analyzed, and the strengths and weaknesses are discussed. Then, external situation analysis can be done to determine the opportunities and threats that may arise as a result of this situation (Aktan, 2008). Sezer (2018) conducted a SWOT analysis on the food and agriculture sector. All results of the SWOT analysis are taken from this study (Table 1).

Table 1. Evaluation of SWOT Analysis on Agriculture Industry.

Strengths	Weaknesses
Developments in irrigation techniques (Madeira, 2017). Innovations in biotechnology (Sachsenmeier, 2016). Breakthroughs to be made in the area of fertilization (Paravan, 2016). Production of innovative methods and techniques in agriculture (Dexia, 2010).	Decreased productivity in agriculture. Due to the increasing structure of food prices, the increase in the interventions on foreign trade such as bans, quotas and taxes on the agricultural sector cause ineffective distribution systems in agricultural trade, According to the current land use data on a global scale, land suitable for agricultural production is currently being used. The use of traditional intensive farming methods leads to the deterioration of the agricultural land (Dexia, 2010). The food and agriculture sector are slow compared to other sectors at the point of benefiting from the technology power that emerged with the industry 4.0 process. For instance, while the level of attractiveness of technological investments is clearly lower, it is also stated that the number of innovative companies based on technology is relatively low. The lack of attractiveness of the agricultural sector as a profession, the lack of viable and attractive jobs in the agricultural sector for young people (WEF, 2018).
Opportunities	**Threats**
Innovations such as smart applications, indoor or urban farming can allow consumers to consume healthy and at the same time reasonably priced foods in a manner that is similar to the comfort of prepared foods. Because of advances in nutrigenetic field, dietary and health needs, taste preferences, nutrition recommendations adapted to the digestive ability can be given. Big data technology can facilitate overall cost accounting by informing policy decisions and changing consumption patterns in favor of the agricultural sector. Connection technologies such as social networks and online e-commerce can provide platforms that will significantly affect consumption patterns and increase access to nutritious food. Consumers who are informed about the environmental and nutritional content of these foods with the blockchain (block chain) technologies in the production and consumption of certain foods may require minimum sustainability and health needs to be met. Embedded microscopic electronic devices such as radiofrequency identification and genetic markers can serve as future barcodes. Thus, when used with mobile phones, they can offer instant access to the freshness, maturity, shelf life or nutritional content of the food. Mobile payments provided by block chaining can provide targeted health and nutrition subsidies efficiently and social networks can enable public health campaigns (WEF, 2018). As part of advances in the field of biology, and as part of advances in the field of gene sequencing, organisms can be personalized as a result of writing DNA. As a result, this will affect the production of agricultural products. Because of the developments and advances in autonomous vehicle technology and artificial intelligence technology, the efficiency of fertilization and water use can be increased with the use of drones developed for the food and agriculture sector. Because of improvements in the gene sequence, it will be possible to modify the animals so that they can be grown in a more economical and more suitable diet conditions, as well as to produce food products that can withstand extreme temperatures or drought (Schwab, 2016).	Increased environmental concerns, including the need to overcome climate change and the sudden rise in oil prices, have led to an increase in interest in the production and consumption of biofuels. Increasing demand for biofuels leads to the limitation of the potential agricultural land needed for the development of agricultural production. beet and sugar cane. As a result, 30% of the US corn production is used for ethanol production, while 9% of Europe's agricultural land is used for biodiesel. Climate change is expected to cause irreversible negative effects on food safety by disrupting the agricultural structure in the long term. The current agricultural land is facing the threat of degradation and destruction due to industrial pollution. The increasing structure of urbanization on a global scale leads to a decrease in the lands that can be used for agricultural production (Dexia, 2010). The absence of a common narrative that can articulate the opportunities and challenges of the 4th Industrial Revolution in a clear and straightforward manner can reveal a popular reaction to this process of transformation. There is no institutional framework that can regulate the progress of innovation at the national and global level, and which can alleviate the deterioration it will emerge .The level of leadership that can reconsider our economic, social and political systems in terms of all sectors is at an inadequate level compared to the size of the transformation that is expected to occur with the process of Industry 4.0 (Schwab, 2016). Although impacts are expected at different scales in different regions of the world, it is concluded that climate change will result in decreasing agricultural yield and leading to significant decreases in world grain production (Stern, 2006). Increased pressure on food supply due to the increase in global population (Brown, 1997).

