SUSTAINABILITY OF AGRICULTURE: AGRITECH PRACTICES

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ABSTRACT

Agriculture is a fundamental sector for a global economic and social development. It provides food, fiber, and raw materials for industries and contributes to the livelihoods of millions of people worldwide. However, agricultural production faces several constraints such as climate change, limited resources, and population growth, among others. These challenges require sustainable solutions to ensure food security, maintain ecological balance, and improve livelihoods. Agricultural technologies provide innovative approaches to overcome these challenges, enhancing productivity, efficiency, and profitability. This paper provides a discussion that agricultural technologies could be a viable and sustainable solution for agricultural production constraints.

***Keywords**: Agriculture Technologies, Sustainability, Production Constraints, Climate Change, AgriTech*

INTRODUCTION

Agriculture plays a vital role in ensuring food security and economic development, especially in developing countries. However, climate change has emerged as a significant constraint to agricultural production as extreme weather events and shifts in temperature and precipitation patterns can negatively affected crop yields and quality. According to United Nations, unsustainable agricultural practices have resulted in 40% of the land degraded for productive agriculture while 90% of the world's overall topsoil further at risk by 2050. Agricultural production requires 70% of the world's fresh water supply which may put 50% of world population under water stress by 2025. Addressing these challenges, innovative agricultural technologies have been developed and implemented around the world holding a significant potential to increase productivity and sustainability in the sector. Spherical Insights released a report on the Global Agritech Market Size dated September 2022 and cited an estimation for the AgriTech market $19.5 billion for 2021 and $46.4 billion by 2030. This paper explores the role of agriculture technologies as a sustainable solution for agricultural production constraints with a focus on potential impacts of climate change. Additionally, this paper provides contributions to promote sustainable agriculture and mitigate the negative impacts of climate change on agricultural production with AgriTech investments.

HISTORICAL OVERVIEW OF AGRICULTURAL TECHNOLOGIES

It started 14000 years ago when human beings domesticated the land and animals and started using efficient breeding methods. Industry 1.0 is considered to have started with the invention of the first steam engine in 1763. The first effects of Industry 1.0 on the agricultural sector were seen with the use of tractors in agriculture in the early 19th century. The reflection of industry 2.0 and 3.0, which started mass production with the beginning of the use of electricity in production and expanded to mass production, on the agricultural sector was seen as the mechanisation of agriculture during the 20th century. With industry 4.0, smart farming methods such as precision farming, traceability and cyber systems have started to be used in the agricultural sector. Therefore, it may be proposed that industrial and agricultural revolutions overlapped each other for the first time in Industry 4.0 era. Figure 1 shows the comparative phases of industrial and agricultural revolutions.

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CONSTRAINTS ON AGRICULTURAL PRODUCTION

Agricultural constraints refer to limitations or challenges that hinder the productivity and growth of agricultural activities. These constraints can be caused by a variety of factors, including natural disasters, climate change, lack of access to technology, inadequate infrastructure, limited access to markets, and limited funding. Agricultural production faces several constraints that limit productivity, efficiency, and profitability. These constraints vary across regions and crops, but some of the main ones are climate change, limited resources, soil der-gradation and pests and diseases.

