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The Role of Technological Innovation in Mitigating Climate Change Risks in Agricultural Investment

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Abstract: This paper examines the critical role of technological innovations in mitigating climate change risks within the agricultural sector, using Cargill as a case study. Climate change poses considerable threats to agriculture, including unpredictable weather patterns, increased severity of extreme events, and disruptions to food production. However, advanced technological solutions such as artificial intelligence, drone technology, and precision agriculture offer promising ways to address these challenges. This essay demonstrates how Cargill has successfully incorporated these technologies to reduce climate-related risks and enhance operational resilience. In addition, the essay provides recommendations for policymakers, large agricultural corporations, and small-scale farmers on leveraging these innovations effectively. These interventions are adaptable to various farming systems, regardless of whether the focus is on livestock or crop production. By embracing these cutting-edge technologies, farmers of all sizes can safeguard their operations from the adverse effects of climate change, ensuring more sustainable and resilient agricultural practices in the long term.

Keywords: Agricultural Industry, Climate Change Risks, Technological Innovation.

1. Introduction

As climate change keeps getting worse and worse, the agricultural sector is suffering negative outcomes. This sector is susceptible to climate change, as it is highly susceptible to consequences of climate change such as increased severity and intensity of extreme weather events. Farmers, therefore, are directly affected by climate change, necessitating the implementation of strategies to enhance their coping. Technological innovations present possible solutions that farmers can adopt to attain this goal. This essay focuses on the applications of artificial intelligence, drone technology, and precision agriculture in agriculture to mitigate against climate change risks. The essay will focus on Cargill's use of these technologies, to show real world applications of these technologies in the agricultural industry. Through the Cargill example, the benefits of these technologies can be more evident. Policy makers, large agricultural players, and small scale farmers will be presented with suggestions on how to implement these technologies to mitigate against climate change risks.

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2. Literature Review

2.1. Climate Change Risks in Agriculture

Climate change risks are the expected adverse consequences or effects of climate change. In agriculture, these risks include hazards like extreme weather being more frequent, an increased intensity of these, or a disruption to weather patterns that farmers rely on. According to Shah et al.'s paper, climate change can lead to reduced agricultural output due to the impact of higher temperatures and more frequent floods and droughts on crops and livestock [1]. These conditions make agriculture more challenging, as floods promote crop diseases and nitrogen losses, while droughts leave little or no water for plant growth [2]. On the other hand, climate change has resulted in weather patterns become unpredictable. As Blackmore et al. notes, farmers are now having to contend with extended dry seasons and rainy seasons than they are used to, which results in lower yields [3]. On the other hand, the warming of the climate has been shown to encourage pest outbreaks [4].The effects of climate change, therefore, is to make agriculture less productive and more expensive for farmers, potentially threatening the global food supply.

2.2. Technological Innovations Addressing Climate Change Risks

2.2.1. Precision Agriculture

Precision agriculture refers to a collection of farming management practices that uses various technologies to observe, measure, and respond to changes in variables related to agricultural production [5]. Rather than being one technology, precision agriculture involves the integration of many technologies. These include GPS, sensors, and data analytics technologies [6]. In practice, these technologies are used to precisely manage inputs such as water, fertilizer, and pesticides. As Monteiro et al. notes, precision agriculture helps to more accurately and resource efficiently conduct both livestock and crop management [7]. Under precision agriculture is the variable rate technology (VRT), which involves applying inputs such as water and agriculture at varying rates on a wider field [8]. This allows farmers to use resources and water only in areas of a field that require them, preventing waste. According to Ahmad et al.'s paper, precision agriculture has emerged as a major approach for dealing with the damaging consequences of climate change, by allowing farmers to tailor their decisions based on the actual status of crops and soil [6]. The technology can help better identify the first signs of a nutrient deficiency that has been on the rise as climate change continues.

2.2.2. Artificial Intelligence

Artificial intelligence is a technology that simulates human thinking. The technology is able to overcome some human limitations because it is run on machines, mostly computer systems. As a result, it is able to process large amounts of data and generate predictions [9]. Increasingly, this technology is being used in the agricultural sector to address some of the challenges resulting from climate change. According to Shah et al.'s paper, platforms such as UjuziKilimo and Apollo Agriculture have been applies in East Africa to help farmers optimize the use of scarce resources [1]. The technology achieves this by sampling data from the soil and returning valuable information on the right quantities of resources to be used as for instance water. It also plays a vital role in the determination of climatic risks too. Insights on the appropriate amount of resources that should be used, such as water. Artificial Intelligence is also helpful in predicting climate-related risks. According to Alonso-Robisco et al.'s paper, machine learning models and artificial intelligence, climate data, type of the soil, and crop development experience help the farmers in real-time assistance and warning [10]. Through this way, the efficiency on resource use and farmers ability to

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cope with climate change is enhanced. In addition, with other advancements in technology, artificial intelligence can be applied to enhance precision agriculture [11]. These farmers will be able to better adapt to the effects of climate change but also aiming at minimizing their emission of carbon.