3.2. Future

Smart Agriculture is an agricultural management concept that uses modern technology to increase the quantity and quality of products. Thanks to smart farming, farmers have access to GPS, soil scanning, data management and Internet of Things technologies. For example, farmers using Smart Farming techniques can monitor the needs of individual animals and adjust their feeding accordingly, thus preventing disease and maintaining herd health.

More professional skills are needed to use new agricultural technologies. In addition to the human resources that can use it, it is inevitable that this skill should be in the farmer.

The agricultural industry must undergo significant transformations to tackle both food safety and climate change challenges.

The basic technologies that farmers needs are: Sensors, Software, Hardware, GPS and Location Technologies, Communication Tools and Data Analysis Systems (Fig 3).
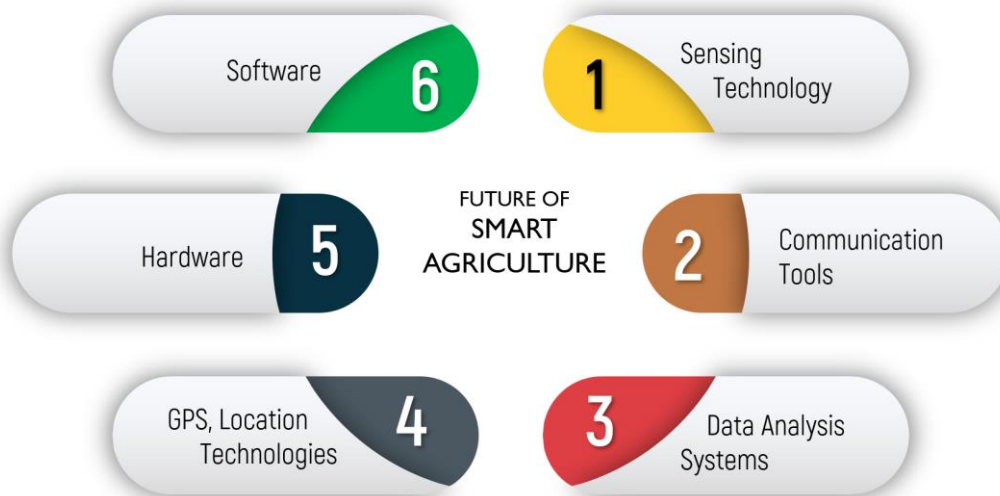

Figure 3. Technologies for Smart Agriculture

The measures to be taken are as follows:

Increasing Productivity: Food and nutritional safety should be increased. Natural agriculture should be done for this. The main goal here is to get more output with less input. Resources should be used more effectively.

Enhanced flexibility: Resistance to drought, pests, diseases and other natural disasters needs to be increased. It is necessary to be able to adapt immediately to irregular seasons and weather conditions and to prevent the decrease of production capacity.

Reduced emissions: Lower emissions are inevitable for each calorie food produced. It is necessary to prevent deforestation as soon as possible and discover new ways to remove carbon from the atmosphere.