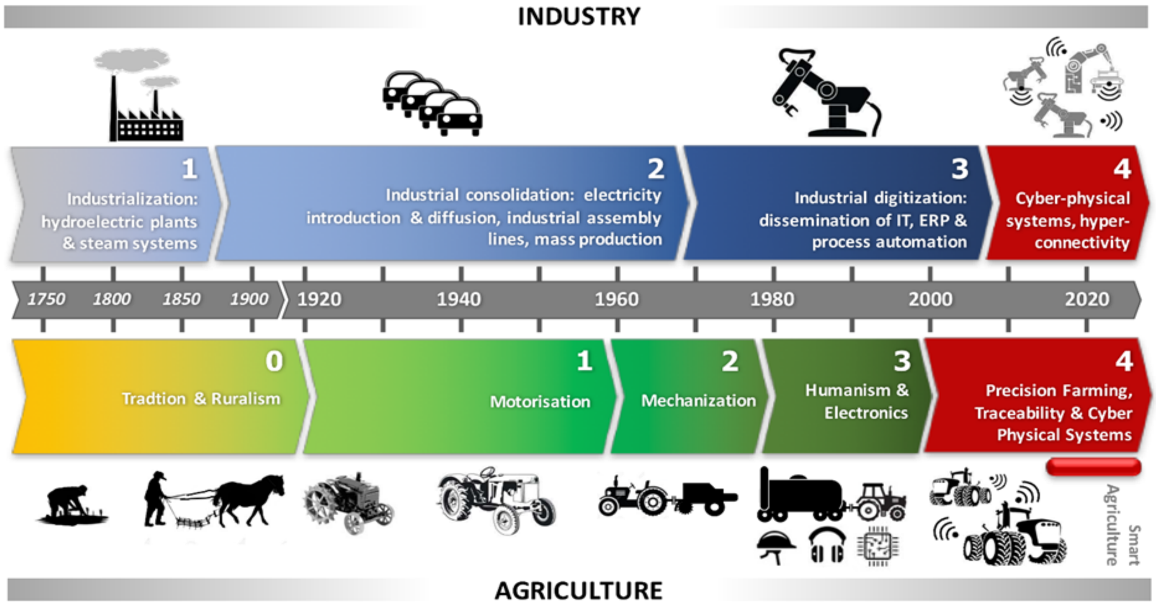
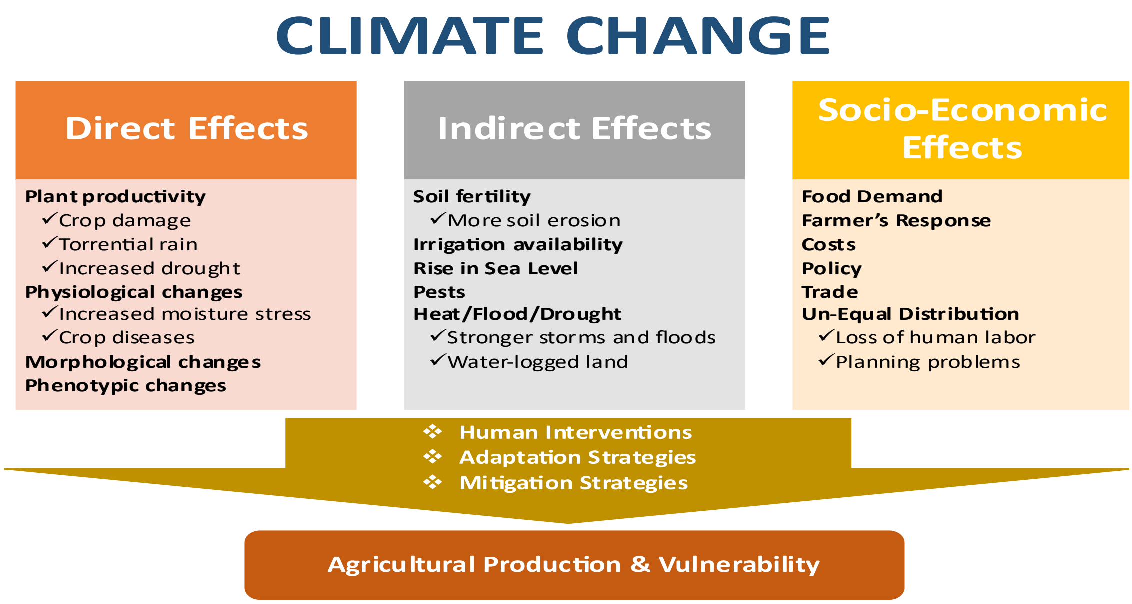