2.2.3. Drone Technology

Drones, UAV or unmanned aircraft, are a type of airborne vehicle that is flown through the use of remote control and not through a pilot who is seated in the cabin. Currently in arable farming, drones have been used extensively in addressing various negative impacts of climate change. Pathak et al. noted that in Asia for example the use of drones is prevalent in various activities that concerns agriculture [12]. For instance, they are useful in observing crops and other aspects of crops such as their health state. Furthermore, drone application can complement other technologies adopted in farming including precision farming that has been known to boost farming productivity [12]. Data collected with the help of drones will allow to fix the usage of the fertilizers, water, seeds, etc., at the areas of the farm which need it. Thus, farmers are readily to reduce cost since they do not have to invest on synthetic seeds, but also other resources like water that are scarce due to climate change [13]. CAP 355 were in the 2023 study to find out if drones could assist the small scale farmers in making their production to be more efficient. In accordance with the stated hypotheses, the outcomes of this study also affirm that this technology can also assist farmers with the choices they make and lower the expenses tied to farming. This study is relevant because it proves that drones are not just useful for large scale farmers, but also farmers with a small acreage.

3. Case Description of Cargill Applying Technological Innovations

3.1. Overview of Cargill

Cargill company was established in 1865 as an export mark and is located in Minneapolis, Minnesota, and operates in the food, agriculture, financial, and industrial markets. The company was founded in Iowa originally as a grain warehouse company and has slowly evolved into a multinational company with almost 160000 employees in 70 countries. The company connects farmers with markets, suppliers with customers, and provides essential agricultural solutions to ensure the global food system operates efficiently. Cargill's mission is to nourish the world in a safe, responsible, and sustainable way, which aligns with its commitment to climate action and sustainability [14]. The company has been able to use strategic innovations and partnerships to adapt to modern agricultural challenges. These challenges include climate change, which the company has navigated and continued to experience increased crop yields and supply chain resilience. Because of its success in using technology to address these various challenges, Cargill is an appropriate case study for this paper.

3.2. Cargill's Application of Precision Agriculture

Today, Cargill implements precision agriculture in different aspects of farming to conserve resources and sustain production. A good example is the SCiO NIR Pocket Spectrometers where farmers using dairy can monitor the nutritive values in feed at real-time. It assists farmers in striking the right balance in terms of feed portions to ensure that the taking of milk is enhanced, and needless feed wastage and the costs that come with it are reduced by Cargill, 2024. Furthermore, Cargill has joined hands with Goanna Ag to implement irrigation efficiency solution in cotton farms. This initiative aims at enhancing proper water use through use of information technology to quantify the right amount of water to be used in irrigation without compromising on the growth of crops [14]. Hence

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those innovations, make it possible for Cargill to accurately control farming factors as well as using sustainable farming methods to overcome the increasing effects of climate change.

3.3. Cargill's Application of Artificial Intelligence

Cargill has also extensively applied the artificial intelligence technology throughout its operations as part of its efforts to enhance sustainability across its supply chain. One prominent example of Cargill's use f artificial intelligence is in its collaboration with Satellite [15]. For this purpose, Cargill has employed satellite monitoring that incorporated the use of artificial intelligence to assist in monitoring levels of deforestation in supply chains of Soy, Palm Oil, and Cocoa. This partnership was further carried out under Cargill's corporate sustainability strategy that aims at keeping the company's supply chains from deforestation by the year 2030 [16]. Cargill also employs artificial intelligence in order to offer to its affiliate farmers real time data that will of help to them in farming to adapt to the impacts of climate change [15]. For example, by using artificial intelligence, Cargill is able to tell these farmers the weather conditions, and alert him. Such insights are intended to help those farmers better cope with impacts of climate change besides minimizing their climate impact. Thus, artificial intelligence is the crucial way Cargill contributes to climate change risk management across the value chain.

3.4. Cargill's Application of Drone Technology

Cargill has also made extensive use of drone technology to enhance its farming. Cargill explains that the company uses a program called CattleView to help in cattle ranching [14]. This program makes use of drones, which perform autonomous flights over the feedlot and capture aerial images. These images are subsequently analyzed using artificial intelligence. The data that these drones capture yields information on the welfare and behavior of livestock [14]. This information is subsequently used to mitigate against the negative effects of climate change. It optimizes cattle feed use and minimizes waste. Additionally, Cargill uses solar powered drones to monitor its supply chain. According to Butler's paper, Cargill uses drones in addition to artificial intelligence analysis to monitor deforestation in its supply chain for palm oil, cocoa, and soy [17]. Thus, drone technology helps Cargill to be more productive and to ensure it adheres to its sustainability goals throughout its supply chain.