With the Internet of Things, making smart farming has become easier. However, in order to optimize this process, these devices connected to the internet and communicating with each other continuously need to work flawlessly in a loop. The Smart Agricultural Cycle can be described as follows: Observation, Diagnosis, Decisions, Action (Fig 4).
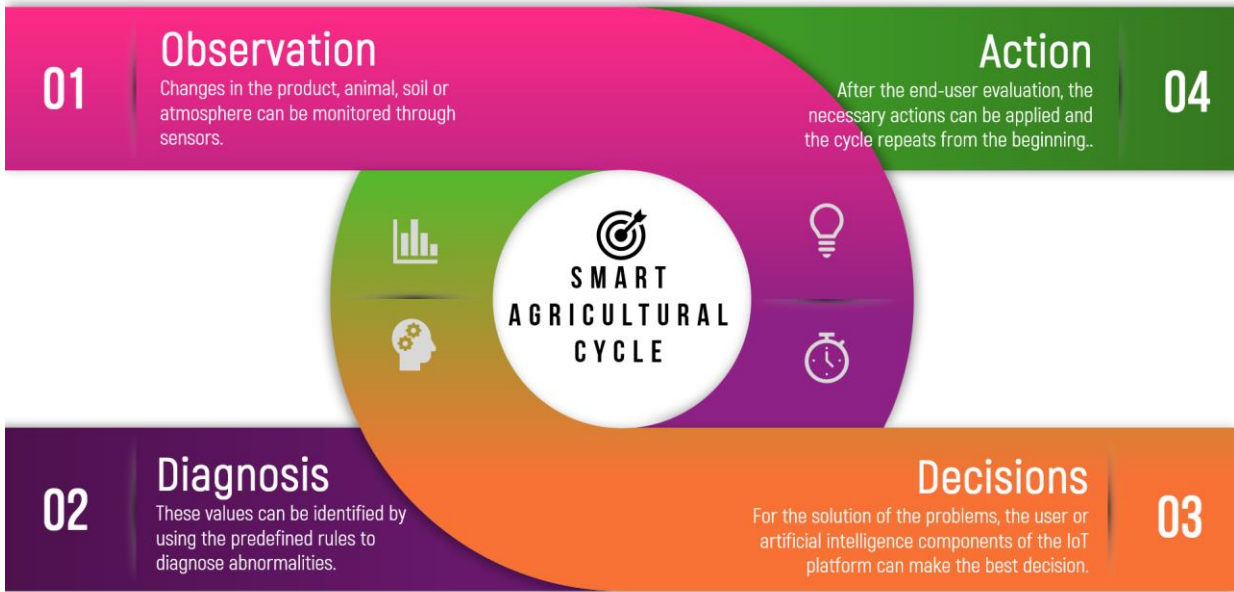
01 Observation
Changes in the product, animal, soil or atmosphere can be monitored through sensors.

04 Action
After the end-user evaluation, the necessary actions can be applied and the cycle repeats from the beginning..

SMART AGRICULTURAL CYCLE

02 Diagnosis
These values can be identified by using the predefined rules to diagnose abnormalities.

03 Decisions
For the solution of the problems, the user or artificial intelligence components of the IoT platform can make the best decision.

Figure 4. Technology Based Smart Agricultural Cycle

Automation in Smart Greenhouses; Production, energy loss and increased labor costs are often seen as a result of manual intervention against environmental impacts in traditional greenhouses. In smart greenhouses, as well as controlling the climate, there is no need for manual intervention since the monitoring is used intelligently. The necessary parameters for the efficient production of the product are determined by means of various sensors. These data are transferred to a cloud-based environment for evaluation.

Agricultural Drones; Since drones collect thermal and visual images while flying, plant health indexes for farmers, chlorophyll measurement, plant count and yield estimation, field water pond mapping, drainage mapping, exploration reports, stock measurement, plant height measurement, nitrogen content in wheat, weed pressure mapping they provide a lot of information. Therefore, drones will be indispensable agricultural vehicles of the future.

4. Discussion and Evaluation

The deep uncertainties surrounding the development and adoption of emerging technologies are the biggest signs that we do not yet know exactly how the transformations caused by this industrial revolution will occur. The complex nature of the emerging technologies and the fact that they have a characteristic that connects many sectors puts the responsibility of acting together to better understand the emerging trends for governments, business, academia and civil society (Schwab, 2016; Sezer, 2018). It is seen that the innovations made in the food and agriculture sector have the potential to change the traditional working style of this sector. It is possible to ensure food safety by increasing food supply by innovations in fields such as fertilization and irrigation directly related to the sector itself. Besides, smart applications, robotics technologies, gene science and biology developments are expected to contribute to the sector by changing consumption habits and working methods (Sezer, 2018). In the future, we will have the opportunity to monitor the whole farm with cloud-connected and unmanned aerial vehicles, such as controlling natural elements such as humidity and temperature, preventing unnecessary use of resources such as water and electricity, and reducing water pollution. In addition, it will be possible to simultaneously evaluate the production performance and analyze all the products and resources in the farm in detail. The internet of things in agriculture will increase in productivity with the spread of technology. Advanced technology and the analysis of undesirable substances such as heavy metals in the soil, remote operation and control capability, protection of natural resources and green energy, the possibility of harvesting of products from decay are the main objectives of the companies in the agricultural sector and with the renewal of the machines with the industrial revolution, more and more quality and productive agriculture will be carried out every day. When smart agriculture can be implemented with all its components, it can undoubtedly bring great benefits to living life and environmental problems through more efficient use of water or optimization of processes and inputs. Will be able to produce effective solutions to the problems of effective use of global resources and nutrition that will emerge with the increasing population of the world. What needs to be done is to make smart agriculture economical, convenient and more accessible to all users.