Figure 1. Phases of industrial and agricultural revolutions

Climate Change: Climate change has adverse effects on agricultural production causing droughts, floods, and pests, among others. The unpredictable weather patterns affect crop growth, yield, and quality, leading to food insecurity and poverty. In the future, climate change is expected to have significant impacts on agricultural production worldwide, both in terms of quantity and quality. Changes in temperature and rainfall patterns due to climate change could alter the timing of planting and harvest seasons, leading to lower crop yields and reduced agricultural productivity. Lobell et al. (2011) has analyzed effects of climate change on global crop production and reported that rising temperatures and increased frequency of extreme weather events such as droughts, floods, and hurricanes could also lead to crop failures and reduced crop quality, which leads to food scarcity, increased food prices, and even famine in many regions of the world. On the other hand, Challinor et al. (2014) suggests that yes, climate change is likely to have negative impacts on crop yields in many regions, but that adaptation measures such as improved crop varieties and water management could help to mitigate these impacts. Figure 2 summarizes the effects of climate change.

Limited Resources: Agriculture depends on limited resources such as land, water, and nutrients. As the world population grows, the demand for food and other agricultural products increases, leading to resource depletion and degradation. Limited resources, such as land, water, and energy, can be significant constraints on agricultural production in many parts of the world. As the global population continues to grow, there is increasing pressure on land resources for food production. The expansion of agriculture into new areas can lead to deforestation, soil erosion, and loss of biodiversity. Water scarcity is a major constraint on agricultural production in many regions, particularly in arid and semi-arid areas. Agricultural production requires significant amounts of energy, both for on-farm activities such as irrigation, crop harvesting, and transportation, as well as for off-farm activities such as fertilizer production and food processing. As energy prices rise and fossil fuel resources become increasingly scarce, energy constraints may limit the ability of farmers to maintain or increase their productivity.

Figure 2. Effects of climate change



Soil Degradation: Soil degradation refers to the decline in soil quality due to various factors, including erosion, nutrient depletion, compaction, salinization, and pollution. Agricultural production is heavily dependent on soil health, and soil degradation can severely constrain crop yields and overall productivity. When soil is degraded, it loses its ability to support healthy plant growth. For example, erosion can strip away topsoil, which is rich in organic matter and nutrients, leaving behind less fertile soil that is less capable of supporting crops. Nutrient depletion occurs when soil is not replenished with essential nutrients such as nitrogen, phosphorus, and potassium. This can result in stunted plant growth, reduced yields, and increased susceptibility to pests and diseases.

Pests and Diseases: Pests and diseases pose a significant threat to agricultural production, leading to crop losses, reduced yield, and low-quality products. Pests and diseases can have a significant impact on agricultural production by reducing crop yields, increasing production costs, and limiting market access. They can also increase production costs (Singh & Singh, 2019) due to the need for pesticides, fungicides, and other control measures. In addition, pests and diseases can limit market access, as some countries impose restrictions on imports of produce that are contaminated with pests or diseases.

AGRICULTURAL TECHNOLOGIES AS A SUSTAINABLE SOLUTION FOR PRODUCTION CONSTRAINTS

Agriculture plays a critical role in providing food security and economic stability for many countries around the world. However, the sector faces significant challenges such as climate change, soil degradation, water scarcity, and pest infestations. Agricultural technologies provide innovative solutions to overcome production constraints and enhance productivity, efficiency, and profitability. The integration of agricultural technologies, or AgriTech, into farming practices has emerged as a sustainable solution for these challenges. These technologies are sustainable because they conserve resources, protect the environment, and improve livelihoods. Tablo 1 presents the smart agri-technologies.

Agricultural technologies provide several benefits that enhance productivity, efficiency, and profitability. They also help to conserve resources such as water, land, and nutrients. Precision agriculture reduces fertilizer and pesticide use, conserving resources and protecting the environment. Conservation agriculture reduces soil erosion and nutrient depletion, enhancing soil health and productivity.