3.5. Impact of Technological Innovations on Cargill's Performance

By applying these technologies to its operations, Cargill has enjoyed several benefits. Kell noted that Cargill has benefited from the use of artificial intelligence by enhancing its ability to conduct supply chain forecasting [18]. Thus, Cargill is better able to predict when shipments will arrive at ports, which helps the company to be more efficient at logistics. Cargill's use of drone technology has improved the firm's profitability by helping them to reduce costs associated with feed costs by up to $1 per animal [14]. Additionally, the technologies that Cargill produces as a result of its research and development efforts are a source of additional revenue for the company. Therefore, apart from the benefits in combating the effects of sustainability that these technologies produce, they also generate income-related benefits for Cargill and its affiliate farmers.

4. Suggestions for the Agricultural Sector

4.1. Policy Suggestions

Subsidies and Financial Incentives: Governments are in a position to provide direct financial incentives towards the adoption of climate smart agriculture technologies. Some of these could be

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subsidies on the acquisition of precision agriculture equipment or AI as well as for drone technology. According to Akkaya et al.'s paper, subsidies have been useful in helping improve sustainable development but there is the need to ensure that subsidies reach those who need them most to produce the intended positive impact to the environment and the society [19].

Research and Development (R&D) Support: Government should give out funds for R&D for extension of climate based agricultural technology. Backing up innovation in AI, precision farming, and regenerative agriculture is important for enhancing the applicability of those technologies. Further, cooperation between public sectors and universities can propel the move to technology forward.

Training and Capacity Building: The research by Akkaya et al. identified lack of knowledge by farmers as a major hindrance to adoption of new technologies [19]. Governments can therefore initiate training and extension services that will create awareness about the use of artificial intelligent, drone, and precision agriculture practices. Such initiatives should also address the digital competencies to avoid the situation where the farmers are not comfortable using any of those technologies.

Regulatory Frameworks and Standards: Regulations could be adopted by the policy makers to encourage use of sustainable technologies. For instance, rewards to organizations that adhere to the carbon footprint codes or previous certifications of farming operations that incorporate sustainable practices would spur technological advancement in agricultural production.

4.2. Private Sector Suggestions

4.2.1. Large Agricultural Players

Leading agricultural firms are perhaps one of the most strategically positioned to harness technological solutions in meeting the challenge of managing climate change risks well. Large players should be early adopters of the technologies of precision agriculture and artificial intelligence, because these generally require a high initial investment. Early adoption will enhance their resource productivity, thus lowering both environmental effects and cost of products and services [20]. Early adoption will also enable them to generate information that can be used to improve these technologies and democratize them so that smaller farmers can also benefit. In addition, the large agricultural firms ought to incorporate AI systems into applications that they can share with smaller scale farmers, either for free or for a small price. Based on big data on weather conditions, soil quality and crops health it is possible to introduce conclusions derived from AI that will improve crops' resistance and yield [21]. By doing this, they can make the market more competitive, as well as increase their ability to collect data by having many farmers using these apps to log in data. Last but not the least, large agricultural players should work with governments and research institutions to make sure that knowledge is created and shared and that technologies being developed are well implemented across the agricultural sector.

4.2.2. Small and Medium Agricultural Players

Small and medium-scale agricultural players are often constrained by financial and technical capabilities in the adoption of sophisticated technologies. Such players can still find ways of attaining advantage from the available innovations though this has to be done in a strategic manner. First, development should center on cheap, easily deployable technologies like the mobile-based platforms with real-time weather updates, markets, and farming tips. These tools can enable the farmers to act and make the proper decisions concerning crop management or the use of resources without much costs [20]. In addition, such farmers that are in close proximity with each other can form corporative societies and other such networks to pool their resources and invest in these technologies. This makes it so that through Cooperatives small farmers can contribute with small amounts to purchase GPS,

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equipment and other technologies that are costly for the individual farmer [22]. Lastly, cooperation with larger farming companies and NGOs could offer the capacity-building for farmers and financing for small- and medium-sized farms crucial for their adaption to climate change through the use of innovative conservation agriculture technologies.

5. Conclusion

This essay shows that technological innovations play a very important role in addressing climate change risks in agriculture. Specifically, the essay shows how precision agriculture, artificial intelligence, and drone technology are helping farmers to be more sustainable, to optimize resources, and to respond to the effects of climate change on their farms. Through the focus on Cargill, the essay shows that these technologies offer significant benefits. These benefits include improving resource management, enhancing productivity, and reducing the environmental impact of agricultural processes. Not only do these technologies help farmers to combat the negative outcomes of climate change, but they also enhance the profitability of farming. With these clear benefits, it is evident that adopting these technologies is a net positive for the agricultural sector. Players involved in agriculture, whether large or small, would be well-served to integrate these innovations into their operations to remain resilient in the face of climate change and ensure sustainable production practices moving forward.

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