With Smart Agriculture, the foundation of what could be called the third Green Revolution is laid. After plant breeding and genetic improvements, the Third Green Revolution agriculture will emerge. This revolution, intelligent agricultural equipment, drones, IoT, robotics, "big data" analytics and so on. It is based on the combined application of data-based analytical technologies.

Smart agriculture therefore has real potential to provide a more productive and sustainable form of agricultural production based on an efficient resource-efficient approach.

References

1. **Akay, M. (2018).** Endüstri 4.0 İle Akıllı Tarıma Geçiş.
2. **Aktan, C.C. (2008).** Stratejik Yönetim ve Stratejik Planlama, Çimento İşveren Dergisi, 22(4), 7.
3. **Duckett, T., Pearson, S., Blackmore, S., & Grieve, B. (2018).** Agricultural Robotics: The Future of Robotic Agriculture. Retrieved from www.ukras.org
4. **Brown, L.R. (1997)**. Facing the challenge of food scarcity: Can we raise grain yields fast enough? In: Ando T., Fujita K., Mae T., Matsumoto H., Mori S., Sekiya J. (eds) Plant Nutrition for Sustainable Food Production and Environment. Developments in Plant and Soil Sciences, vol 78. Springer, Dordrecht
5. **Dexia Asset Management (2010).** Food Scarcity- Trends, Challenges, Solutions.
6. **FAO (2017).** The future of food and agriculture – Trends and challenges. Rome.
7. **Kahraman, M. (2019).** Endüstri 4.0'la Birlikte Gelen Akıllı Tarım, https://www.endustri40.com/endustri-4-0la-birlikte-gelen-akilli-tarim/
8. **Madeira, J. (2017).** Compta and Grundfos organize an international IoT event in Portugal, https://www.ceb-solutions.com/compta-grundfos-organize-international-iot-eventportugal/
9. **Meola, A. (2016).** Why IoT, big data & smart farming are the future of agriculture, https://www.businessinsider.com/internet-of-things-smart-agriculture-2016-10.
10. **Paravan, C. (2016).** Leveraging new opportunities in the fertilizer industry, https://blogs.siemens.com/en/competitive-industries.entry.html/28288-leveraging-newopportunities-in-the-fertilizer-industry.html.
11. **Robotics Online (2017).** "Robotics in Agriculture: Types and Applications", https://www.robotics.org/blog-article.cfm/Robotics-in-Agriculture-Types-and-Applications/74, 7 Kasım, 2019.
12. **Sachsenmeier, P. (2016).** Industry 5.0-The Relevance and Implications of Bionics and Synthetic Biology, Engineering, 2, 225-229.
13. **Schwab, K. (2016).** The Fourth Industrial Revolution. Switzerland: World Economic Forım.
14. **Sezer, F (2018)**. Endüstri 4.0'ın Gıda Kıtlığı Sorununa Olası Etkileri, 4th SCF International Conference on "Economic and Social Nevsehir Impacts of Globalization" and "Future of Turkey-EU Relations", 26 April, 182-187.
15. **Stern, N. (2006).** The Stern Review on the Economics of Climate Change. Government of the United Kingdom.
16. **World Economic Forum (WEF) (2018).** Innovation with a Purpose: The role of technology innovation in accelerating food systems transformation. https://www.weforum.org/reports/innovation-with-a-purpose-the-role-of-technologyinnovation-in-accelerating-food-systems-transformation.