Table 1. Smart Agritechs

Agricultural Technology	Innovative Solution	Where & How Used
Precision Agriculture	Use of big-data, analytics and sensors to optimize crop growth and yield.	Helps farmers to apply fertilizers and pesticides precisely, reducing waste and protecting the environment.
Conservation Agriculture	Focuses on soil conservation, reducing soil erosion and enhancing soil fertility.	Conserves resources, enhances productivity and improves soil health.
Smart Farming	Use of advanced technologies such as artificial intelligence (AI), Internet of Things (IoT), and cloud computing to optimize farming practices.	Smart farming enables farmers to collect and analyze big-data from farm fields and other sources. This helps farmers to make more informed decisions about planting, irrigation, pest management, and other farming practices.
Integrated Pest Management	Focuses on pest and disease control through integrated approaches.	Reduces the use of pesticides, protects the environment and enhances crop quality.
Biotechnology	Uses genetic engineering to enhance crop productivity, quality and resilience.	Enhances productivity, reduces waste, and improves food security.
Genetically Modified Corps (GMC)	GM crops are crops that have been altered in a laboratory to have desirable traits such as resistance to pests, diseases, and herbicides.	They increase crop yield and reduce the use of pesticides, while opponents raise concerns about their potential impact on human health and the environment.
Climate-Smart Agriculture	Focuses on enhancing agricultural resilience to climate change	Involves adaptive practices such as water management, soil conservation and crop diversification to enhance productivity and reduce vulnerability to climate change.
Robotics	Use of robots in agriculture to perform tasks such as planting, harvesting and spraying. Robotics enables farmers to automate repetitive and labor-intensive tasks.	Robotics can used to collect data from farm fields and other sources, enables farmers to automate repetitive and labor-intensive tasks, which reduces labor costs and improves efficiency.
Vertical Farming	Involves growing crops in vertically stacked layers using artificial lighting and controlled environments.	Increase agricultural production by reducing the need of agri-soil and water use and improve sustainability.

AgTech enhances productivity by optimizing crop growth and yield. Precision agriculture, for example, helps farmers to apply fertilizers and pesticides precisely, reducing waste and enhancing crop growth. Additionally, agricultural technologies provide several other advantages that enhance productivity, efficiency, and sustainability. Figure 3 below shows the solutions fora gri constraints.

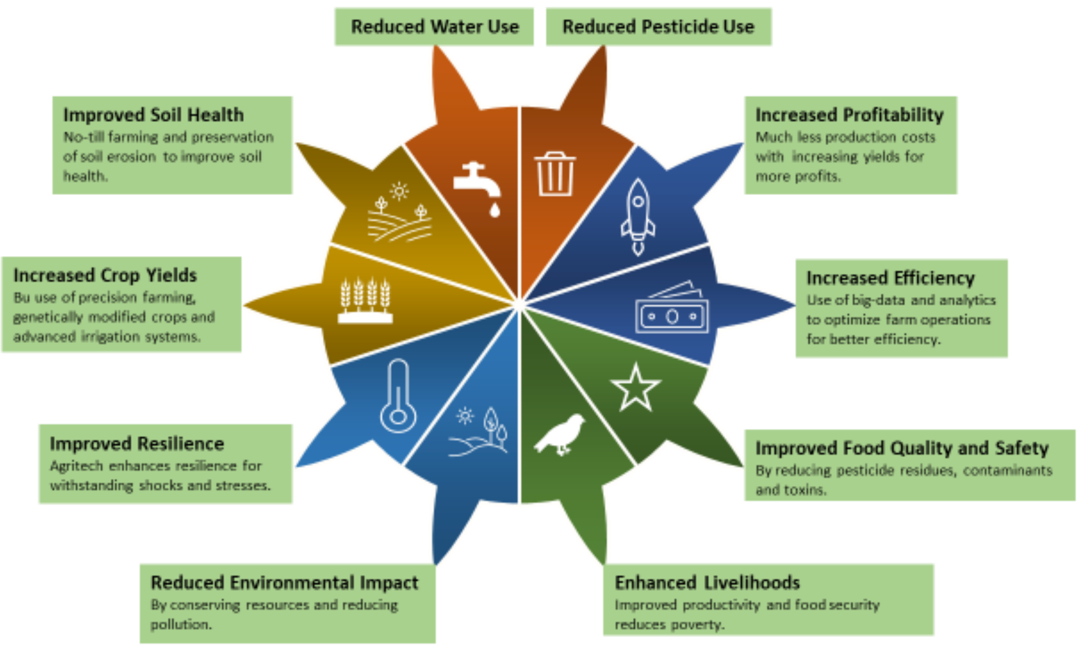


Figure 3. Solutions for agri constraints

Agricultural technologies have contributed to increased production and sustainability in agriculture. These technologies have enabled farmers to produce more food with fewer resources, reducing the environmental impact of agriculture and improving the livelihoods of farmers.

AGRICULTURE TECHNOLOGY STARTUP ECOSYSTEM DEVELOPMENT

According to Smart Agriculture Report by Allied Market Research, global smart agriculture market - powered by AgTech – was valued at $16,7 billion in 2019 and is expected to surpass $29,2 billion by 2027. Also, connected technologies, adoption of IoT and artificial intelligence will furthermore help farmers to be more efficient and effective. Newly developed smart agriculture technologies such as smart sensors, robotic automation, modern biologicals and digital big data will help farmers face todays and tomorrows challenges. There are some countries who are more developed in AgTech funding with higher number of venture capital deals as well as focused technology developments in the field. According to AgFunder's "AgriFood Tech Investing Report H1 2021" the first half of 2021 saw a record-breaking $14.7 billion invested in agtech globally, already surpassing the total investment of $13.8 billion in 2020. The report states that "agtech investment has been growing steadily over the past decade, but the pandemic accelerated investment as it highlighted vulnerabilities in the food supply chain." Table 2 presents the number of agri-tech startups and their economic impcat in the most advanced countries.

Table 2. 12 most advanced countries in agritech technologies

#	Country	# of Agri-Tech Startups	GDP (Trill.$, 2021)	Agri-Industry (%GDP)	Agri-Exports (Bil.$, 2020)
1	United States	3475	22.67	0,0087	133.2
2	United Kingdom	689	3.05	0,0061	29.8
3	Canada	632	1.84	0,0172	49.7
4	Australia	526	1.49	0,0210	43.6
5	China	368	16.39	0,0709	34.7
6	Netherlands	320	1.10	0,0063	105.9
7	Germany	297	4.32	0,0067	78.7
8	France	292	2.97	0,0161	67.6
9	Israel	225	0.43	0,0148	3.6
10	New Zeland	185	0.21	0,0517	6.2
11	Japan	76	5.15	0,0119	6.5
12	South Korea	72	1.71	0,0262	10.4

United States is one of the leading countries in agricultural technology, with a thriving agtech industry. According to a report by AgFunder, investment in US agtech reached a record high of $22.3 billion in 2020, with growth of 15% from the previous year. US is also known for large agriculture land and traditional agricultural production, so creating climate-friendly sustainable solutions for the industry is essential. China is another country that has made significant investments in agricultural technology in recent years. According to AgFunder report, investment in Chinese agtech reached $4.6 billion in 2020, with growth of 52% from the previous year. India is rapidly adopting agricultural technology to improve agricultural productivity and sustainability. According to Allied Market Research's 2020 report on Smart Agriculture Market, the Indian agricultural technology market is expected to grow at a CAGR of 12.2% from 2020 to 2027, faster than global growth average of 9.7%. Israel is known for its advanced agricultural technology, particularly in the area of precision agriculture. According to a report by Startup Nation Central, Israel has more than 400 agtech companies, and the country's agtech industry has attracted over $800 million in investments since 2013. Brazil is one of the largest agricultural producers in the world and has been investing heavily in agricultural technology in recent years. According to a report by AgFunder, investment in Brazilian agtech reached $550 million in 2020, with growth of 27% from the previous year.

Overall, investment in agricultural technology has been growing rapidly in many countries around the world, driven by the need to improve agricultural productivity and sustainability. As technology continues to advance, we can expect to see further growth in the adoption and use of agricultural technology in the coming years. According to AgFunder's "AgriFood Tech Investing Report 2020," global venture capital funding for agtech increased from $2.36 billion in 2010 to $22.3 billion in 2019. In 2020, despite the pandemic, agtech funding remained strong with $22.3 billion invested globally. Overall, these trends suggest that global venture capital funding for agtech has been steadily increasing over the past decade and has continued to grow even in the face of a global pandemic. Table 3 shows biggest investments in agri-tech in the recent years.

Table 3. Top 10 AgriTech investments

#	Company Name	Investment	Agri-Tech Focuse	Origin	Date
1	Plenty	$1.1 billion	Vertical Farming	USA	August 2017
2	Gingko Bioworks	$240 million	Biotechnology company that creates custom microbes for industrial applications	USA	December 2018
3	Indigo Agriculture (2nd Round)	$200 million	Agtech company focused on improving crop yields through the use of natural	USA	August 2019
4	Gro Intelligence	$200 million	Agricultural data analytics company	USA	February 2019
5	Indigo Agriculture	$200 million	Agtech company focused on improving crop yields through the use of natural	USA	September 2017
6	Benson Hill	$200 million	Develops sustainable crop genetics	USA	September 2018
7	Farmers Business Network	$155 million	Platform for farmers to exchange information and purchase agricultural inputs	USA	January 2018
8	AgBiome	$114 million	Agtech company focused on developing microbial solutions for agriculture	USA	March 2018
9	Pivot Bio	$100 million	Uses microbes to improve crop yields	USA	January 2019
10	Infarm	$100 million	Urban Farming Startup	Germany	June 2019

Smart agricultural technologies are not only good venture options but also are a must to maintain the sustainable welfare of world population. Technologies supporting these agri-output intermediaries has social impact as well as economic impact. Access to food and water is the basic need of every single human and if and when there are limitations to meeting basic human needs, it will bring further problems. It is expected for the AgTech trend to gain momentum, provide more investment options to capital holders but also give higher returns to investors.

CONCLUSION

Agriculture is an essential part of human life and plays a critical role in ensuring food security and sustainable development. However, the challenges faced by the agriculture sector such as climate change, population growth and limited resources have made it imperative to explore and develop new technologies to improve agricultural production, sustainability, and profitability.

Agricultural technologies provide innovative solutions to overcome the constraints facing agricultural production. These technologies enhance productivity, efficiency, and sustainability, reducing poverty, improving food security, and protecting the environment. Precision agriculture, conservation agriculture, integrated pest management, biotechnology and climate-smart agriculture are some of the agricultural technologies that provide sustainable solutions to agricultural production constraints. The benefits of agricultural technologies include resource conservation, increased profitability, improved food quality and safety, enhanced livelihoods, reduced environmental impact, and improved resilience. These technologies have also enabled farmers to produce more food with fewer resources, reducing the environmental impact of agriculture and improving the livelihoods of farmers. Therefore, governments, farmers, and other stakeholders should embrace agricultural technologies to enhance agricultural productivity, efficiency, and sustainability.

By leveraging technology, farmers can improve productivity, reduce costs, and access markets more efficiently. However, the success of agritech solutions depends on several factors, including access to financing, supportive policy environments, and adequate training and support for farmers to adopt new technologies.

AgriTech is developed and adapted in some of the countries more than the others. Parallel to those developments, AgriTech funding is higher especially in the USA and India, where agriculture is a big part of economy. As production methods evolve in line with technology, aiming for more efficient and climate-friendly solutions, AgriTech supports environmental sustainability as well. The new economy created around agricultural technologies is expected not only to help farmers further grow their businesses but also to create sustainable production under constantly changing climate conditions. It is projected that AgriTech solutions and use are likely to grow higher than global economic growth.

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